University 8 Mai 1945 Guelma

Faculty of Mathematics, Computer Science and Sciences of Matter

NCNETi'23

The 1st National Conference on New Educational Technologies & Informatics

Proceedings

3-4 October 2023

LabSTIC University 8 Mai 1945

DIWAN INFORMATIQUE

Preface

These proceedings present the articles presented at the First National Conference on Educational Technologies and Informatics (NCNETI'2023), which took place in Guelma, Algeria, from October 3 to 4, 2023. NCNETI'23 is a hybrid conference dedicated to presenting recent research on educational technologies and informatics. Furthermore, NCNETI'23 provided an opportunity for researchers and doctoral students to present their research advances and results in terms of theories, methodologies, and applications related to new educational technology and informatics developments.

This event covered a diverse spectrum of research topics, such as:

- Educational technology
- Machine learning & Big Data in education
- Internet of Things (IoT) and its use in education
- E-learning, mobile learning, and Intelligent tutoring systems
- Smart learning environments
- Artificial Intelligence & its Application
- Web Intelligence application
- Computer Networks, Mobility and Pervasive Systems
- Social and Green Computing
- Intelligent and Decision Support Systems
- Big Data Analytics and Applications
- Computer Vision & Pattern
- Software Systems, Architectures, Applications and Tools
- Multimedia Systems and Applications
- Human-Computer Interaction
- Health Informatics
- IT for agriculture, tourism, and natural resource management
- IT for Renewable Energy and Sustainable Development

The program for the first edition of this manifestation included both long and short articles devoted to theoretical research and applications related to different themes covered by this conference. The program committee evaluated 73 submitted articles and accepted 56 ones from them with a rate of acceptation equal to 76%.

The conference program also included three plenaries presented by renowned Algerian researchers. The first plenary was presented on ligne by Professor Okba Kazar, who is a researcher at the University of United Arab Emirates, Al Ain, Abu Dhabi, United Arab Emirates. Professor Kazar presented a conference entitled "From Artificial Intelligence towards ChatGPT." This conference aimed to present the main stages of the creation of Artificial Intelligence until the main recent research with ChatGPT and ChatBots.

The second plenary conference was about the use of artificial intelligence in the e-learning context. It was presented face-to-face by Dr. Drissi Samia from Souk-Ahras University, Algeria. This conference discussed the main issue of "How will Artificial Intelligence revolutionize E-learning?". The keynote speaker explained the actual research about using artificial intelligence techniques in the e-learning context with the recent trends and some real examples.

The last plenary conference was presented online by Dr. Soufiene Djahel from the University of Huddersfield, UK. His conference had a title: "Connected Autonomous Systems: Opportunities and Challenges." Dr. Soufiene Djahel presented the main principles of

Connected Autonomous Systems and some of their application in real situations in the United Kingdom.

Finally, we thank the authors for their excellent papers, the guest speakers, the members of the program committee, and the members of the conference organizing committee for their contribution to the success of the first edition of the National Conference on Educational Technologies and Informatics.

Program committee chairman

Prof. Dr. Yacine Lafifi

Word of the Organizing Committee Chairman

Our sincere thanks to all the participants of NCNETI'23, the First National Conference on New Educational Technologies and Informatics, a hybrid conference held on 3-4 October 2023 at the University 8 Mai 1945 Guelma, Algeria. The main objectives for the conference were as follows:

- Provide a platform for the presentation of the latest research and significant advances in various fields.
- Facilitate networking and collaboration between researchers, professionals, and students.
- Promote knowledge sharing and discussion of emerging challenges.

The conference attracted 73 participants from over 25 Algerian universities. After a review process, which was carried out by 33 reviewers, 56 papers were selected for presentation. 50% of these papers were presented face-to-face and the others were presented online. We have to mention that the accepted papers cover a wide range of topics, from Artificial Intelligence and its applications in various fields to new educational technologies.

During the conference, we were honored to welcome three speakers who presented three plenary sessions (online and face to face). The aims of their presentations were about new problematics related to Artificial Intelligence and Education technologies.

We warmly thank our honorary chairs for their guidance. We would also like to thank the guest speakers, participants, program committee members, session chairs, and all those who have made NCNETI'2023 a success.

We look forward to seeing you at the next edition of the NCNETI conference.

On behalf of the NCNETI 2023 Organizing Committee
Organizing Committee Chairman
Dr. Ali Seridi

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- Samia drissi (Souk ahras university)
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- Toufik Marir (Oum El Bouaghi University)
- Zohra Mehenaoui (Guelma University)

Programm of NCNETI'23

Day 1	Tuesday, October 3rd 2023	
8:30 – 9:00	*Registration*	
9:00 – 9:30	**OPENING CEREMONY**	
	Plenary Conferences I	
	Presidents: Pr. Hamid Seridi & Pr. Yacine Lafifi	
9:30 – 10:15	Conference 1 (Online): **"From Artificial Intelligence towards ChatGPT"** **Pr. Okba Kazar** University of United Arab Emirates, Al Ain, Abu Dhabi, United Arab Emirates	
10:15 – 11:00	Conference 2: **"How will Artificial Intelligence revolutionize E-learning?"** **Dr. Samia Drissi** University of Souk-Ahras	
11:00 – 11:10	***Coffee break***	
11:10 – 12:20	**Short Communications Session 1**	
	Presential presentations: Hall ***Presidents: Dr. Houda Tadjer & Dr. Djalila Boughareb***	***Virtual presentations: Conference room*** ***Presidents: Dr. Khaled Halimi & Dr. Lynda Djakhdjakha***
11:10 – 11:20	**"An intelligent system to support the teaching of algorithms".** Ali Seridi. Yamina Bordjiba, Riad Bourbia, Aya Bouguern. *(Univ of Guelma)*	**"Analyse des mécanismes d'évaluation de la qualité de conception orientée objet ".** Mokhtaria Bouslama. *(Univ of Oran)*
	"Environment training to identify the image". Abderrahman Mehellou , Benalia M'hamdi, Abderrahman Amari, Talal Giua. *(Univ of Djelfa)*	
11:20 – 11:30	**"Comparative Study Between Conventional and Metaheuristic MPPT Algorithms for Solar Applications Under Standard Testing Conditions".** Mederbel Ayoub, Khadraoui Mohammed, Sahraoui	**"Influencer detection in online social networks".** Halima Baabcha, Meriem Laifa, Samir Akhrouf. *(Univ of Bordj Bou Arreridj)*

	Kamel, Medles Mourad, Miloua Redouane Nakrela Abdelkader, Atouya Bouzidi. *(U. of Sidi Bel Abbes)*	
	"Assessment of Learners' Academic Performances using Learning Analytics Techniques." Zohra Mehenaoui, Houda Tadjer, Yacine Lafifi, Rahma Zedadra. *(Univ of Guelma)*	
11:30 – 11:40	**"USE of e-learning in architectural education field. Case study: students of department of architecture, Guelma's University."** Fatma Zohra Hafsi. *(Univ of Guelma)*	**"L'extraction automatique des entités nommées Spatiotemporelles basée sur les Règles JAPE."** Atmane Hadji, Rania Yacoub, Nadjla Melghid. *(Univ of Mila)*
	"Recommendation of Educational Resources based on Learners' Learning Styles." Safia Bendjebar, Lina Djihane Bordjiba, Yacine Lafifi. *(Univ of Guelma)*	
11:40 – 11:50	**"A concise overview of Bias and Unfairness in ML Models."** Djalila Boughareb, Hana Bordjiba, Hamid Seridi, Nadir Farah. *(Univ of Guelma)*	**"A Human-based Metaheuristic Algorithm for Large-scale Multi-objective Problems."** Aouadj Wafa, Seghir Rachid. *(Univ of Batna2)*
	"Towards an efficient Multi-Robots Search and Rescue strategy ". Ouarda Zedadra, Amina Zedadra, Douaa Ghelis. *(Univ of Guelma)*	
11:50 – 12:00	**"Détection des difficultés d'apprentissage dans un réseau social éducatif "** Amina Zedadra, Ouarda Zedadra, Hind Abidat. *(Univ of Guelma)*	**"H-infinity Control of Nonlinear Systems Using Non-Quadratic Lyapunov Functions An LMI approach."** Khalida Mimoune, Mohamed Yacine Hammoudi, Souri Mohamed Mimoune, Zahia Djeblahi. *(Univ of Biskra)*
	"A New Learner Model to Predict 'Slow Learners' Using Machine Learning." Rochdi Boudjehem, Yacine Lafifi (*Univ of Guelma*)	
12:00 – 12:10	**"An ontology-based questions-answering system to support learners in online learning environments."** Riad Bourbia, Samia Drissi, Yacine Lafifi. *(Univ of Guelma)*	**"Deep Supervised Hashing with Multiscale Feature Fusion (DSHMFF)."** Adil Redaoui, Kamel Belloulata. *(Univ of Sidi Bel Abbes)*
	"PREGO: Plateforme d'apprentissage collaborative favorisant le regroupement optimisé des apprenants." Mourad Hadjeris, Toufik Sari, Yacine Lafifi, Abdeldjalil Rouaissia. *(Univ of Annaba)*	
12:10 – 14:00	***Lunch***	

14:00 – 15:15	**Oral presentations Session 1 (Presential)** ***Presidents: Pr. Zineddine Kouahla & Dr. Samia Drissi***	
14:00 – 14:15	**“Machine learning techniques for solar irradiance forecasting using different training datasets.”** Radouane Nebili, Khaled Khelil, Farid Berrezzek, Lokmene Melalikia. *(Univ of Souk Ahras)*	
14:15 – 14:30	**“LSTM deep learning model for wind speed forecasting in the region of Adrar.”** Melalkia lokmene, Berrezzek Farid, Khaled Khelil, Nebili Radouane. *(Univ of Souk Ahras)*	
14:30 – 14:45	**“Energy demand prediction using machine learning algorithms for home energy management.”** Abderraouf Bouakkaz, Adel Lahsasna, Salim Haddad, Chaima Bensaci *(Univ of Skikda)*	
14:45 – 15:00	**“Anticipating Student Dropout in MOOCs based on Classification Predictive Model.”** Houssam Eddine Aouarib, Fatima Zohra Laallam, Salah Eddine Henouda. *(Univ of Ouargla)*	
15:00 – 15:15	**“Artificial Group Teaching Optimization Algorithm with Information Sharing for Li-Ion Battery parameters estimation.”** Walid Merrouche, Badis Lekouaghet, Elouahab Bouguenna. *(Univ of Algiers)*	
15:15 – 15:30	***Coffee break***	
15:30 – 17:00	**Parallel virtual oral presentation sessions**	
	Oral presentations Session 2 (Virtual session): Conference room ***Presidents: Dr. Ali Khebizi & Dr. Adel Benamira***	***Oral presentations Session 3 (Virtual session): e-Learning room*** ***Presidents: Pr. Mohamed Nemissi &*** ***Dr. Rochdi Boudjehem***
15:30 – 15:45	**“Enhancing Person Re-Identifcation through Tensor Feature Fusion.”** Akram Abderraouf Gharbi, Ammar Chouchane, Mohcene Bessaoud, Abdelmalik Ouamane, El ouanas Belabbaci. *(Univ of Biskra)*	**“Dynamic Threshold-Based Suitability Approach for Energy-Efficient VM Migration in Cloud Environments.”** Younes Khair. *(Univ of Bechar)*
15:45 – 16:00	**“A Powerfull Face Preprocessing For Robust Kinship Verification based Tensor Analyses.”** Ammar Chouchane, Mohcene Bessaoudi. *(Univ of Biskra)*	**“Balanced exploration and exploitation properties of multi-objective Arithmetic Optimization Algorithm.”** Farid Boumaza, Djaafar Zouache, Abou Elhassan Benyamina. *(Univ of Oran)*
16 :00 – 16:15	**“Ear recognition system based on multi-scale feature extraction technique.”** Lebed Toufik, Boukharouba Abdelhak. *(Univ of Guelma)*	**“Fine-tuning CNNs for automated diagnosis of pneumonia from Chest X-rays.”** Hayet Benbrahim1, Ali Behloul. *(Univ Batna 2)*
16:15 – 16:30	**“Multimodal 3D MRI Segmentation using dResU-Net for the detection of Brain Tumor”.** Messaoud Hameurlaine. *(Univ of Tissemsilt)*	**“A hybrid genetic algorithm-interior point method for optimal sliding mode with MRAS speed estimation of double stator induction motor.”**

		Azeddine Beghdadi, Othmane Boughazi, Abdelouahed Touhami, Zeynab Cherki. *(Univ of Bechar)*
16:30 – 16:45	**“Face Recognition Based On Transfer Learning: A Comparative Study.”** Randa Nachet, Tarik Boudghene Stambouli. *(Univ of Oran)*	**“Using Edge Computing for Improving Healthcare in Smart Cities.”** Laid Kenioua, Kamel Maaloul, Lejdel Brahim. *(Univ of El-Oued)*
16:45 – 17:00	**“A comprehensive Studies Between Maximum Power Peak using Stochastic Techniques for PV Systems under PSC.”** Zahia Djeblahi, Belkacem Mahdad , Kamel Srairi *(Univ of Biskra)*	**“Large-Step GRU-DQN: A deep Reinforcement Learning Approach for Dynamic Vehicle Control in Intersections.”** Rais Med Saber, Zouaidia Khouloud, Boudour Rachid, Bougueroua Lamine. *(Univ of Annaba)*

Day 2	Wednesday, October 4th 2023
8:30 – 9:00	*Registration*
	Plenary Conference II ***Presidents: Pr. Mohamed Nadjib Kouahla & Pr. Brahim Farou***
9:00 – 10:00	Conference 3 (Online) **“Connected Autonomous Systems: Opportunities and Challenges”** **Dr. Soufiene Djahel** University of Huddersfield, UK
10:00 – 11:00	**Oral presentations Session 4 (Presential)** ***Presidents: Dr. Karima Boussaha & Dr. Zohra Mehenaoui***
10:00 – 10:15	**“Formation automatique de groupes d’apprenants par une méthode de classification multi-label.”** Noureddine Gouasmi, Lamia Mahnane, Yacine Lafifi, Randa Bounemra. *(Univ of Guelma)*
10:15 – 10:30	**“Arabic speech Augmentation for mispronunciation detection.”** Meriem LOUNIS, Billel DENDANI, Halima Bahi. *(Univ of Annaba).*
10:30 – 10:45	**“A Gamification-based approach to improve the learners' engagement in online learning environments.”** Souhila Zerdoudi, Houda Tadjer, Yacine Lafifi. *(Univ of Guelma)*
10:45 – 11:00	**“Adaptive grouping of learners in a CSCL environment.”** Mourad Hadjeris, Toufik Sari, Yacine Lafifi. *(Univ of Annaba)*
11:00 – 11:10	***Coffee break***

11:10 – 11:50	***Short Communications Session 2***	
	Presential presentations: Hall ***Presidents: Dr. Ali Seridi & Dr. Karima Benhamza***	***Virtual presentations: Conference room*** ***Presidents: Dr. Chemsennehar Bencheriet & Dr. Safia Bendjebar***
11:10 – 11:20	**“Un apprentissage personnalisé à base des annotations dans les MOOC.”** Asma Boudria, Yacine Lafifi, A. Amine Samsar, Ghania Amrani *(Univ of Guelma)*	**“Optimization of 3D Design Processes with ChatGPT Technology”.** Rachad Moumni, Idriss Benlaloui, Nadir Benalia1, Laroussi Kouider. *(Univ of Djelfa)*
	“Density-Based Overlapping Community Detection.” Wafa Louafi, Faiza Titouna. *(Univ of Batna 2)*	

11:20 – 11:30	**"Using CNN and the probabilistic diffusion model for image superresolution."** Nadia Guerroui, Hind Boubidi, Hamid Seridi. *(Univ of Guelma)*	**"Commande Synergétique Terminale d'un Système Photovolaïque."** Khalissa Behih, Nadjat Zerroug, Ziyad Bouchama. *(Univ of Setif)*
	"From recognition to generation: facial expression transfer with StyleGan2". Yamina Bordjiba, Nabiha Azizi, Ali Seridi, Hayat Farida Merouani, Youcef Anis Dahlouk *(Univ of Guelma)*	
11:30 – 11:40	**"Towards an Approach for Improving Behavioral Engagement."** Houda Tadjer, Zohra Mehenaoui, Yacine Lafifi, Inès Gasmi. *(Univ of Guelma)*	**"Commande MPPT Optimale d'un Système Solaire Photovoltaïque."** Nadjat Zerroug, Khalissa Behih, Ziyad Bouchama. *(Univ of Setif)*
	"Privacy-preserving blockchain-based federated learning for Arrhythmia detection." Selma Aouamria, Djalila Boughareb, Mohammed Nemissi, and Hamid Seridi. *(Univ of Guelma)*	
11:40 – 11:50	**"Big Data: The Future of Analytics"** Fareh Fouzia (Univ of Guelma)	**"Study the influence of the choice of the Similarity Measures in the Recommendation System."** Djelloul Bettache, Nassim Dennouni. *(Univ of Chlef)*
	"Transforming Urban Living: The Impact of IT in Smart Cities - A Case Study Analysis" Fareh Fouzia (Univ of Guelma)	
	Parallel virtual oral presentation sessions	
11:50 – 12:35	***Oral presentations Session 5 (Virtual): Conference room*** ***Presidents: Dr. Ouarda Zedadra & Dr. Nadia Guerroui***	***Oral presentations Session 6 (Virtual): e-Learning room*** ***Presidents: Dr. Nadjette Benhamida & Dr. Amina Zedadra***
11:50 – 12:05	**"Enhancing The Performance of A Hybrid OCDMA/OFDM Optical System Incorporating A New Spectral Coding Block Via FSO Channel."** Mohamed Rahmani, Abdelhamid Cherifi, Ghoutia Naima Sabri. *(Univ of Bechar)*	**"Customised learning: Techniques and standards for adaptive e-learning."** Fateh Benkhalfallah, Mohamed Ridda Laouar. *(Univ of Tebessa)*
12:05 – 12:20	**"Towards A Greener Future: The Power of Renewables in Intelligent Energy Management".** Mohamed Salah Benkhalfallah, Sofia Kouah. *(Univ of Oum El Bouaghi)*	**"Détection Automatique Des Sentiments Dans Les Réseaux Sociaux à base de Gazetteer et les règles JAPE(Ligue des champions UEFA). "** Atmane Hadji, Ibrahim Bendaoud, Amine Boundja. *(Univ of Mila)*

12:20 – 12:35	**“Stereo SALM of mobile robot.”** Zoulikha Bouhamatou. *(Univ of Batna2)*	**“A new solution for multimedia transmission over Internet of Things Environments.”** Naziha Ali Saoucha. *(Univ of Algiers)*

12:35 – 12:45	**Closing ceremony**
12:45 – 14:30	***Lunch***

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INVITED SPEAKERS

Okba KAZAR

Pr. Okba KAZAR obtained his engineer diploma and magister's degree followed by a state doctorate diploma from the University of Constantine (Algeria). He published more than 396 papers; he participates as a chair and session chair in international conferences. He published three books: "Manuel d'intelligence artificielle", "Big Data Security" and "L'intelligence artificielle par la pratique". He published also more than 14 book chapters. He supervised 38 PhD and more than 60 magister (and master).
His main research field is artificial intelligence. He is interested to the multi-agent systems and their applications, PHM in medical and industrial fields, ERP, advanced information systems, robotic, web services, semantic web, Big Data, Internet of Things and cloud computing. He had the status of visiting professor in many universities in Europe especially in France and Spain. Professor KAZAR was professor at computer science department of the University of Biskra and he was the director of the Smart computer science laboratory (LINFI). Currently, he is at the United Arab Emirates University (UAEU, Abu Dhabi, UAE).

Title of Speech: From Artificial Intelligence towards ChatGPT.

Abstract

Nowadays, artificial intelligence has taken on a new and large scale in terms of application, research, and investment. Along with generative artificial intelligence, robotics is imposing itself as a scientific issue for another aspect of artificial intelligence, namely artificial emotion. The latter gives another dimension to artificial intelligence by interest in modelling and implementing emotions in a robot through artificial learning, which will allow it to interact with human beings by taking into account emotional aspects.

This intervention presents the motivations as well as the scientific challenges of artificial emotion with an experiment based on generative artificial intelligence via Chatgpt.

Samia DRISSI

Dr. Samia DRISSi is an Associate Professor at the department on Computer Science at Souk-Ahras University in Algeria since 2009 and is affiliated with LIM Laboratory. She received her PhD in computer science from the University of Annaba (Algeria) in 2015. She is an editorial board member of many international journals and conferences. Her research includes e-learning, adaptive hypermedia systems, semantic web, and artificial intelligence.

Title of speech: How will Artificial Intelligence revolutionize E-learning?

Abstract

In the digital transformation era, the education landscape is evolving at an unprecedented pace. Traditional classrooms give way to digital learning environments using Learning Management systems (LMSs) or Massive Open Online Courses (MOOCs). This transition has been significantly accelerated by the integration of Artificial Intelligence (AI) (Hawarna, 2023). Generative Artificial Intelligence (GAI) utilizes machine learning, neural networks, and other techniques to generate new content (e.g. text, images, music) by analyzing patterns and information from the training data (Ooi et al., 2023). Recently, (GAI) tools like Bard and ChatGPT, which can develop advertising content, digital marketing strategy, chatbot-based solutions, and blog posts, have become increasingly accessible and have impacted the education sector in numerous ways, including learning, teaching, assessment, and administration (Chiu, 2023). Therefore, in this paper, we investigate how AI is revolutionizing education and explore the prospective capability of GAI to transform the e-learning sector. Accordingly, we suggest some future research directions for AI in general and GAI specifically in education. Firstly, we underline the profound effect of personalized learning experiences enabled by AI to boost learner engagement and enhance student performance. Secondly, we show how AI can transform recommendation systems by offering a more personalized learning

experience adapted to the needs and profiles of learners. Then, we explore how AI can detect learners in danger by analyzing data on their behavior, progress and performance. Next, we investigate how GAI can provide helpful tools for teachers, such as MCQ generators that simplify their daily tasks. Finally, we discuss significant concerns about the negative implications of GAI, providing various insights on the opportunities, challenges, and research agendas in the education sector.

References

Chiu, T. K. (2023). The impact of Generative AI (GenAI) on practices, policies and research direction in education: A case of ChatGPT and Midjourney. Interactive Learning Environments, 1-17.

Hawarna, S. (2023). Using Artificial Intelligence And Other Frontier Technologies To Transform The E-Learning Industry. *Journal of Namibian Studies: History Politics Culture*, *35*, 1663-1675.

Ooi, K. B., Tan, G. W. H., Al-Emran, M., Al-Sharafi, M. A., Capatina, A., Chakraborty, A., & Wong, L. W. (2023). The potential of generative artificial intelligence across disciplines: perspectives and future directions. Journal of Computer Information Systems, 1-32.

Soufiene DJEHEL

Dr. Soufiene DJEHEL is a Senior Lecture in Cyber Security at the University of Huddersfield (UK) and a visiting Associate Professor in the School of Computer Science at University College Dublin (Irland). He was the founding of the Smart and Sustainable Cities (S2C) lab with bthe department of computing and mathematics at Manchester Met Univ from 2017 until August 2022.

Dr. DJEHEL earned his PhD in wireless networks security from Lile 1 University of Science and Technology in 2010. He published more than peer-reviewed research articles in international journals and conferences on wireless networks, network security, IoT, intelligent transportation systems, CAVs and UAVs. He supervised to successful completion 7 PhD Students and 28 Master Students, and currently supervising 5 PhD students. His research was supported by Newton Mosharrafa Fund, JSPS, IntelliCentrics UK LDT, EPSRC DTP and the transport Systems Catapult. He served as Senior Lecture at MMU (UK); Engineering Research Manager at University College Dublin (IE); Postdoctoral Fellow at ENSIEE (FR); Associate Lecturer and Researcher at Lile 1 University of Science and Technology (FR), and Teaching Assistant at IMT Nord Europe (FR). He is fellow of Higher education academy in UK member of EPSRC peer review college and the Vice-Chair of the IEEE TCGCC SIG on Green Internet of Vehicles.

Dr. DJEHEL is regularly invited to undertake different leadership roles several IEEE sponsored international conferences; and served as expert reviewer for three European research Councils. He is also the recipient of the FY2021 JSPS Invitational Fellowship for research in Japan award from the Japan Society for the promotion of Science.

Title of speech: Connected Autonomous Systems: Opportunities and Challenges.

Full Papers

Energy demand prediction using machine learning algorithms for home energy management

Abderraouf Bouakkaz[1], Adel Lahsasna[2], Salim Haddad[3], Chaima Bensaci[4]

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Abstract

In the face of global energy challenges, the ability to adapt and innovate is crucial for humanity's survival and progress. Effective energy management plays a pivotal role in optimizing energy consumption patterns and enhancing efficiency. This involves implementing strategies such as energy conservation practices, adopting energy-efficient technologies, and leveraging smart grid systems for improved monitoring and control.

To address these goals, this study proposes a energy demand forcasting with an integrated machine learning algorithms for energy prediction in residential homes. By utilizing various machine learning algorithms, the system aims to predict energy consumption, ultimately optimizing energy performance. The performance and effectiveness of these algorithms are thoroughly evaluated, highlighting the potential benefits of machine learning in achieving energy efficiency and cost reduction within homes.

Keywords: *Machine learning, prediction, renewable energy, energy consumption, energy management systems.*

Introduction

Humanity is currently navigating a challenging period in terms of energy, and the ability to adapt and innovate will be crucial and decisive for the survival of the human race within a highly developed environment. While making accurate forecasts about the future of energy production and consumption is exceptionally difficult due to the complex energy landscape at both national and global levels, it is evident that energy demand continues to rise while production undergoes a complex and uncertain transitional phase ((IEA), 2022).

Energy consumption challenges arise from various factors, including population growth, urbanization, and industrialization. As societies expand, the demand for energy, especially electrical energy, escalates. This surge in demand places strains on existing energy infrastructure and necessitates the development of new energy sources and technologies (Fettweis, 2008)(Santamouris, 2021).

Accurate energy demand forecasts provide essential information for resource planning (Islam, 2020). It assists policymakers, energy companies, and utilities to determine the necessary capacity for power generation, transmission, and distribution. Consequently, sufficient resources will be allocated for future energy needs without excessive overcapacity or shortages. Additionally, energy-efficient technologies can be promoted, demand-side management programs implemented (Boshell, 2008), and energy conservation policies developed (Bertoldi, 2022).

There are several studies provide valuable insights into different approaches and methodologies used in energy demand forecasting. For instance, (Suganthi, 2012) focuses on monthly electric energy demand forecasting using a trend extraction approach. (Ghalehkhondabi, 2017) provides an overview of energy demand forecasting models used between 2005 and 2015, it examines different modeling techniques, including econometric models, time series models, artificial intelligence-based models, and hybrid models. Energy demand forecasting: Importance, challenges, and general methodology proposed by (Islam, 2020),the paper discusses the importance of energy demand forecasting, highlighting its role in policy-making, infrastructure planning, and grid management. It identifies the challenges associated with energy demand forecasting, such as uncertainties, data availability, and complex relationships between demand and its drivers.

These studies highlight the importance of energy demand forecasting, the challenges involved, and various methodologies and techniques used in the field. In our paper, we used machine learning techniques and we selected four different algorithms to perform the prediction of energy consumption for a different seasons.

Materials and Methods

In this study, the prediction of energy consumption and cost of energy consumption will be performed using several machine learning algorithms. The following steps will be followed:

- Step 1: Selecting training data: The first step involves selecting a representative set of data that will be used to train the machine learning models. This training data should encompass a wide range of scenarios and cover different variables that impact energy consumption and cost. In this study, we used three main parameters as features (global horizontal irradiation, temperature and the power demand).
- Step 2: Selecting a machine learning algorithm: Based on the specific requirements and characteristics of the data, several regression machine learning algorithms will be chosen for the prediction task. Various algorithms, such as linear regression, random forests, support vector machines, or artificial neural networks, may be considered.
- Step 3: Applying cross-validation technique: To evaluate the performance and generalization ability of the chosen machine learning algorithm, cross-validation will be applied. This involves splitting the training data into multiple subsets or folds (in our case, we chose a k = 10) and iteratively training and testing the model on different combinations of these subsets. The results obtained from cross-validation provide a more robust assessment of the model's predictive capability.
- Step 4: Fit the training data and calculate the Mean Squared Error (MSE): The selected machine learning algorithm will be trained using the training data. During the training process, the algorithm will learn patterns and relationships within the data to make accurate predictions. The MSE will be calculated by comparing the predicted values with the actual values from the training data. The MSE provides a quantitative measure of the prediction error.
- Step 5: Making predictions for new data: Once the machine learning model is trained and evaluated, it can be used to make predictions for new, unseen data. This involves providing the model with input data related to energy consumption and cost and obtaining the corresponding predicted values. These predictions can then be used to gain insights, make informed decisions, and optimize energy management in residential homes.

Results and Discussion

This section is devoted to present the obtained results for both energy prediction for different seasons using different algorithms such as: linear regression (LR), random forest (RF), support vector machine (SVM) and artificial neural networks (ANN) in order to select the performance of each algorithm. The selected machine learning algorithms were performed by Python version 3.11.

For energy consumption prediction, we used the solar irradiation and temperature for three months with time step of one hour.

First quarter of the year

The results of energy consumption prediction for the first quarter (January, February, and March) is summarized in Tab.1 while the regression curves for each algorithm is shown in Fig.1.

For the first quarter, the total real energy consumption equal 2042.322 kWh, while the predicted energy consumption for each algorithm is:

- ✓ Linear regression (LR) algorithm; the total predicted energy was 2044.005 kWh with error equal 1.683 kWh (0.082%).
- ✓ Random forest algorithm (RF), the total predicted energy was 2040.781 kWh with error equal - 1.542 kWh (0.075 %).
- ✓ Support vector machine (SVM), the total predicted energy was 1950.026 kWh with error equal -92.296 kWh (4.519%).
- ✓ Artificial neural networks (ANN), the total predicted energy was 2043.567 kWh with error equal 1.245 kWh (0.061%).

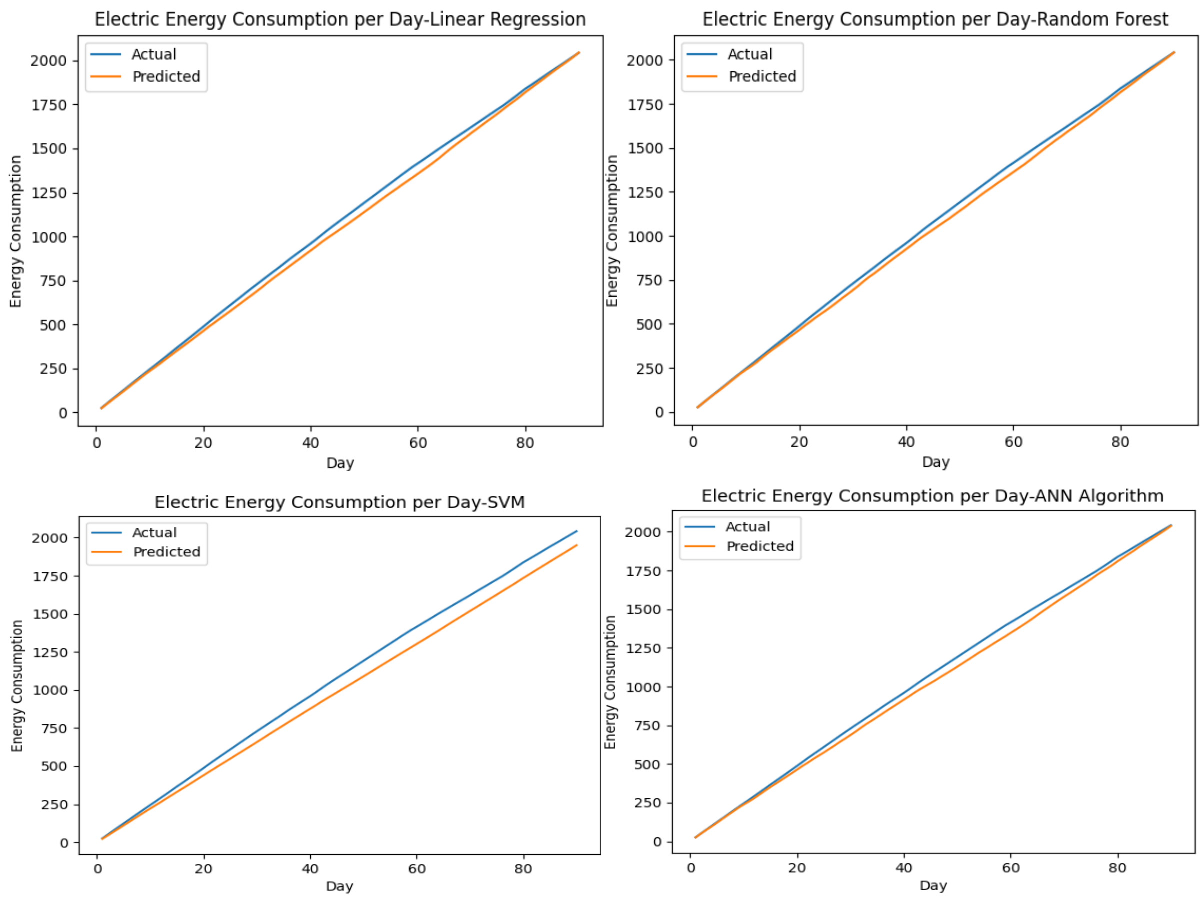


Fig.1. The energy consumption for first quarter.

Tab.1. presentation the results of the energy consumption prediction (first quarter)

Predictor algorithm	Predicted energy consumption (kWh)	Real energy consumption (kWh)	Error (kWh)	Error (%)	MSE
LR	2044.005	2042.322	1.683	0.082	0.121
RF	2040.781	2042.322	- 1.542	0.075	0.099

SVM	1950.026	2042.322	-92.296	4.519	0.122
ANN	2043.567	2042.322	1.245	0.061	0.117

Second quarter of the year

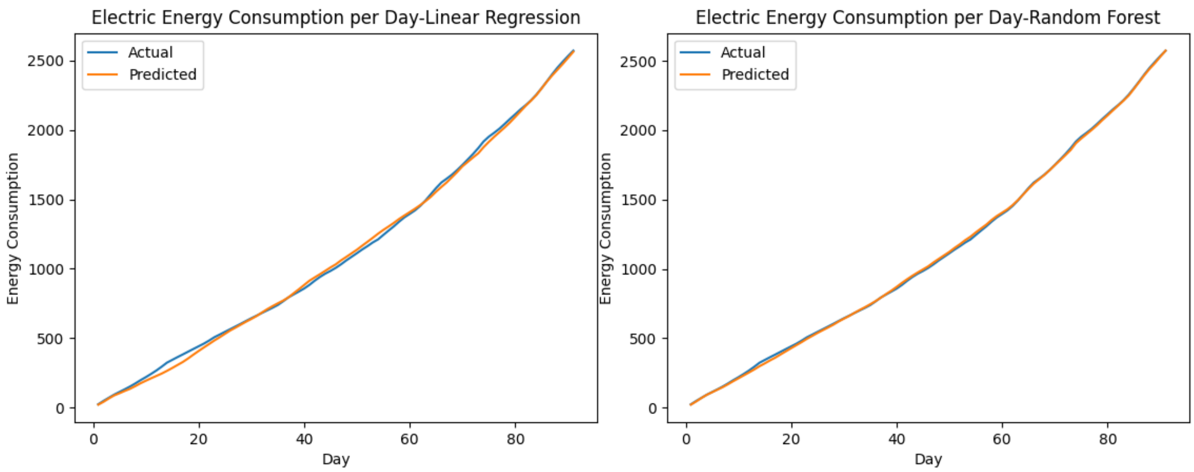
The results of energy consumption prediction for the second quarter (April, May and June) is summarized in Tab.2 while the regression curves for each algorithm is shown in Fig.2.

For the second quarter, the total real energy consumption equal 2572.678 kWh, while the predicted energy consumption for each algorithm is:

- ✓ Linear regression (LR) algorithm; the total predicted energy was 2564.643 kWh with error equal - 8.035 kWh (0.312%).
- ✓ Random forest algorithm (RF), the total predicted energy was 2574.152 kWh with error equal 1.475 kWh (0.057%).
- ✓ Support vector machine (SVM), the total predicted energy was 1981.517 kWh with error equal -591.16 kWh (22.978%).
- ✓ Artificial neural networks (ANN), the total predicted energy was 2646.02 kWh with error equal 73.342 kWh (2.851%).

Tab.2. presentation the results of the energy consumption prediction (second quarter)

Predictor	Predicted energy consumption (kWh)	Real energy consumption (kWh)	Error (kWh)	Error (%)	MSE
LR	2564.643	2572.678	- 8.035	0.312	0.384
RF	2574.152	2572.678	1.475	0.057	0.142
SVM	1981.517	2572.678	-591.16	22.978	0.519
ANN	2646.02	2572.678	73.342	2.851	0.418



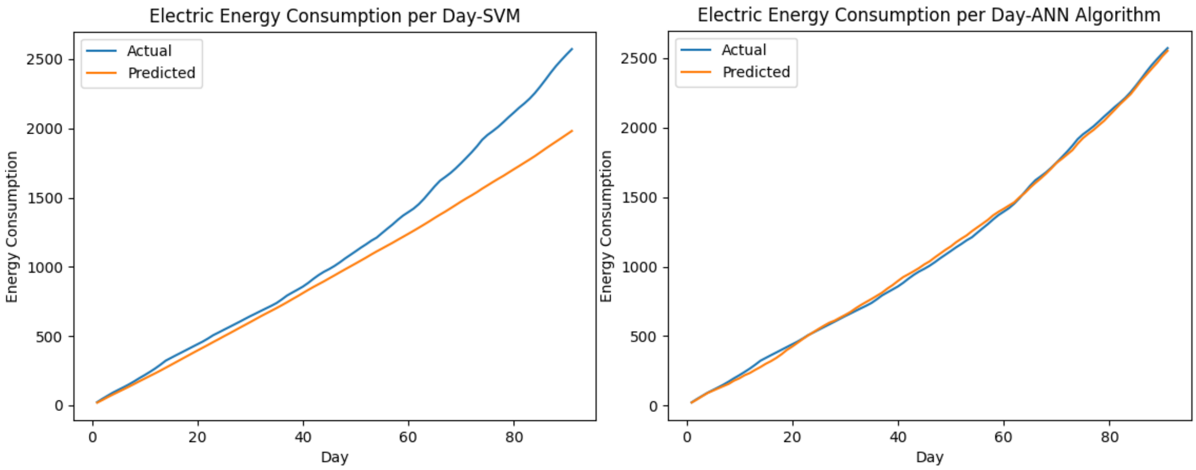


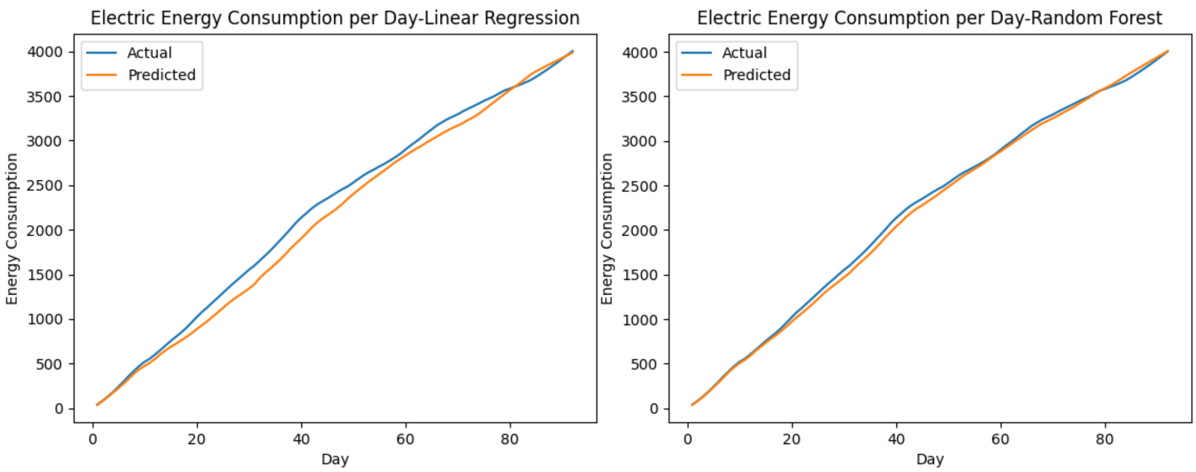
Fig.2. The energy consumption for second quarter: (a: LR; b: RF; c: SVM; d: ANN)

Third quarter of the year

The results of energy consumption prediction for the third quarter (July, August and September) is summarized in Tab.3 while the regression curves for each algorithm is shown in Fig.3.

For the third quarter, the total real energy consumption equal 4004.297 kWh, while the predicted energy consumption for each algorithm is:

- ✓ Linear regression (LR) algorithm; the total predicted energy was 3987.462 kWh with error equal -16.835 kWh (0.420%).
- ✓ Random forest algorithm (RF), the total predicted energy was 4005.775 kWh with error equal 1.479 kWh (0.037%).
- ✓ Support vector machine (SVM), the total predicted energy was 3292.043 kWh with error equal -712.254 kWh (17.787%).
- ✓ Artificial neural networks (ANN), the total predicted energy was 4067.916 kWh with error equal 63.619 kWh (1.589%).



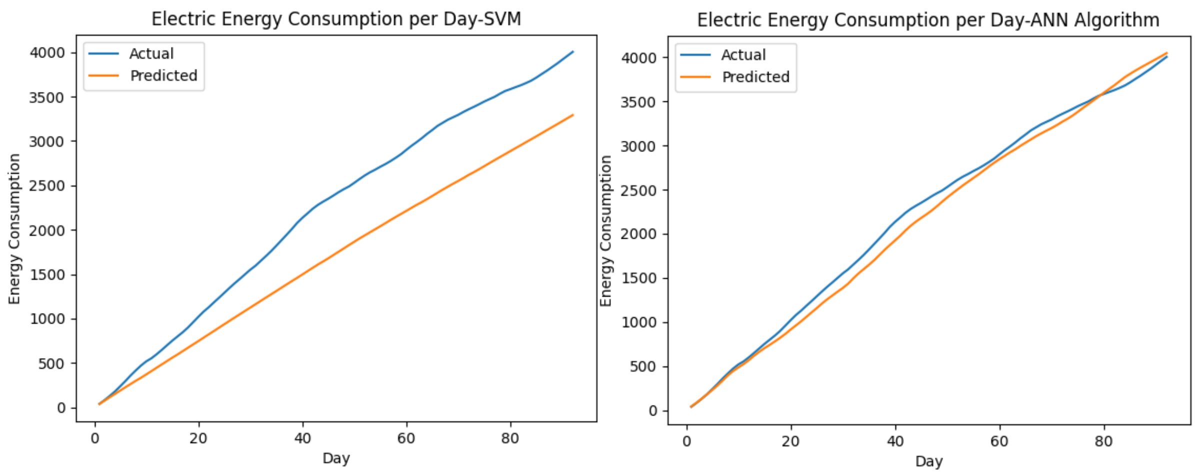


Fig.3. The energy consumption for third quarter.

Tab.3. presentation the results of the energy consumption prediction (third quarter)

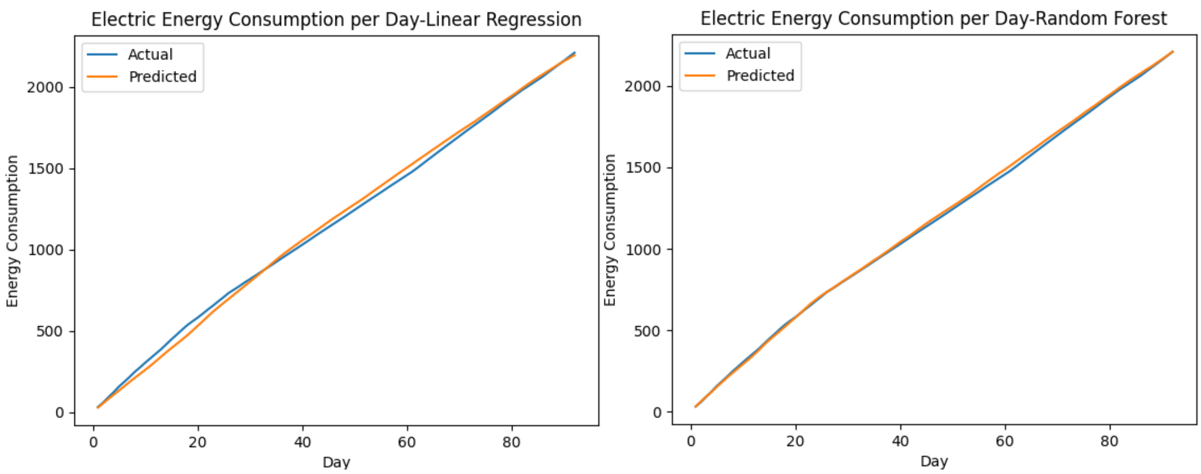
Predictor	Predicted energy consumption (kWh)	Real energy consumption (kWh)	Error (kWh)	Error (%)	MSE
LR	3987.462	4004.297	-16.835	0.420	0.832
RF	4005.775	4004.297	1.479	0.037	0.347
SVM	3292.043	4004.297	-712.254	17.787	1.036
ANN	4067.916	4004.297	63.619	1.589	0.878

Fourth quarter of the year

The results of energy consumption prediction for the fourth quarter (October, November and December) is summarized in Tab.4 while the regression curves for each algorithm is shown in Fig.4.

Tab.4. presentation the results of the energy consumption prediction (fourth quarter)

Predictor	Predicted energy consumption (kWh)	Real energy consumption (kWh)	Error (kWh)	Error (%)	MSE
LR	2194.975	2210.039	-15.064	0.682	0.209
RF	2211.515	2210.039	1.477	0.067	0.137
SVM	1975.587	2210.039	-234.452	10.608	0.217
ANN	2200.607	2210.039	-9.432	0.427	0.201



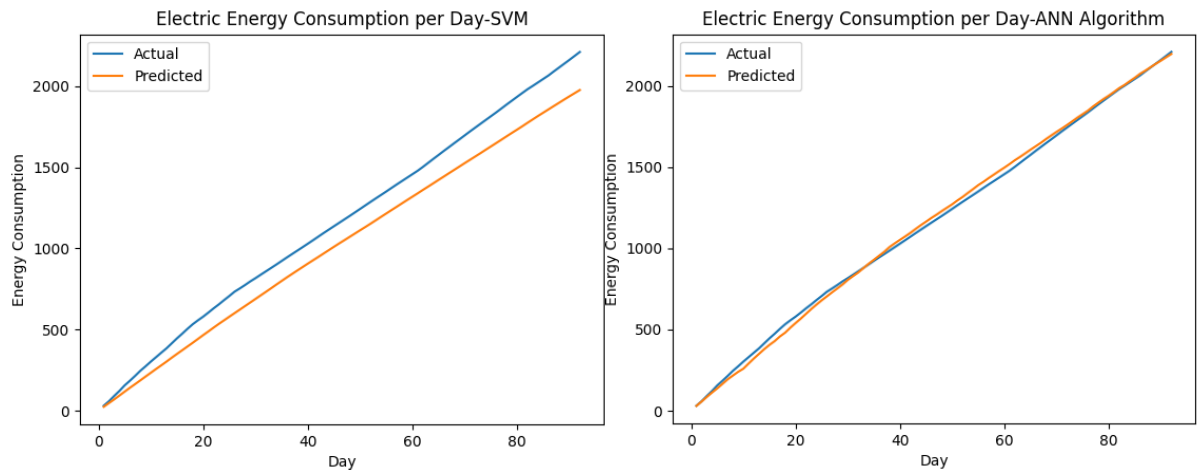


Fig.4. The power consumption for first quarter.

For the fourth quarter, the total real energy consumption equal 2210.039 kWh, while the predicted energy consumption for each algorithm is:

- ✓ Linear regression (LR) algorithm; the total predicted energy was 2194.975 kWh with error equal 1.477 kWh (0.682%).
- ✓ Random forest algorithm (RF), the total predicted energy was 2211.515 kWh with error equal 1.479 kWh (0.067%).
- ✓ Support vector machine (SVM), the total predicted energy was 1975.587 kWh with error equal -234.452 kWh (10.608%).
- ✓ Artificial neural networks (ANN), the total predicted energy was 2200.607 kWh with error equal -9.432 kWh (0.427%).

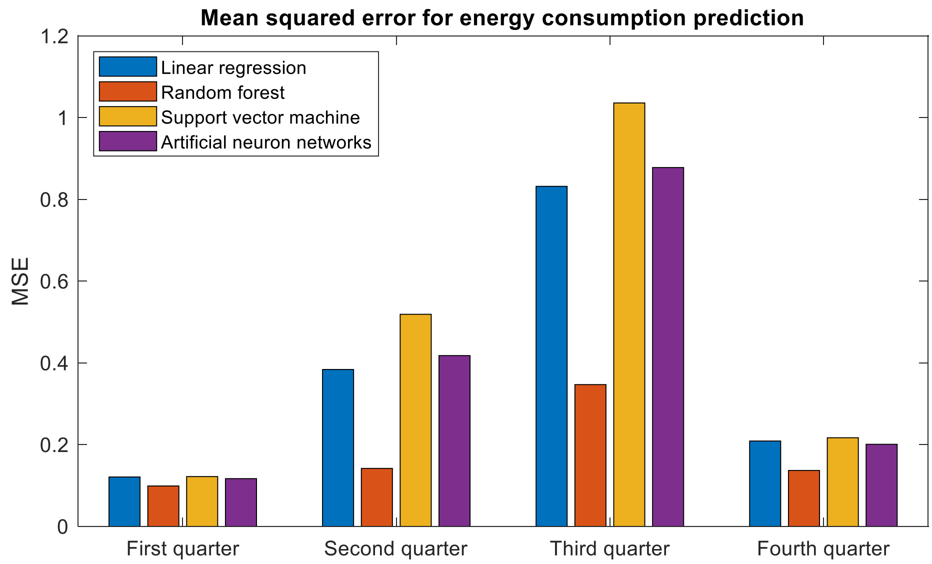


Fig.5. The mean squared error for energy consumption prediction

The Fig.5 shows the mean squared error (MSE) for the energy prediction obtained by each algorithm. The MSE recorded for each algorithm is:

- ✓ The first quarter: 0.121, 0.099, 0.122, and 0.117 for LR, RF, SVM and ANN respectively.

- ✓ The second quarter: 0.384, 0.142, 0.519 and 0.418 for LR, RF, SVM and ANN respectively.
- ✓ The third quarter: 0.832, 0.347, 1.036 and 0.878 for LR, RF, SVM and ANN respectively.
- ✓ The fourth quarter: 0.209, 0.137, 0.217 and 0.201 for LR, RF, SVM and ANN respectively.

Based on the previous results, for the energy consumption prediction, the random forest algorithm (RF) is the best with minimum errors regarding to the total energy consumption errors with followed by the linear regression (LR) and artificial neural networks (ANN), while the support vector machine (SVM) is the worst regarding to these errors.

For the mean squared error (MSE), also, the random forest (RF) has the best performance (the best fit) with minimum MSE followed in this time by the ANN algorithm and LR, while the SVM has the worst regarding the MSE.

Conclusion

In this paper, we evaluated different machine learning algorithms to predict energy consumption in different seasons. According to the results of the prediction, the random forest algorithm performs best for both energy consumption predictions. With the help of these forecasts, the system makes it possible to control energy consumption in the home.

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Enhancing Person Re-Identification through Tensor Feature Fusion

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Abstract

In this paper, we present a novel person reidentification (PRe-ID) system that based on tensor feature representation and multilinear subspace learning. Our approach utilizes pretrained CNNs for high-level feature extraction, along with Local Maximal Occurrence (LOMO) and Gaussian Of Gaussian (GOG) descriptors. Additionally, Cross-View Quadratic Discriminant Analysis (TXQDA) algorithm is used for multilinear subspace learning, which models the data in a tensor framework to enhance discriminative capabilities. Similarity measure based on Mahalanobis distance is used for matching between training and test pedestrian images. Experimental evaluations on VIPeR and PRID450s datasets demonstrate the effectiveness of our method.

Keywords: *Person Re-Identification, tensor feature fusion, multilinear subspace learning, pre-trained CNN, LOMO, GOG, TXQDA.*

Introduction

In the past few years, artificial intelligence has sparked a transformative revolution across multiple domains, significantly impacting people's lives. Among its many applications in areas such as security, commerce, healthcare, and education, smart video surveillance stands out [1]. By incorporating computer vision through machine learning techniques, smart video surveillance encompasses various tasks, including person reidentification. Person Re-Identification (PRe-ID) specifically aims to determine the similarity between images of individuals captured by non-overlapping cameras [2]. This task plays a crucial role in enhancing security and identification processes within the field of video surveillance. Firstly, the goal of person PRe-ID is detecting the similarity between person images sorted from non-overlapping cameras. Several problems are existing with PRe-ID systems due to various factors, such as low resolution, occlusion, illumination variation, and pose changes [3]. PRe-ID system contains three principal phases: features extraction, learning, and mathing scores. To achieve the best scores result many works propose different types of descriptors for robust data representation. Some of those descriptors focus on local features like color, texture, edges, and contours, Shengcai Liao et.al [4] proposed Local Maximal Occurrence (LOMO) to process viewpoint changes and illumination variations. Tetsu Matsukawa et al. [5] applied a Hierarchical Gaussian descriptor (GOG) on each local region of the image to extract local features. In [6] they proposed a global representation of an image through LDFV descriptor, which represents local features like image intensity, and color. Also in [7] they used a Hybrid Spatiogram which was collected from several color channels to extract the features. Some others use deep learning and transfer learning models to extract the deep features [8]–[11], these approaches aim to enhance feature representation to improve the performances. Another side, some works propose methods to improve the learning stage like XQDA [4], EquiDML [12], and KRKISS [13] by increasing the between class and decreasing the within class.

Our contributions in this paper are summarized in the following:

1. We propose a new multilinear representation of features based on pretrained Convolutional Neural Networks (CNNs) as a high-level feature extractor, merged with two local features descriptors Local Maximal Occurrence (LOMO) and Gaussian Of Gaussian (GOG). The fusion of these features in a tensor representation allows for capturing both spatial and semantic information, leading to improved discriminative capabilities.
2. Additionally, we propose a new multilinear subspace projection algorithm named (Tensor-based Cross-View Quadratic Discriminant Analysis). TXQDA effectively exploits the inter-camera correlations and inter-modal interactions present in the tensor feature representation. By modeling the data in a multilinear framework, it learns a discriminative subspace that enhances the separability between different individuals.
3. To evaluate the proposed method, we conducted experiments on two challenging person re-identification datasets, VIPeR and PRID450s. The matching-based Mahalanobis distance is employed for similarity computation between query and gallery samples. The experimental results demonstrate the effectiveness of our approach, achieving significantly improved re-identification performance compared to existing methods. The obtained results affirm the potential of tensor-based fusion and multilinear subspace learning techniques in advancing the field of person re-identification.

The rest of this paper is organized as follow, the proposed methodology is provided in Section II, in which we describe the Tensor feature representation scheme and the Multilinear subspace learning process. Then, the Results and discussions are presented in Section III. Finaly, conclusion and future
directions are given in Section IV.

Methodology

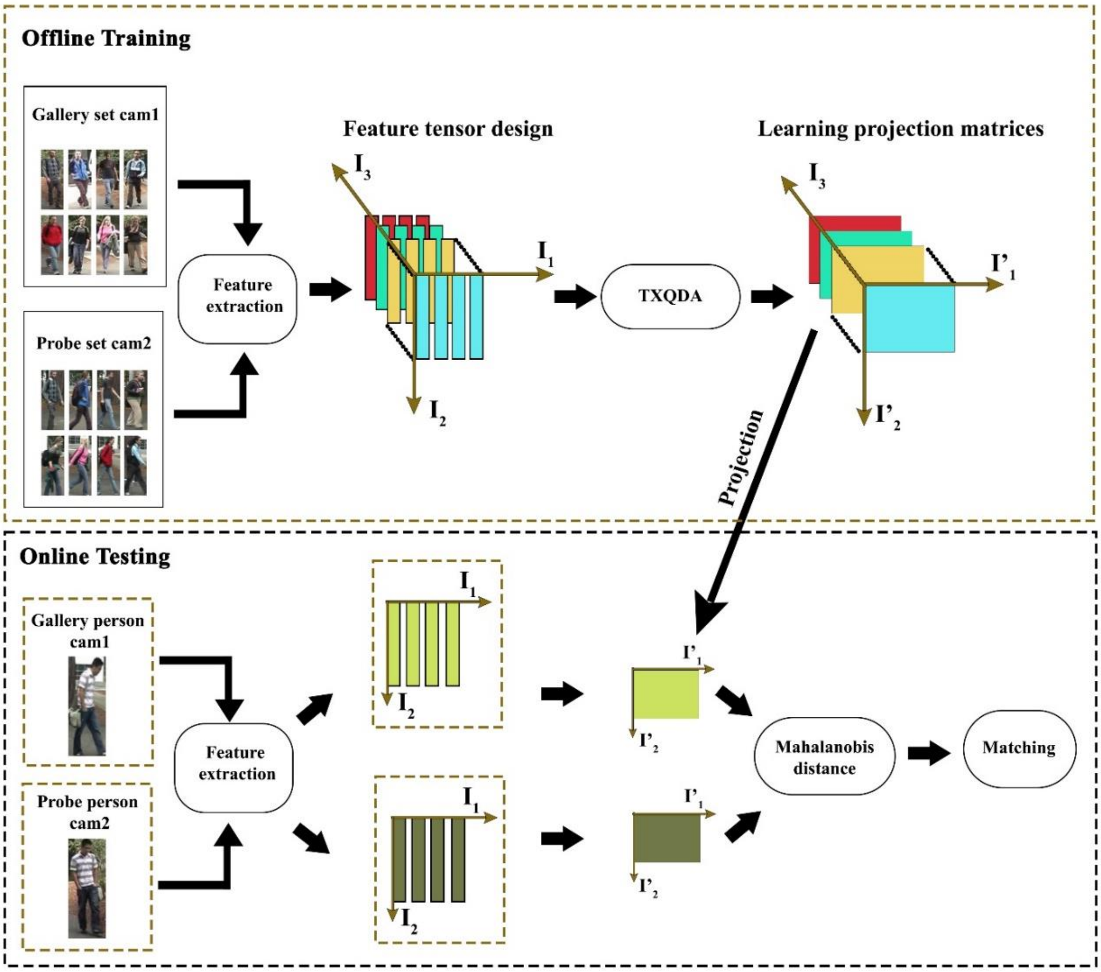
A. Proposed Person Re-Identification approach The proposed approach of Person Re-identification (PReID) system is shown in Fig. 1 Generally, the mechanism of Person Re-identification is to detect similar images of the candidate person through the gallery image datasets of various cameras. So, the system ranks the images of persons relying on the similarity with the probe. Based on the previous, our system includes of three essential stages: Design the Tensor of the extracted features, multilinear subspace learning, and matching with score normalization.

B. Tensor feature representation and multilinear subspace learning

To extract the image features, Three descriptors are used CNN [14] for deep features, LOMO [4] and GOG [5] for shallow features to produce three features vectors for each person image of the gallery, these descriptors are very effective in low- resolution, lighting, viewpoint, and background variations. For robust representation, each vector splits into parts to create a 3-order tensor, each tensor has three modes, the first one represents the number of feature parts, the second mode is the features, and the third mode represents the persons. Then, we combine the tensors to get CNN+LOMO Tensor and CNN+GOG Tensor. Fig. 2 Illustrates the technique of feature extraction and tensor design.

In the offline training phase, the proposed technique TXQDA projects the training tensors X and Y on a new discriminant subspace, and the dimensions of both tensors are reduced to obtain new dimensions $I'_1 \times I'_2$ for mode-1 and mode-2 respectively, where $I'_1 \times I'_2 << I_1 \times I_2$. The dimension of mode-3 represents the persons in the database, so it remains the same. Fig. 3 depicts the different steps of TXQDA algorithm. In the online testing phase, the same procedures occur on each probe of pair images. After the projection, the matching of a probe with the gallery is performed by computing the Mahalanobis distance [15] in the new discriminant subspace.

Fig. 1 The proposed approach pipeline of Person Re-id.



Results and discussion

A. Dataset

We evaluated the effectiveness of our approach by comprised of comparing our experiment against state-of-the-art methods, on two challenging PReID datasets: VIPeR [16], and PRID450S [15].

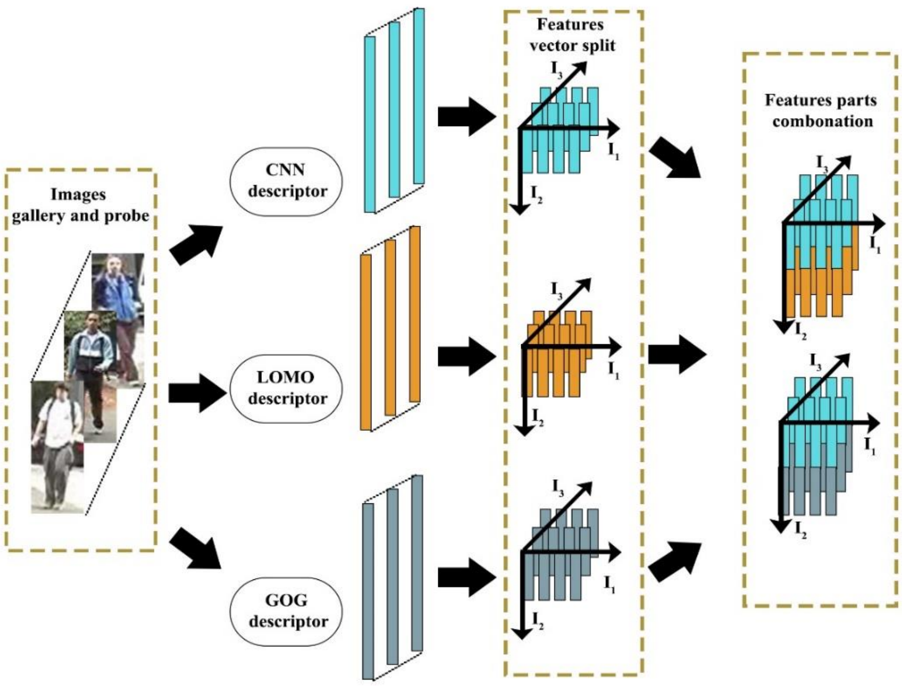


Fig. 2: The tensors design process.

1)VIPeR Dataset

It captured from two surveillance cameras and contains 632 pairs of person images. Each image in this dataset has a size 128x48 pixels. The main challenges in this dataset are variations in illumination, and viewpoint [19, 21].

2) PRID450S Dataset

It captured from two cameras and contains 450 pair of identitie images. Each image in this dataset has a size 128x48 pixels. Images in this dataset contain illumination and pose variation, significant differences in background and viewpoint [19, 21].

We use the 10-folder cross-validation protocol [17,19, 20, 22] in the experiments and evaluate the performance of our approach using the cumulative matching characteristics (CMC) curves. The results into rank-1, rank-5, rank-10, rank-15, and rank-20 are given. The experimental results of the two used datasets VIPeR, PRID450s are shown in Table I and Table II respectively, and their CMC curves are illustrated in Fig. 4 and Fig. 5.

B. Tensors features comparison

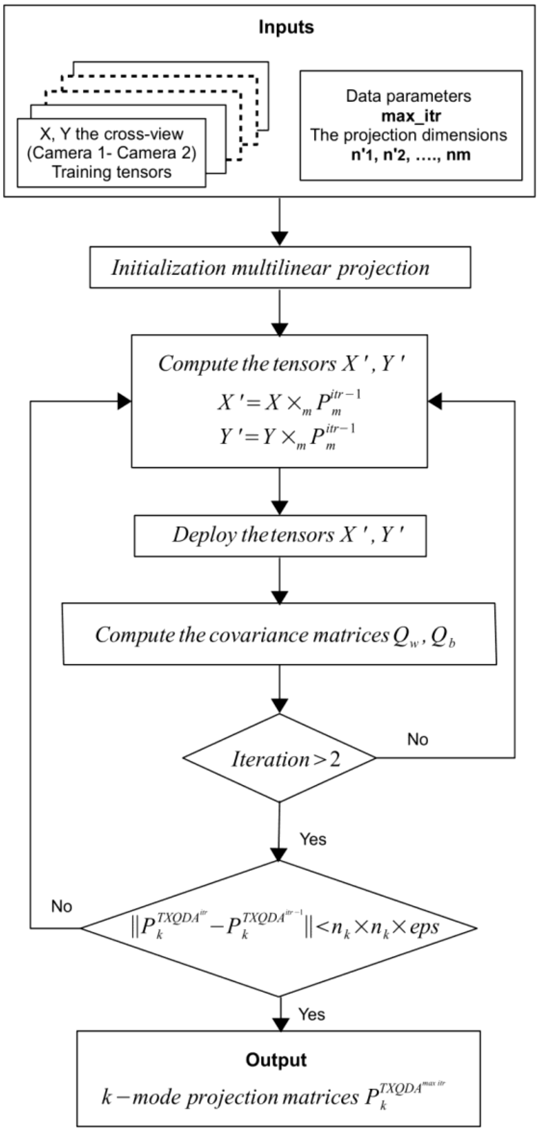


Fig. 3 TXQDA algorithm

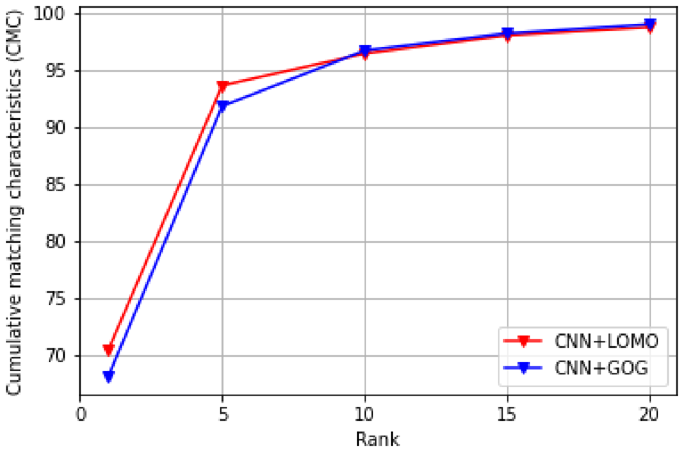


Fig. 4 CMC curves of the best features on PRID450s database

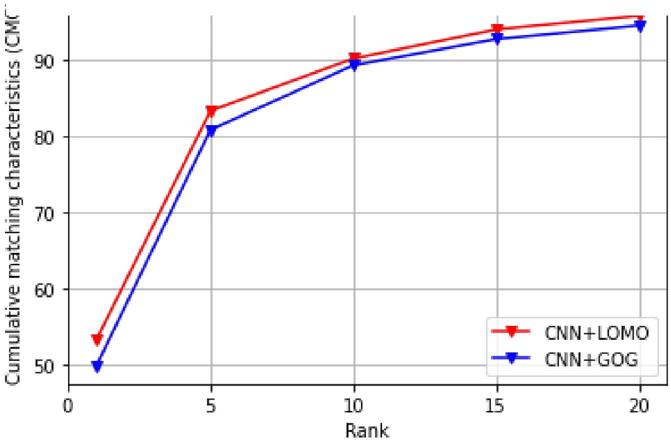


Fig. 5 CMC curves of the best features on VIPeR database

Generally, CNN+LOMO tensor has achieved the best results against CNN+GOG tensor, but the TXQDA output dimension has a role in the variation of the scores percentages. In PRID450s dataset, the rank-1 of CNN+LOMO tensor reached 70.40% in dimension 200 and decreased in dimension 250, while the rank-1 of CNN+GOG tensor reached its best result 68.09% in dimension 250. In VIPeR dataset, the two tensors reached the best result in dimension 250 where CNN+LOMO achieved 53.16% and CNN+GOG achieved 49.72%.

C. Comparison against the state-of-the-art

We have compared our method with previous work methods in recent years, and have achieved the best scores results in the used datasets. Table III shows our technique against the state-of-the-art works from rank-1 to rank-20.

Table I: Performance analysis and results on prid450s

Features types	Dim	Matching rates (%)			
		Rank-1	Rank-5	Rank-10	Rank-20
CNN+LOMO	50	62.53	90.09	95.38	98.27
	100	67.73	92.76	96.53	98.80
	150	69.82	93.38	96.40	98.80
	200	70.40	93.64	96.44	98.76
	250	69.78	93.02	96.22	98.67
CNN+GOG	50	57.73	87.07	94.00	98.00
	100	64.80	90.49	96.04	98.76
	150	66.18	91.42	96.36	98.84
	200	67.20	91.91	96.67	98.93
	250	68.09	91.82	96.71	99.02

Table II: Performance analysis and results on viper

Approach	Year	VIPeR		PRID450s	
		Rank-1	Rank-20	Rank-1	Rank-20
FT-CNN+XQDA [8]	2016	42.50	92.00	58.20	94.30
SSDAL+XQDA [18]	2016	43.50	89.00	22.60	69.20
Kernel X-CRC [23]	2019	51.60	95.30	68.80	98.40
VS-SSL [24]	2020	43.90	87.80	63.30	97.00
SLDL [25]	2022	51.23	95.02	-	-
CNN+LOMO+TXQDA(Our)	2022	53.16	95.82	70.40	98.76
CNN+GOG+TXQDA(Our)	2023	49.72	94.53	68.09	99.02

Table III: Comparison with the sota of rank-1 and rank-20 identification rates (%) on the viper and prid450s datasets

Conclusion

In this paper, we propose a novel approach for person reidentification by combining tensor feature representation and multilinear subspace learning techniques. Our method leverages the power of pretrained CNN as a high-level feature extractor, along with two complementary descriptors, LOMO and GOG. Furthermore, we incorporate a new multilinear subspace projection named TXQDA which is used to reduce the high dimension of the high-order tensor and create a new features representation with augmentation of the inter-class and detraction of the intra-class**.** As a future work, we propose to develop a new deep model trained by all the available datasets of Person re-identification in order to improve our system.

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A Powerful Face Preprocessing For Robust Kinship Verification based Tensor Analyses

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Abstract

Kinship verification using facial photographs captured in the wild is difficult area of research in the science of computer vision. It might be used for a variety of applications, including image annotation and searching for missing children, etc. The largest challenge to kinship verification in practice is the fact that parent and child photos frequently differ significantly from one another. How to effectively respond to such a challenge is important improving the efficiency of kinship verification. For this purpose, we introduce a system to check relatedness that starts with a pair of face images of a child and a parent, after which it is revealed whether two people are related or not. The first step in our approach is face preprocessing with two methods, a Retinex filter and an ellipse mask, then a feature extraction step based on hist-Gabor wavelets, which is used before an efficient dimensionality reduction method called TXQDA. Finally, determine if there is a relationship. By using Cornell KinFace benchmark database, we ran a number of tests to show the efficacy of our strategy. Our findings show that, in comparison to other strategies currently in use, our system is robust.

Keywords: *Kinship Verification, Machine Learning, Retinex Filter, Hist-Gabor Wavelets, TXQDA.*

Introduction

The likeness between two people based on using the physical features of the person, including the hairstyle, pose, hand bone and facial features (nose, eye, ear, and mouth) is one of the most important factors for kinship verification. Although the results can vary comparing with analyzing using DNA sequence, the physical features can be used as an initial investigation and can quickly detect whether two people have a kinship relationship and analyzing facial images is one of the major research topics in biometrics, computer vision, and pattern analysis. In the past few decades, face verification and people recognition problems have been the focus of considerable attention. Kinship verification through facial images in practice, it has many applications such as finding missing children, family album organization and creation of family trees. How to successfully attack such challenge (illuminations, Expressions, poses, large divergence between the images) is important for improving kinship verification performance [1].

Among the difficulties found in this study is the apparent similarity of two people who have no relationship and the case when people have blood relationship and don't have a similar appearance. In addition, effect of the different conditions of images captured [2]. The researcher's attention has shifted to propose an algorithm that determines whether a pair of facial images belonging to a class is kin or non-kin. Analyzing kinship through human facial image is a challenging task and based on the literature, few attempts have been made to do this and the difficulties in recognizing kinship can be divided into the following two categories: (1) directly challenging (related to kinship itself) and (2) indirectly challenging (related to the environment of the database). Moreover, feature extraction is most sensitive and important because special features made available for discrimination straight affect the efficacy of the kinship verification and recognition tasks.

However, although many of the published algorithms have demonstrated excellent recognition results, there are still many open problems. In this paper, we propose a new system of kinshi verification that is composed of five stages: starting by obtaining pairs facial images after the face preprocessing step, where facial images are processed by two methods Retinex filter and

Elliptical mask in to correct illumination and pose and other variations, then we used the features extraction where these facial images are subject to many methods to extract useful information known as features, in this work we used Gabor wavelets model that is collection of mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Finally, the similarity measurement stage to measure similarity between face samples [3].
The main contributions of this work to improve the performance of kinship verification are summarized as follows:

We propose two new methods on the preprocessing stage which are:

1. The Retinex filter in which it's a powerful method for image enhancement in poor visibility conditions that simultaneously provides dynamic range compression, color consistency and lightness rendition, also its denoising process may provide good noise removal. It is markedly superior to a strong increase in local contrast and overall sharpness, especially in scenes of poor visibility.
2. The elliptical mask it's a traditional method utilizes inherently elliptical nature of human head and fits an ellipse to the head its then used to mask out all unwanted feature point especially in complex environment.

The rest of the paper is organized as follows: An Overview of the proposed approach is given in Section 2. Implementation and results a challenging database as well as the discussions analyses are presented in Section 3. Finally, conclusion is sketched in Section 4.

Work outline

Our architecture for kinship matching system. It consists of three major parts: Preprocessing, Feature Extraction and Dimensionality reduction with Matching. Each part is discussed in details in the next sections. Our system contains two phases off-line and on-line. The training phase (off-line) is responsible for learning the discriminative features for each pair of images in the dataset. The testing phase (on-line) estimates the performance of the training stage by testing face image pairs randomly via kin-fold cross validation technique. The Matching stage determines if the pair of face images are kin related or not by comparing their feature vectors using cosine similarity metric. Each stage is explained in details in the following sections.

A. Preprocessing stage

The preprocessing stage is responsible for preparing the facial images to the training stage. The processed images for Cornell KinFace dataset are resized to 200 × 200 pixels and cropped to identify the face region between pixel number 55 to 180 along the X axis and from pixel number 43 to 157 along the Y axis. then the images will pass two stages: The Retinex filter and the elliptical mask. After that the images are supplied to the local feature representation and extraction stage to extract the main features from the processed faces, each method is explained in details in the following sections.

1) The Retinex filter

The Retinex theory developed by Land and McCann in 1971 [6], models the color perception of human vision on natural scenes. It can be viewed as a fundamental theory for intrinsic image decomposition problem, which aims at decomposing an image into illumination and reflectance (or shading) components. The Retinex theory is proposed to simulate the human retina system and assumes that the color of the object is determined by its reflection ability of light of different wavelengths, which is independent of the illumination on the object. The source image S (x, y) can be separated into the reflectance image R (x, y) and the illumination image L (x, The Retinex Theory is to remove the illumination impact from the source image and gets the reflectance image which can reflect the surface characteristics of the object. To compute the reflectance image, logarithmic transformation deployed on both sides of the Eq. (1). So, the estimation of R (x, y) can be implemented as follow:

$$\mathrm{Log}\,[\mathrm{S}\,(\mathrm{x},\mathrm{y})] \;=\; \log\,[\mathrm{R}\,(\mathrm{x},\mathrm{y})] \;+\; \log\,[\mathrm{L}\,(\mathrm{x},\mathrm{y})] \qquad (1)$$

2) The Elliptical mask

The outline of the human head can be generally as being elliptic in nature to segment the face region from the rest of the image we have tried the approach of fitting the best ellipse to the outline of the head The basis of the elliptical mask is the use of a parameter domain this means, given a point (x; y) in the plane, find the parameters of an ellipse passing through that point. The parameters are the center point (x0; y0), the semi-major axis a, and the semi-minor axis b of the ellipse, the method of finding them is in the equation of ellipse below [4, 5].

$$\frac{(x-x_0)^2}{a^2}+\frac{(y-y_0)^2}{b^2}=1 \qquad (2)$$

B. Feature Extraction

Facial feature extraction is an essential step in the face detection. The feature-based methods focus on developing the discriminative facial features [6, 7].The extracted features contain meaningful information of the face that describes the face behavior. Many researchers have proposed variety of techniques for feature extraction, and have tried to solve the problems that exist in this stage we are using Gabor Wavelet for the feature extraction.

1) Feature Extraction using Hist-Gabor Wavelets

Gabor filters has been found to be particularly appropriate for texture representation and discrimination. It shows that the Gabor receptive field can extract the maximum information from local image regions. Researchers have also shown that Gabor features, when appropriately designed, are invariant against translation, rotation, and scale. The filter has a real and an imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually (see Fig. 1) [8, 9].

Real

$$g(x,y;\lambda,\theta,\psi,\sigma\gamma)=\exp\left(-\frac{x'^2+y^2y'^2}{2\sigma^2}\right)\cos(2\pi\frac{x'}{\lambda}+\psi) \qquad (3)$$

Imaginary

$$g(x,y;\lambda,\theta,\psi,\sigma\gamma)=\exp\left(-\frac{x'^2+y^2y'^2}{2\sigma^2}\right)\sin(2\pi\frac{x'}{\lambda}+\psi) \qquad (4)$$

Were

$$x'=x\cos\theta+x\sin\theta \qquad (5)$$

$$y'=-x\sin\theta+y\cos\theta \qquad (6)$$

and λ represents the wavelength of the sinusoidal factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function, ψ is the phase offset, σ is the sigma of the Gaussian envelope and γ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function. When exploited for feature extraction, a filter bank with several filters is usually created and used to extract multi-orientation and multi-scale features from the given face image. This filter bank commonly consists of Gabor filters of 5 different scales and 8 orientations. Gabor features representation of the face image is the result of image I (x, y) convolution with the bank of Gabor filters $g_{u,v}$(x, y). We use Gabor filter with different scales by changing the settings the following settings repeatedly:

Orientations ($\boldsymbol{\theta}$): 45°, 67.5°, 360°, 112.5°.

Wavelength ($\boldsymbol{\lambda}$): 16, 22.63.

Gaussian's variance: we set it equal to wavelength.

Phase offsets ($\boldsymbol{\varphi}$): = 0, 90°.

The process goes as follows:

- Each face image from our datasets is subdivided into a certain number of blocs $M \times N$, where N= $\frac{X}{P1}$ and M = $\frac{Y}{P2}$, $P2$ and $P1$ denote the number of pixels corresponding to the number of blocks along X and Y respectively.
- The resulted matrix is arranged into another matrix of size ($P2 \times P2$) × ($M \times N$).
- Histograms of 256 bins are applied to aggregate the features from each bloc to get a matrix of size (256) × ($M \times N$).
- The resulted feature matrix is reshaped to a set of vectors where each vector represents one scale of the features, we get ($Scales$) × (256) × ($M \times N$)). Scales are set to: 4, 6, 8, 10. e. Finally, these features are concatenated (flattened) into a one-dimensional vector of length $Scales \times 256 \times M \times N$.

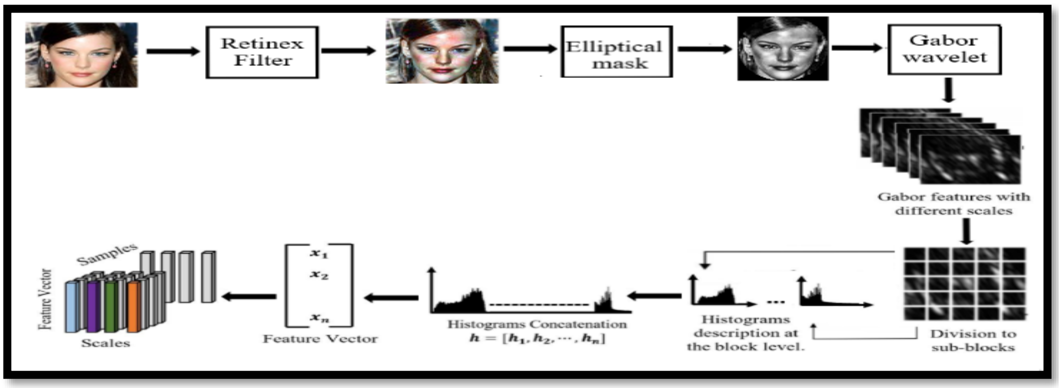

Fig. 1: Feature extraction using Hist-Gabor wavelets

C. Tensor dimensionality reduction and classification

Let a Tensor cross-view training set of c classes where [10] : X ∈ R $R^{I_1 \times I_2 \times \ldots \times I_N \times n}$ contains n samples of one view (Parents samples) and Z ∈ $R^{I_1 \times I_2 \times \ldots \times I_N \times m}$ contains m samples of other view (Children samples). The goal of our TXQDA is the calculation of N projection matrices ($W_1 \in R^{I_1 \times I'_1}$, $W_2 \in R^{I_2 \times I'_{12}}$, …,$W_N \in R^{I_N \times I'_N}$) [10].

Where, W_K is the eigenvectors matrix and Λ_K the eigenvalues matrix. The iterative process of TXQDA breaks up on the recognition of one of the following situations:

1/The number of iterations reaches a predefined maximum;

2/The difference of the estimated projection between two consecutive iterations is less than a threshold

$$||W_k^{iter} - w_k^{iter-1} < I_K I_K|| \quad (8)$$

where I_K is the k mode dimension of W_k^{iter} . The number of iterations, for our TXQDA algorithm, is empirically tuned and the better value is $Iteration_{max}$= 2.

1) TXQDA algorithm

The input of this algorithm is defined as follow [10]:

- The tensor X ∈ X ∈ R $R^{I_1 \times I_2 \times \ldots \times I_N \times n}$ contains n samples of one view (Parents samples).
- The tensor Z ∈ $R^{I_1 \times I_2 \times \ldots \times I_N \times m}$ contains m samples of other view (Children samples).
- $Iteration_{max}$is the maximal number of iterations.
- The final lower dimensions: $I'_1 \times I'_2 \times \cdots \times I'_N$.

Whereas the output can define as follow:

The projection matrices $W_K = W_k^{iter} \in R^{I_k \times I'_k}$, k=1…, N.

D. Matching

In order to compare two face pairs, we use simplified features projected through TXQDA space. These features are connected to form a feature vector. Then, we apply cosine similarity to each pair of tests of the two face images to complete the matching score [10, 18].

Implementation and results

We perform a number of experiments to discover the best results for kinship verification and we fixed the parameters of the Gabor wavelets with best performing number of scales and number of blocs, the number of features projection is changed iteratively with the step of 10 as shown in the Table I.

Table I: The best sittings we used in Gabor wavelets

Number of scales	Number of blocs	Number of features projection
6	12 / 16	150-200

A. Cornell kinship database

To evaluate the performance of the proposed kinship verification approach, we considered one kinship database (Cornell KinFace). This database consists of 150 pairs of parent-child images, which is collected through an on-line search. The face images are chosen to be frontal and a neutral facial [11].

Here we present the results of our experiments on Cornell KinFace dataset with three methods:

- Basic system (without retinex and elliptical mask)
- Retinex filter
- Elliptical mask
- Retinex filter & elliptical mask combined

In which Tables II, III, IV, V illustrate the mean accuracy folds of our simple basic, elliptical mask, Retinex filter, Elliptical mask & Retinex filter combined and the Fig. 1 represents the accuracies in histograms

Table II: The accuracy for the simple basic method of kinship verification for TXQDA using Hist-Gabor wavelets

Method	Number of features projection	Mean Accuracy %
Basic system	150	92.30%
	160	92.35%
	170	92.40%
	180	92.40%
	190	92.40%
	200	**92.76%**

Table III: The accuracy for the Retinex filter method of kinship verification for TXQDA using Hist-Gabor wavelets

Method	**Number of features projection**	**Mean Accuracy %**
Retinex Filter	150	92.71%
	160	92.40%
	170	92.79%
	180	92.75%
	190	92.40%
	200	**92.78%**

Table IV: The accuracy for Elliptical mask method the of kinship verification for TXQDA using Hist-Gabor

Method	**Number of features projection**	**Mean Accuracy %**
Elliptical Mask	150	92.33%
	160	92.32%
	170	92.35%
	180	92.00%
	190	92.00%
	200	**92.00%**

Table V: The best accuracy for all methods performance of kinship verification for TXQDA using Hist-Gabor wavelets

Methods	**Number of features projection**	**Mean Accuracy %**
Basic system	180	92.76%
Retinex filter	200	92.76%
Elliptical mask	170	92.35%
Retinex Filter + Elliptical Mask	190	**93.80%**

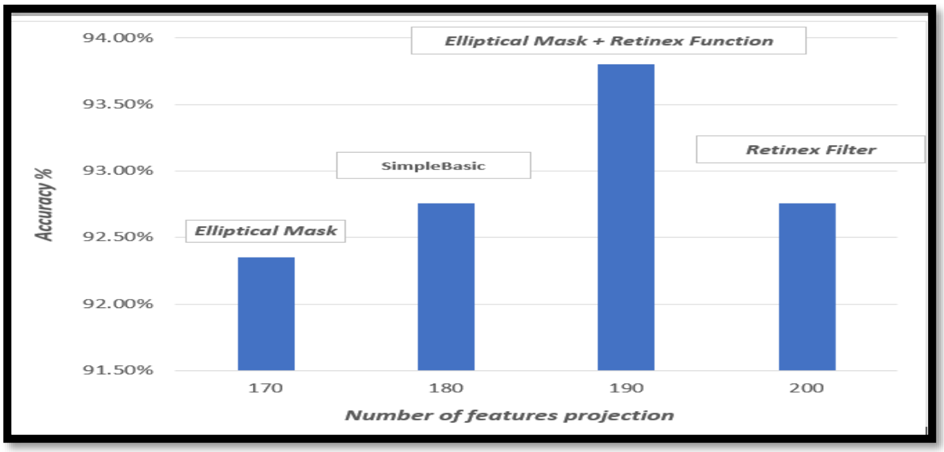

Fig. 2: Histogram of the best accuracy (%) for the whole methods performance of kinship verification

B. Discussion

The experiments that we conducted using two types of preprocessing (Retinex filter & Elliptical mask) and the evaluation results of the proposed TXQDA using (Hist-Gabor wavelets) and cosine similarity and their combinations are shown in Fig. 2 on benchmark kinship datasets (Cornell KinFace). These results outline three principal observations which are detailed in the following:

The power of Retinex filter and Elliptical mask

Retinex filter has shown itself to be a very versatile automatic image enhancement algorithm that simultaneously provides dynamic range compression, color constancy, and color rendition and good image quality, for better illustration of the performances of different features.
Elliptical mask is our key idea to infer relative offset parameters directly from visible parts so as to maintain key benefits described in Second. And by further leaning occluded patterns, the confidence score of visible parts of an occluded object is leveraged from incorporated information of its estimated ellipse. we apply those two methods in our images from the dataset and it is remarkable that Retinex filter and Elliptical mask shows a high performance with in the Cornell KinFace dataset (see table V) we can observe from the increase in the accuracy.

The advantage of using TXQDA for dimensionality reduction

TXQDA preserves the data structure, where these data stacked in a tensor mode providing the maximum extraction of information also helps lightening the small sample size problem and It can obviate the curse of dimensionality dilemma by using higher order tensors and k-mode optimization approach, where the latter is performed in a much lower-dimension feature space than the traditional vector-based methods and Many more feature dimensions are available in TXQDA than the traditional vector-based methods [10]

C. Comparison with state-of-the-art methods

The best performance of the proposed methods of the preprocessing stage (the Retinex filter & the Elliptical mask) and the Hist-Gabor wavelets of the extraction phase TXDA tensor design of Gabor wavelets and compared with recent techniques in Table VI for Cornell database. The related works are cited according to the type of learning used, metric, multi-metric and multilinear learning approaches. The comparison shows that our proposed method outperforms the recent state of the art on the Cornell KinFace database and showed a remarkable increase in the mean accuracy (see Table VII).

Table VI: Comparison of realized performance against existing methods in Cornell KinFace dataset

Approach type	Author	Mean Accuracy %
Metric learning	Lu et al [12] .	69.50%
	Zhou et al [13]	81.40%
	Laiadi et al [14]	77.60%
Multi Metric Learning	Lu et al [12] .	71.60%
	Yan et al [15].	73.50%
	Mahpod et al [16]	76.60%
Multilinear Subspace Learning	Bessaoudi et al [17].	86.87%
	Laiadi et al [10].	93.04%
	Proposed	**93.80%**

Table VII: Increase in mean accuracy of the proposed approach against state-of-the art methods on Cornell Kinface dataset

Approach type	Best method	Increase Mean Accuracy%
Metric learning	Zhou and al [13].	12.36
Multi Metric Learning	Mahpod et al [16].	17.16
Multilinear Subspace Learning	Laiadi et al [10].	0.76

Conclusion

Kinship verification through facial image is an active research topic due to its potential application, in this chapter we described a novel approach with highly efficient methods in which takes two as input then give kinship result (kin/ no kin) as an output. our approach based on 2 methods for preprocessing stage which are Retinex filter and Elliptical mask and the Hist-Gabor wavelets for the feature extraction step that consists of dividing sample images into a number of blocks, extracting histogram features from each block and then concatenating these features into one feature vector representing each sample image, alongside with TXQDA the new dimensionality reduction and classification method to classify for the decision of kinship verification. The approach contains three steps which are: (1) face preprocessing, (2) deep features extraction (3) Classification. Experiments are conducted on one public database Cornell KinFace. Furthermore, our work achieves an impressive verification accuracy of 93.80% which is better than all the state-of-the-art results in kinship verification literature.

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Détection Automatique Des Sentiments Dans Les Réseaux Sociaux à base de Gazetteer et les règles JAPE(Ligue des champions UEFA)

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Résumé

L'analyse des sentiments dans les réseaux sociaux est devenue un domaine de recherche très actif ces dernières années. Avec l'explosion des médias sociaux et la quantité massive de données générées par les utilisateurs, il est devenu essentiel de comprendre les opinions et les sentiments exprimés en ligne. Il est donc devenu crucial de développer des méthodes automatiques pour extraire et interpréter les opinions des utilisateurs. L'analyse des sentiments est utilisée pour classer les sentiments exprimés de différentes manières telles que négatives, positives ou neutres. Dans ce travail nous présentons une approche basée sur un système de détection d'opinions dans les réseaux sociaux (Facebook) sur la coupe de ligue des champions (UEFA). L'implémentation de notre solution a été réalisée en utilisant la plateforme GATE(General Architectur for Text Engineering). Ce travail contribue ainsi dans le domaine de l'analyse des sentiments et des opinions dans les réseaux sociaux en utilisant des Gazetteers en exploitons les règles JAPE(Java Annotation Patterns Engine).

Mots-clés: *Analyse des Sentiments, Réseaux Sociaux, Gazetteer, JAPE, Ligue des Champions.*

Introduction

Dans notre travail, nous focalisons sur l'analyse des opinions exprimées concernant la Ligue des champions de football. Nous étudions les informations et les commentaires publiés sur les réseaux sociaux (Facebook) afin d'extraire des informations sur les préférences des fans, les performances des équipes, les joueurs influents et les tendances émergentes dans la compétition. Notre objectif est de comprendre les opinions des supporteurs et d'analyser les sentiments et les préférences exprimés à l'égard de la Ligue des champions de football. Les analystes et les médias sportifs utilisent ces opinions pour évaluer les forces et les faiblesses des équipes, prédire les résultats des matchs et fournir des commentaires et des analyses aux fans. Les opinions des personnes permettent d'avoir un aperçu de la perception du jeu, des stratégies des équipes et de l'impact des performances individuelles. Dans ce contexte, nous avons proposé une approche d'analyse d'opinion basée sur un Gazeteer , le but de ce travail est de présenter certaines techniques pour améliorer la détection automatique des opinions et les sentiments à partir des commentaires dans les réseaux sociaux. L'objectif est d'utiliser un gazetteer dans l'extraction des opinions est de renforcer la performance des résultats donnés et améliorer leur qualité.

Méthodes Proposée

L'architecture suivante (figure 1) représente la conception détaillée de notre système d'analyse des opinions. Le système proposé se compose de plusieurs étapes :

- Collection des données
- Prétraitement et analyse de texte (Tokenisation, Sentence Splitter, Part Of Speech Tagger,..)
- Création de Gazeteers
- Résultats et Analyse des informations

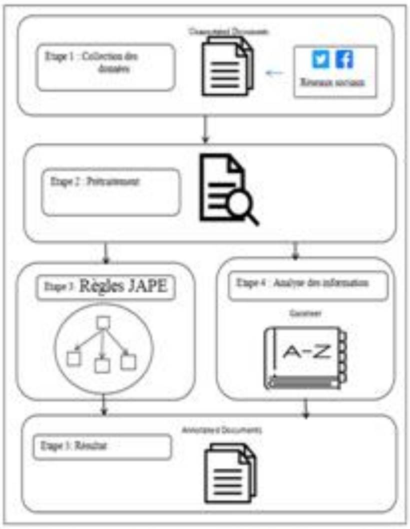

Fig. 1. Architecture générale du système proposé **Fig. 2.** Exemple Règles JAPE **Fig. 3.** Exemple Gazetter dans GATE

Dans cet exemple, nous prenons deux opinions, opinion du match et opinion de l'équipe, où opinions des supporteurs qui se divisent en une opinion négative, une opinion positive, et une opinion neutre, et les mots qui expriment qui sont parmi les listes du gazetters.

Table 1: Exemple Liste de Gazeteer

	Opinion positive	**Opinion négative**	**Opinion neutre**
Opinion du match	Exhilarating,highly entertaining,memorable match,Historic remnants Remnants,Historic match	Frustrating,Underwhelming Subpar,Dismal,Mediocre Sloppy	neutral fan, evenly matched Balanced match,thrilling game well fought , neutral observers
Opinion de l'équipe	Effective,Dominant Skilled,Cohesive,Effective Competitive	execution fell, vulnerable,underwhelming Weak,Inept,Inefficient	Evident,steady,Competent Capable, Decent, Adequate

Résultats et discussion

Après l'exécution du document en utilisant les règles JAPE(figure 2), le système est désormais capable de détecter les entités nommées "Opinion Match Positive", "Opinion Match Négative" et "Opinion Match Neutral" correspondant aux opinions sur un match de Ligue des Champions.

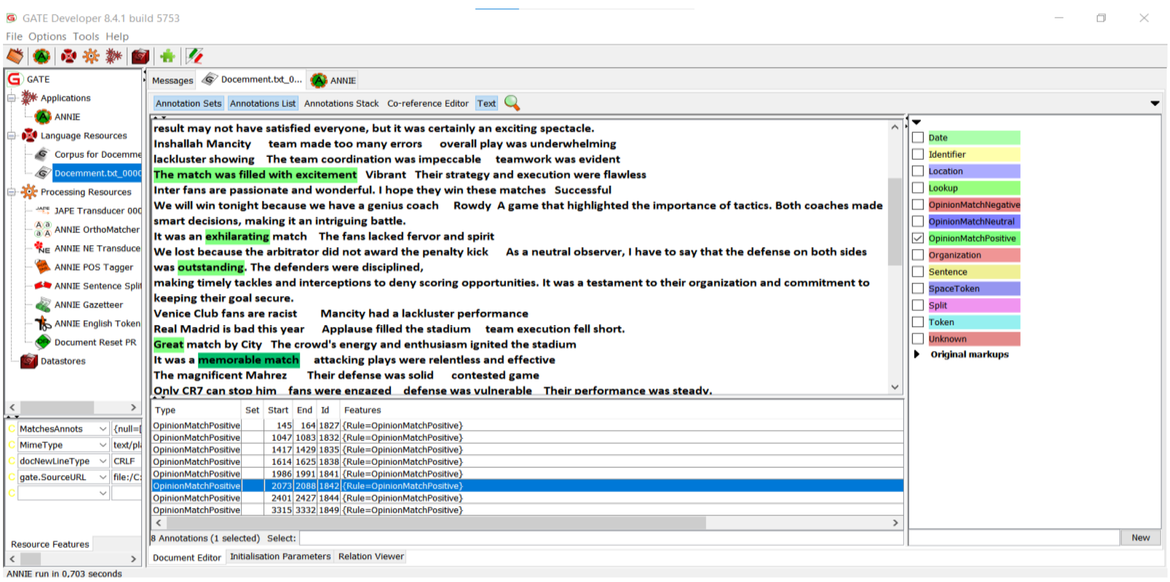

Fig. 4. Extraction d'entités nommées (Opinion Team Positive) avec les règles JAPE.

Nous présentons des formules pour l'évaluation telles que la précision, le rappel et F-mesure et qui sont des mesures largement utilisées dans les évaluations en TALN.

$$\text{Pécision} = \frac{\text{Nombre d'ENS correctement reconnus}}{\text{Nombre d'ENS reconnues}}$$

$$\text{Rappel} = \frac{\text{Nombre d'ENS correctement reconnus}}{\text{Nombre d'ENS de corpus}}$$

La F-mesure est la combinaison de la précision et du rappel et leur pondération. La formule de la F-mesure est comme suit :

$$\text{F} - \text{mesure} = \frac{2(\text{précision} * \text{rappel})}{\text{précision} + \text{rappel}}$$

Tab.2. Résultats d'extractions des entités nommées

Les entités nommées	Entités Nommées	Précision	Rappel	F-mesure
Opinion Positive du Match	20	0.11	0.8	0.75
Opinion Négative du Match	16	0.09	0.84	0.32
Opinion Neutre du Match	17	0.09	0.84	0.77
Opinion Positive du Team	29	0.16	0.85	0.77
Opinion Négative du Team	16	0.09	0.69	0.31
Opinion Neutre du Team	9	0.05	0.76	0.73

Conclusion

Dans ce travail, nous abordons la phase de mise en œuvre de notre approche proposée. Il comprend une description générale des langages et des outils utilisés pour le développement de notre application. Nous avons appliqué une approche à base de règles JAPE et à base de gazatter dans l'environnement GATE pour extraire les opinions comme exemple "Opinion Team" et "Opinion Match". Nous avons également présenté les résultats.

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A hybrid genetic algorithm-interiorpoint method for optimal sliding mode with MRAS speed estimation of double stator induction motor

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Abstract

The research on DSIM control and increasing its effectiveness and durability, made us think about using a strong estimating system to estimate the speed and the rotor flux, so we did this research based on the sliding mode speed sensorless vector control bas the Model Reference Adaptive System (MRAS) of double stator induction motor is presented. In order to achieve a robust system, after trying this technique we found it difficult to find the parameters of the sliding mode, so we suggested using two methods to find the optimal parameters which are the genetic algorithm and the hybrid genetic algorithm to ensure robust control without a sensorless.

The results presented to Matlab showed a positive effect on the behavior of the system, as presented by the two algorithms, especially the hybrid genetic algorithm, in finding the optimal parameters, which enabled us to obtain a more robust system.

Keywords: *Dual Star Induction Motor (DSIM), field oriented control (FOC),sliding mode, model reference adaptative control, genetic algorithm, hybrid genetic algorithm.*

Introduction

The double stator induction machine needs a double three-phase supply, which has many advantages [1, 2]. It minimizes the torque pulsations and uses power electronics components which allow a higher commutation frequency compared to the simple machines, However the double stator Induction machines supplied by a source inverter generate harmonics which result in supplementary losses [1]. The double star induction machine is not a simple system, because of a number of complicated phenomena, which appear in its function, as saturation and skin effects [3].

The double star induction machine is based on the principle of double stators displaced by $\alpha=30°$ and rotor at the same time. The stators are similar to the stator of a simple induction machine and fed with 3 phases alternating current and provide a rotating flux. Each star is composed by three identical windings with their axes spaced by $2\pi/3$ [4, 5].

The field-oriented control decoupling between these variables, and the torque is made similar as the one of a direct current machine [6]. One may note that the field-oriented control scheme is very sensitive to induction machine parameters variations [7]. However, many problems, in order to apply the sensors, are the mounting of the sensor and the additional costs, etc [8].

MRAS is one of the best techniques due to its simplicity, good performance and stability. MRAS consists of reference model, an adaptive model and an adaptation mechanism.

Sliding mode controller with speed estimator has been suggested to achieve robust DSIM performance.

The sliding mode controller provides fast dynamic response, stable control system and easy access to hardware and software. Although this control method causes some defects associated with the large torque chattering that appears in steady state.

Chattering involves high-frequency control switching and may lead to excitation of unmodelled high frequency system dynamics. Chattering also causes high heat losses in electronic systems and undue wear in mechanical systems [9]. In order to reduce the system chattering a sign function is used.

Genetic algorithm (GA) is one kind of global optimization techniques with the advantage of dealing with the integer variables. Interior point method (IPM) offers fast convergence to solve large-scale nonlinear program problem. Both of them have been successfully applied to solving the parameters of sliding mode problem [10], but the difficulty of IPM in dealing with discrete variables and the tardiness of GA in searching optimal solution virtually remain unsolved.

This paper explains the implementation of a high performance sliding mode sensorless control model reference adaptive (MRAS) scheme for a DSIM, with used adaptive heuristic methods GA and GAH.

Dynamic Model Of Double Star Induction Motor

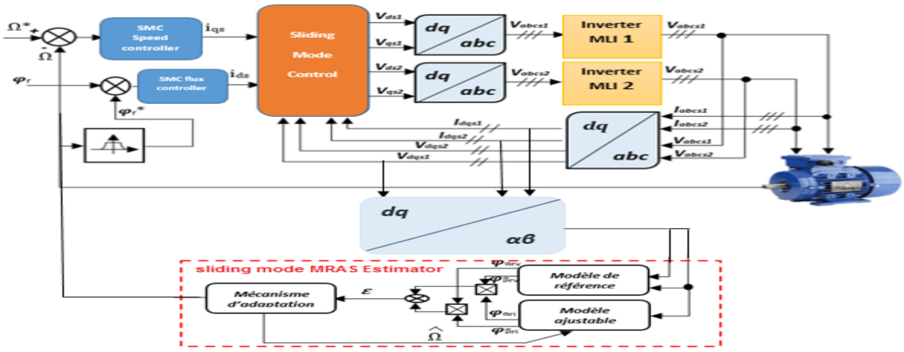


Fig. 1. sliding mode sensorless vector control of DSIM.

A schematic of the stator and rotor windings for a machine dual three phase is given in Figure1.

Field Oriented Control Of Double Star Induction Motor

The objective of space vector control is to assimilate the operating mode of the asynchronous machine at the one of a DC machine with separated excitation, by decoupling the torque and the flux control. With this new technique of control and microprocessor development we can obtain speed and torque control performances comparable at those of DC machine [11].

By applying field oriented control principle

($\varphi_{dr} = \varphi_r$ and $\varphi_{qr} = 0$) to equations (3) ,(4) (5) and (6), the field-oriented model of the motor is given by the following equation system:

$$\frac{di_{ds1}}{dt} = \frac{1}{L_{s1}}\begin{bmatrix} V_{ds1} - R_{s1}i_{ds1} - a_2(a_3(i_{ds1} + i_{ds2}) - a_4\varphi_r) \\ + \omega_s[(L_{s1} + a_1)i_{qs1} + a_1 i_{qs2})] \end{bmatrix}$$

$$\frac{di_{qs1}}{dt} = \frac{1}{L_{s1}}\left[V_{qs1} - R_{s1}i_{qs1} - \omega_s[(L_{s1} + a_1)i_{ds1} + a_1 i_{ds2} + a_2\varphi_r)]\right]$$

$$\frac{di_{ds2}}{dt} = \frac{1}{L_{s2}}\begin{bmatrix} V_{ds2} - R_{s2}i_{ds2} - a_2(a_3(i_{ds1} + i_{ds2}) - a_4\varphi_r) \\ + \omega_s\left[(L_{s2} + a_1)i_{ds2} + a_1 i_{ds1} + a_2\varphi_r\right] \end{bmatrix}$$

$$\frac{di_{qs2}}{dt} = \frac{1}{L_{s2}}\left[V_{qs2} - R_{s2}i_{qs2} - \omega_s[(L_{s2} + a_1)i_{ds2} + a_1 i_{ds1} + a_2\varphi_r)]\right] \quad (1)$$

$$\frac{d\varphi_r}{dt} = a_3(i_{ds1} + i_{ds2}) - a_4\varphi_r$$

$$T_{em} = p\frac{L_m}{L_m + L_r}\varphi_r(i_{qs1} + i_{qs2})$$

$$\frac{d\omega_r}{dt} = a_6 T_{em} - a_6 T_r - a_7\omega_r$$

$$a_1 = \frac{L_m.L_r}{L_m + L_r}\ ;\ a_2 = \frac{L_m}{L_m + L_r}$$

$$a_3 = \frac{R_r.L_m}{L_m + L_r}\ ,\ a_4 = \frac{R_r}{L_m + L_r}$$

$$a_5 = \frac{P.L_m}{L_m + L_r}\ ,\ a_6 = \frac{T_r}{J}\ ,\ a_7 = \frac{K_f}{J}$$

The expressions of the rotor currents may be given as:

$$i_{dr} = \frac{1}{L_r + L_s}\left[\varphi_r - L_m(i_{ds1} + i_{ds2})\right] \quad (2)$$

$$i_{qr} = -\frac{L_m}{L_r + L_m}(i_{qs1} + i_{qs2}) \quad (3)$$

$$\omega_{gl} = \frac{R_r}{L_m + L_r}(i_{qs1} + i_{qs2}) \quad (4)$$

Adaptive System With Reference Model (MRAS)

Speed estimation based on MRAS is one of the best techniques due to its simplicity, good performance and stability [12]. In MRAS the reference model estimator is based on stator voltage model which does not contain the rotor speed parameter and adjustable model is based on current model which contains the rotor speed. The basic concept of MRAS is that the reference model and adaptive model independently estimates the required machine parameter using measured stator voltages and currents in the corresponding reference frame, in this work stationary reference frame is considered. The parameter estimated by the reference model and adaptive models are compared and the difference between them is the speed-tuning signal, which is tuned using an adaptation technique, and adjusts the adaptive model to reduce the error between them to zero. When the error between reference and adaptive model reduced to zero, the estimated speed is equal to the actual rotor speed of the drive. The adaptation mechanism should satisfy the Popov's criterion of hyper stability. Based on the speed-tuning signal MRAS can be classified in to three types, Rotor flux MRAS, Back emf MRAS and Reactive power MRAS and the mathematical equations for reference model and adaptive models are givenin [12,13].

Rotor Flux Based MRAS

The rotor flux-based MRAS technique was mainly developed by Schauder [3], [5], for the estimation of rotor flux and rotational speed. Fig. 1 shows that the reference model in this method is independent of rotor speed and which provides a certain reference flux. The adjustable model, depends directly on the rotor speed and provides a certain estimated flux. The error between these two models is processed by a PI, to give the rotor speed. [9,10].

a) reference model

The reference rotor flux components obtained from the reference model are given by:

$$\begin{cases} \dfrac{d\hat{\varphi}_{r\alpha-v}}{dt} = \dfrac{L_m + L_r}{L_m}\left[V_{s\alpha\alpha} - R_{s1} i_{s\alpha\alpha} - \sigma(L_s + L_m)\dfrac{di_{s\alpha\alpha}}{dt} - \dfrac{L_m L_r}{L_m + L_r}\dfrac{di_{s\alpha\alpha}}{dt} \right] \\ \dfrac{d\hat{\varphi}_{r\beta-v}}{dt} = \dfrac{L_m + L_r}{L_m}\left[V_{s\beta\beta} - R_{s1} i_{s\beta\beta} - \sigma(L_s + L_m)\dfrac{di_{s\beta\beta}}{dt} - \dfrac{L_m L_r}{L_m + L_r}\dfrac{di_{s\beta\beta}}{dt} \right] \end{cases} \quad (5)$$

b) adaptive model

the adaptive model is described by the current model [7-9]:

$$\begin{cases} \dfrac{d\hat{\varphi}_{r\alpha-i}}{dt} = \left[\dfrac{L_m}{T_r}(i_{s\alpha\alpha} + i_{s\alpha\alpha}) - \dfrac{1}{T_r}\hat{\varphi}_{r\alpha-i} - \omega_r \hat{\varphi}_{r\beta-i} \right] \\ \dfrac{d\hat{\varphi}_{r\beta-i}}{dt} = \left[\dfrac{L_m}{T_r}(i_{s\beta\beta} + i_{s\beta\beta}) - \dfrac{1}{T_r}\hat{\varphi}_{r\beta-i} + \omega_r \hat{\varphi}_{r\alpha-i} \right] \end{cases} \quad (6)$$

c) adaptation mechanism

The error between the reference model and the adjustable model is defined as follows:

$$\varepsilon = \hat{\varphi}_{r\alpha-i}\,\hat{\varphi}_{r\beta-v} - \hat{\varphi}_{r\alpha-v}\,\hat{\varphi}_{r\beta-i} \quad (7)$$

The adaptation law is classically given by a PI controller of the following expression [8], [14]:

$$\hat{\omega} = \varepsilon\left(k_p + \frac{k_i}{s} \right) \quad (8)$$

The speed resulting from (6) is in turn reinjected into the adjustable model in such a way that the error converges to zero.

From these results, it is obvious that for the reference model we will take the reference value of rotor flux in (7), and since (8) asks the information of the speed, it will be taken for the adjustable model this is shown in Figure 3.

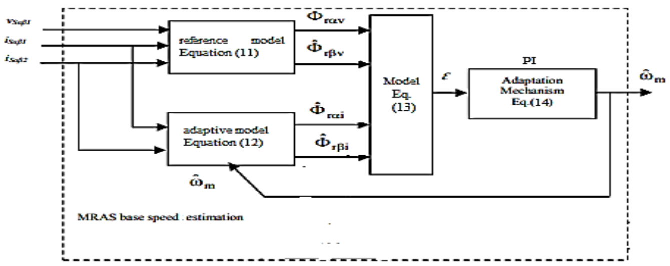


Fig.3 . Block diagram of the classical MRAS technique applied to the DSIM.

in order to give a more robust system, given the unsatisfactory results given by Classic PI , So we introduced a more powerful regulator, which are based on a sliding mode technique

Sliding mode control Of Double Star Induction Motor

Design of the switching surfaces

In this work six sliding surfaces are used and taken as follows since a first order model is used.

$$\begin{aligned} S(\omega_r) &= \omega_r^* - \omega_r \\ S(\varphi_r) &= \varphi_r^* - \varphi_r \\ S(i_{ds1}) &= I_{ds}^* - i_{ds1} \\ S(i_{ds2}) &= I_{ds}^* - i_{ds2} \\ S(i_{qs1}) &= I_{qs}^* - i_{qs1} \\ S(i_{qs2}) &= I_{qs}^* - i_{qs2} \end{aligned} \quad (9)$$

With ω_r^* and φ_r^* are respectively the reference variables of the rotor speed and the flux. $S(\omega_r), S(\varphi_r)$ are related to the outer loops, whereas $S(i_{ds1})$, $S(i_{ds2})$, $S(i_{qs1})$, $S(i_{qs2})$ are related to the inner loops. The i^*_{ds} and i^*_{qs} reference are determined by the outer loops ,and take respectively that values of the control variables i_{ds} and i_{qs}.

Development of the control laws

By using the equation systems (1) and (9), the regulators control laws are obtained as follows :

For the speed regulator

$$S(\omega_r).S^{\cdot}(\omega_r) \prec 0 \Rightarrow \quad I_{qs}^* = i_{qs}^* + \lambda_1 x_1 \quad (10)$$

And $i_{qs}^* = i_{qseq} + i_{qsn}$

With $i_{qseq} = a_8 \dfrac{1}{\varphi_r^*}\left[\cdot \omega^* + a_7 \omega_r + a_6 C_r\right]$

$$a_8 = \frac{J(L_m + L_r)}{P^2 * L_m}$$

$$i_{qsn} = \begin{cases} \dfrac{K_{\omega r}}{\varepsilon_{\omega r}}.S(\omega_r) & \text{if} \quad |S(\omega_r)| \prec \varepsilon_{\omega r} \\ K_{\omega r}.Sgn(S(\omega_r)) & \text{if} \quad |S(\omega_r)| \succ \varepsilon_{\omega r} \end{cases}$$

For the flux regulator

$$S(\varphi_r).S^{\cdot}(\varphi_r) \prec 0 \Rightarrow I_{ds}^* = i_{ds}^* + \lambda_2 x_2 \quad (11)$$

And $i_{ds}^* = i_{dseq} + i_{dsn}$

$$i_{dseq} = \frac{1}{a_3}\left[\cdot \varphi^* + a_4 \varphi_r\right]$$

$$i_{dsn} = \begin{cases} \dfrac{K_{\varphi r}}{\varepsilon_{\varphi r}}.S(\varphi_r) & \text{if} \quad |S(\varphi_r)| \prec \varepsilon_{\varphi r} \\ K_{\varphi r}.Sgn(S(\varphi_r)) & \text{if} \quad |S(\varphi_r)| \succ \varepsilon_{\varphi r} \end{cases}$$

The regulators control laws, for the control variables i_{ds1}, i_{ds2} and i_{qs1}, i_{qs2} of the internal loops are given by :

For the control variable i_{ds1} et i_{ds2}

$$S(i_{ds1}).S^{\cdot}(i_{ds1}) \prec 0 \Rightarrow v_{ds1} = v_{ds1eq} + v_{ds1n} \quad (12)$$

With $v_{ds1eq} = L_{s1}\dot{i}^{*}_{ds} + R_{s1}i_{ds1} - \omega_s\left[L_{s1}i_{qs1} + T_r\varphi_r\omega_{gl}\right]$

$$v_{ds1n} = \begin{cases} \frac{K_{d1}}{\varepsilon_{d1}}.S(i_{ds1}) & \text{if} \quad |S(i_{ds1})| \prec \varepsilon_{d1} \\ K_{d1}.Sgn(S(i_{ds1})) & \text{if} \quad |S(i_{ds1})| \succ \varepsilon_{d1} \end{cases}$$

$$S(i_{ds2}).S^{\cdot}(i_{ds2}) \prec 0 \Rightarrow v_{ds2} = v_{ds2eq} + v_{ds2n} \quad (13)$$

With $v_{ds2eq} = L_{s2}\dot{i}^{*}_{ds} + R_{s2}i_{ds2} - \omega_s\left[L_{s2}i_{qs2} + T_r\varphi_r\omega_{gl}\right]$

$$v_{ds2n} = \begin{cases} \frac{K_{d2}}{\varepsilon_{d2}}.S(i_{ds2}) & \text{if} \quad |S(i_{ds2})| \prec \varepsilon_{d2} \\ K_{d2}.Sgn(S(i_{ds2})) & \text{if} \quad |S(i_{ds2})| \succ \varepsilon_{d2} \end{cases}$$

For the control variable i_{qs1} et i_{qs2}

$$S(i_{qs1}).S^{\cdot}(i_{qs1}) \prec 0 \Rightarrow v_{qs1} = v_{qs1eq} + v_{qs1n} \quad (14)$$

With $v_{qs1eq} = L_{s1}\dot{i}^{*}_{qs} + R_{s1}i_{qs1} + \omega_s\left[L_{s1}i_{ds1} + \varphi_r\right]$

$$v_{qs1n} = \begin{cases} \frac{K_{q1}}{\varepsilon_{q1}}.S(i_{qs1}) & \text{if} \quad |S(i_{qs1})| \prec \varepsilon_{q} \\ K_{q1}.Sgn(S(i_{qs1})) & \text{if} \quad |S(i_{qs1})| \succ \varepsilon_{q} \end{cases}$$

$$S(i_{qs2}).S^{\cdot}(i_{qs2}) \prec 0 \Rightarrow v_{qs2} = v_{qs2eq} + v_{qs2n} \quad (15)$$

With $v_{qs2eq} = L_{s1}\dot{i}^{*}_{qs} + R_{s2}i_{qs2} + \omega_s\left[L_{s2}i_{ds2} + \varphi_r\right]$

$$v_{qs1n} = \begin{cases} \frac{K_{q}}{\varepsilon_{q}}.S(i_{qs}) & \text{if} \quad |S(i_{qs})| \prec \varepsilon_{q} \\ K_{q}.Sgn(S(i_{qs})) & \text{if} \quad |S(i_{qs})| \succ \varepsilon_{q} \end{cases}$$

- For estimated speed sliding mode surface

The sliding surface of the estimated speed is:

$$s(\varepsilon) = \varepsilon + M\int \varepsilon.dt \quad (16)$$

Where $M \succ 0$ and $\varepsilon = \hat{\varphi}_{r\alpha-i}\,\hat{\varphi}_{r\beta-v} - \hat{\varphi}_{r\alpha-v}\,\hat{\varphi}_{r\beta-i}$

The derivative of $s(\varepsilon)$ gives :

$$s(\varepsilon) = \dot{\varepsilon} + M\varepsilon \quad (17)$$

Where :

$$\dot{\varepsilon} = \dot{\hat{\varphi}}_{r\alpha-i}\,\hat{\varphi}_{r\beta-v} + \hat{\varphi}_{r\alpha-i}\,\dot{\hat{\varphi}}_{r\beta-v} - \dot{\hat{\varphi}}_{r\alpha-v}\,\hat{\varphi}_{r\beta-i} - \hat{\varphi}_{r\alpha-v}\,\dot{\hat{\varphi}}_{r\beta-i} \quad (18)$$

the substituting of the adaptive model equation (7) into (18):

$$\dot{\varepsilon} = \hat{\varphi}_{r\alpha-i}\ \dot{\hat{\varphi}}_{r\beta-v} - \dot{\hat{\varphi}}_{r\alpha-v}\ \hat{\varphi}_{r\beta-i} + \frac{L_m}{T_r}\left[(i_{s\alpha1} + i_{s\alpha2})\hat{\varphi}_{r\beta-v} - (i_{s\beta1} + i_{s\beta2})\hat{\varphi}_{r\alpha-v}\right] - \frac{1}{T_r}\left[\hat{\varphi}_{r\alpha-i}\ \hat{\varphi}_{r\beta-v} + \hat{\varphi}_{r\alpha-v}\ \hat{\varphi}_{r\beta-i})\right] - \hat{\omega}_m\left[\hat{\varphi}_{r\beta-i}\ \hat{\varphi}_{r\beta-v} + \hat{\varphi}_{r\alpha-i}\ \hat{\varphi}_{r\alpha-v})\right] \quad (19)$$

By letting:

$$\chi_1 = \hat{\varphi}_{r\alpha-i}\ \dot{\hat{\varphi}}_{r\beta-v} - \dot{\hat{\varphi}}_{r\alpha-v}\ \hat{\varphi}_{r\beta-i} + \frac{L_m}{T_r}\left[(i_{s\alpha1} + i_{s\alpha2})\hat{\varphi}_{r\beta-v} - (i_{s\beta1} + i_{s\beta2})\hat{\varphi}_{r\alpha-v}\right] - \frac{1}{T_r}\left[\hat{\varphi}_{r\alpha-i}\ \hat{\varphi}_{r\beta-v} + \hat{\varphi}_{r\alpha-v}\ \hat{\varphi}_{r\beta-i})\right] \quad (20)$$

$$\chi_2 = \hat{\varphi}_{r\beta-i}\ \hat{\varphi}_{r\beta-v} + \hat{\varphi}_{r\alpha-i}\ \hat{\varphi}_{r\alpha-v} \quad (21)$$

Equation (17) and (19)can be written as :

$$\dot{\varepsilon} = \chi_1 - \hat{\omega}_m \chi_2 \quad (22)$$

And

$$\dot{S}(\varepsilon) = \chi_1 - \hat{\omega}_m\ \chi_2 + M\varepsilon \quad (23)$$

By replacing $\hat{\omega}_m$ with equivalent and attractive control $\hat{\omega}_m = \hat{\omega}_{m-eq} + \hat{\omega}_{m-n}$ in aquation (23), we find :

$$\dot{S}(\varepsilon) = \chi_1 - \hat{\omega}_{m-eq}\chi_2 - \hat{\omega}_{m-n}\ \chi_2 + M\varepsilon \quad (24)$$

During sliding mode and in the established regime, we have $s(\varepsilon) = 0$ and therefore $\dot{s}(\varepsilon) = 0$ and $\hat{\omega}_{m-n} = 0$ hence :

$$\hat{\omega}_{m-eq} = \frac{\chi_1 + M\varepsilon}{\chi_2} \quad (25)$$

During the convergence mode, the Lyapunov condition (7) must be checked. By replacing (25) into (34) we obtain:

$$\dot{S}(\varepsilon) = \hat{\omega}_{m-n}\ \chi_2 \quad (26)$$

We take for the attractive control :

$$\hat{\omega}_{m-n} = k_\varepsilon\ \frac{S(\varepsilon)}{|S(\varepsilon)| + \xi_\varepsilon} \quad (27)$$

The block diagram of the sliding mode MRAS estimator is shown in Fig.4:

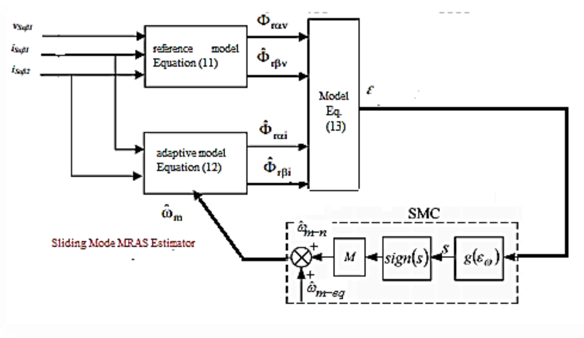


Fig.4. Block diagram of the sliding mode MRAS technique applied to the DSIM.

To test the sliding system, give good results, and eliminate the problem of finding its parameters, we have added two heuristics methods (GA and GAH). And we will explain it in the results obtained.

GA Optimization of SMC Controller

Genetic algorithms are powerful general purpose stochastic optimization methods which have been inspired by the Darwinian evolution of a population subject to reproduction, crossover the mutations in a selective environment where the fitness survive. GA combines the artificial survival of the fitness with genetic operators abstracted from nature to form a very robust mechanism that is suitable for a variety of optimization problems. In mathematical terms the goal of genetic algorithm is to minimize an objection function $F(S_k)$, where S_k is the search candidate (optimal solution), which is kth individual in the population S (where the population is set of possible solutions). The individuals of the population are expressed in a binary string form and the GA then manipulates these strings by using genetic operators (reproduction, crossover, mutation) to obtain improved solutions (where the fittest individual survive), until the optimal solution is obtained [24].

It is one of advantages of a GA that is uses stochastic operators instead of deterministic rules to search for a solution. Furthermore, a GA consider many points in the search space simultaneously, not a single point, thus it has a reduced chance of converging to local minimum, in which other algorithms may end up. In order to optimize K and ξ gains SMC of the adaptive mechanism via the Genetic algorithms, the fitness function defined as the difference between measured speed and estimated speed is selected as:

$$e = \frac{1}{n}\sum(w_r - \hat{w}_r)$$

where e is error value, n is number of data, w_r is the rotor speed (Rad/s) and $\hat{w}_r$ is the estimated speed (Rad/s).

Optimization was taken out in 20 generations with size of population of 20 individuals. GA parameters are given in Table 1.

Table 1. GA parameters for SMC controller Optimization.

Generation	10
Population	10
Crossover Fraction	0.8
Mutation Function	Gaussian

Interior-point methods

Interior-point methods (also referred to as barrier methods or IPMs) are a certain class of algorithms that solve linear and nonlinear convex optimization problems. John von Neumann [1] suggested an interior-point method of linear programming, which was neither a polynomial-time method nor an efficient method in practice. In fact, it turned out to be slower than the commonly used simplex method.

An interior point method, was discovered by Soviet mathematician I. I. Dikin in 1967 and reinvented in the U.S. in the mid-1980s. In 1984, Narendra Karmarkar developed a method for linear programming called Karmarkar's algorithm, which runs in provably polynomial time and is also very efficient in practice. It enabled solutions of linear programming problems that were beyond the capabilities of the simplex method. Contrary to the simplex method, it reaches a best solution by traversing the interior of the feasible region. The method can be generalized to convex programming based on a self-concordant barrier function used to encode the convex set.

Any convex optimization problem can be transformed into minimizing (or maximizing) a linear function over a convex set by converting to the epigraph form.[2] The idea of encoding the feasible set using a barrier and designing barrier methods was studied by Anthony V. Yurii Nesterov and Arkadi Nemirovski came up with a special class of such barriers that can be used to encode any convex set. They guarantee that the number of iterations of the algorithm is bounded by a polynomial in the dimension and accuracy of the solution.[3] Karmarkar's breakthrough revitalized the study of interior-point methods and barrier problems, showing that it was possible to create an algorithm for linear programming characterized by polynomial complexity and, moreover, that was competitive with the simplex method. Already Khachiyan's ellipsoid method was a polynomial-time algorithm; however, it was too slow to be of practical interest. The class of primal-dual path-following interior-point methods is considered the most successful. Mehrotra's predictor–corrector algorithm provides the basis for most implementations of this class of methods.[4]

The parameters of SMC (PSMC) problem in (1) can be solved by a nonlinear IPM based on a logarithmic barrier primal dual algorithm defined in [5] and [6]. In this method, all the decision variables, in (1), are first assumed to be continuous. Besides the slack variables, the Lagrange multipliers are introduced to deal with the in equality and equality constraints, and the logarithmic barrier functions are used to guarantee the non-negativity conditions of the slack variables. The ORPF problem can be transformed into the sub-problem of the following Lagrange function without the constraints:

$$\begin{aligned} L(z,y,l,u,v,w) &= f(z) - v^T(z - l - z_{\min}) \\ &- y^T g(z) + w^T(z + u - z_{\max}) - \mu \sum_i (\ln l_i + \ln u_i) \end{aligned} \quad (28)$$

where u and l are the slack variables $(u \geq 0, l \geq 0)$; $y, v,$ and w are the Lagrange multiplier $(v \geq 0, w \geq 0)$; and μ is the barrier parameter ($\mu \succ 0$).

Hybrid genetic algorithm-interior point method GA+IPM

A hybrid method GA+IPM integrating the GA and the IPM is introduced in this section. This method can be mainly divided into two parts. The first part employs the IPM to solve the parameters of SMC (PSMC) problem approximated as a continuous problem. Then the optimal solution obtained is rounded off, in which continuous values for discrete variables are discretised, and used as the initial population of GA. The second part is to combine the GA with the IPM to solve the PSMC for the final optimal solution.

Simulation Results

The parameters of the simulated system are presented in the appendix A. Simulation tests were carried out to compare the system of DSIM with PI, SMC, SMC_GA and SMC_GA+IPM. Using a Sliding mode control of dual star induction motor. The tests were performed in both open loop and sensorless modes of operation. Selected simulation results from these tests are shown in the following sections.

Table II: The parameters of PI, SMC and The best solution obtained by GA and HGA.

PI Controller	**Kp_{wr}**	**ki_{wr}**	**Kp**	**Ki**	**$Kp_{w\text{-}est}$**	**$Ki_{w\text{-}est}$**						
	0.78	**3.13**	**110**	**1420**	**0.56**	**1420**						
SMC Controller Gains	**K_{wr}**	**ξ_{wr}**	**$K_{\phi r}$**	**$\xi_{\phi r}$**	**K_{d1}**	**ξ_{d1}**	**K_{q1}**	**ξ_{q1}**	**K_{d2}**	**ξ_{d2}**	**K_{q2}**	**ξ_{q2}**
	100	**0.4**	**120**	**0.01**	**1500**	**0.12**	**1000**	**0.18**	**1500**	**0.12**	**1000**	**0.18**
SMC+GA	**250.84**	**0.623**	**271.9**	**0.142**	**1105.7**	**0.95**	**2706.28**	**0.32**	**4372.03**	**0.47**	**4895.45**	**0.51**
SMC-(GA+IPM)	**300.4**	**0.1191**	**617.1**	**0.511**	**5252.2**	**0.72**	**2493.3**	**0.124**	**7296.9**	**0.14**	**7657.7**	**0.233**

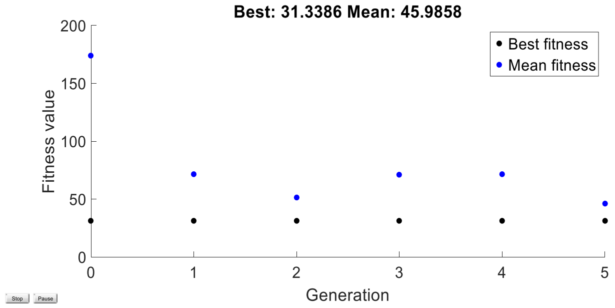


Fig.5.The best fitness and mean fitness of Genetic Algorithm (GA).

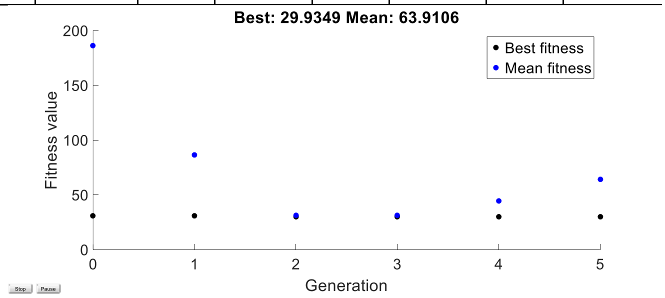
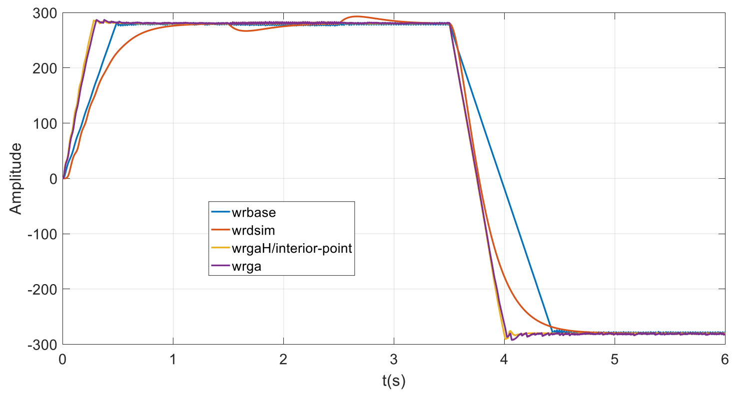


Fig.6.The best fitness and mean fitness of Hybrid Genetic Algorithm (HGA).



Zoom

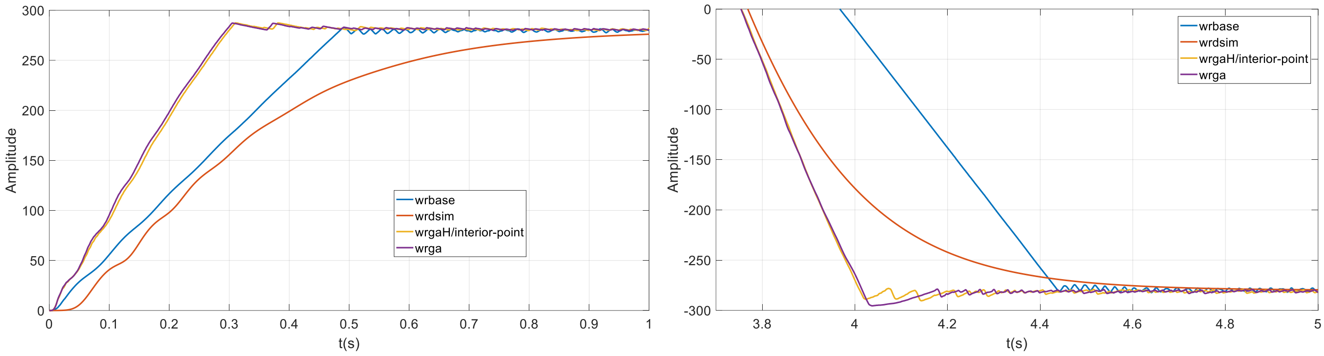


Fig.7. Representation of estimated speed of DSIM.

The figs.5 and 6 shows the best fitness and mean fitness of Genetic Algorithm (GA) and the best fitness and mean fitness of Hybrid GA+IPM.

The fig 7 presents the system's reponces of the three proposed controllers.

The both SMC and SMC controllers with GA and HGA are robust than PI which is affected by the change of the load. According to the figs C-D which show the zoom of the system's reponses in the intervals [0 - 0.6] and [3.8 - 4.8] The controllers SMC-GA and SMC-GA+IPM are the faster and more robust.

Through these results presented in the application, we note that the genetic algorithm and the hybrid algorithm combining the two methods of the genetic algorithm and the internal point provided better results by finding optimal parameters for the sliding mode controllers.

Conclusion

In this resaerch, the motor speed is estimated based on the flux rotor model reference adaptive method. Due to the large number of high-order harmonics and noise in the voltage model and the existence of the speed fluctuation problem in the traditional vector control system, the speed estimation accuracy and system dynamic performance are seriously affected. By the introduction of PI controllers, and according to Lyapunov's stability theorem, SMC controllers are designed to replace the current regulators of traditional vector control system and PI regulator of sensorless speed system.

In order to obtain the optimal value of the speed estimation, we did optimizing the SMC controllers using two methods GA and Hybrid GA+IPM. The simulation results show that noise of system and speed fluctuations are basically eliminated, and speed estimation accuracy and dynamic performance are obviously improved.

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Balanced exploration and exploitation properties of multi-objective Arithmetic Optimization Algorithm

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Abstract

Arithmetic Optimizaton Algorithm (AOA) (Abualigah& Gandomi,2021) is a recent developed metaheuristic that draws inspiration from the fundamental arithmetic operations in mathematics (Division(D), Multiplication (M), Addition (A), and Subtraction (S)). In this work, we have enhanced the properties of exploration and exploitation to effectively investigate the search space. Subsequently, we extended the Arithmetic Optimization Algorithm to a multi-objective version called MOAOA (Multi-Objective Arithmetic Optimizaton Algorithm). This enhanced algorithm is designed to address multiple objectives in diverse problem domains. The MOAOA utilizes an archive repository to store and retrieve the non-dominated solutions generated during the optimization process. From this population archive, leaders are chosen to guide the solutions of the main population towards promising search locations. furthermore, the epsilon-dominance and crowding distance strategies are used to strike a balance between convergence and diversity in the resulting Pareto set. These strategies ensure that the obtained solutions exhibit both high quality and spread across the objective space. The proposed MOAOA is validated on various well-known benchmarks functions. In addition, its performance is compared agains the prominent state-of-art algorithms. The experimental results show that our algorithm provide very competitive results and, in most cases, show better convergence behavior with googd diversity of solutions.

Keywords: *Multi-objective Optimization, dominance relation, swarm intelligence, metaheurstic, Pareto Front.*

Introduction/Background

In recent years, there have been many multi-objective optimizers proposed to solve multi-objective optimization problems(MOPs), such as: multi-objective dragonfly algorithm (Mirjalili, 2016), multi-objective moth flame optimization (MOMFO) (Zouache, Abdelaziz, Lefkir, & Chalabi, 2021), multiobjective ant lion optimizer (MOALO) (Mirjalili, Jangir, & Saremi, 2017), multi-objective grey wolf optimizer (MOGWO)(Mirjalili& Coelho,2016), multi-objective chicken swarm optimization (MOCSO) (Zouache& Abdelaziz,2019)..etc. Due to the contradictory nature of objectives, there is generally no one optimum solution in multi-objective optimization, but instead a collection of alternative solutions known as Pareto optimal solutions (Wang et al., 2023). These solutions are optimal in the meaning that there are no other solutions in the search space that are better for all objectives addressed. As expected, significant challenges were posed that need specific strategies to handle them,

including the balance between the exploration and the exploitation properties, since these are the essential criteria in multi-objective optimization. In this work, we present our proposed algorithm based on the equilibrium between exploration and exploitation properties. The subsequent section present more details of the proposed MOAOA method.

Arithmetic Optimization Algorithm (AOA): A Brief Overview

An overview of the original Arithmetic Optimization Algorithm is presented as follows.

Arithmetic plays a fundamental role in number theory and holds a central position in mathematics, alongside geometry, algebra, and data analysis. Arithmetic operators, such as multiplication, division, subtraction, and addition, are the conventional measures routinely employed to analyze numbers (Abualigah & Diabat, 2021). These mathematical operators form the basis of the original Arithmetic Optimization Algorithm (AOA), which is used to optimize candidate solutions and determine the best solutions based on specific objective functions. Optimization problems are pervasive across various quantitative fields, including design, finance, machine learning, and management science and industry. The quest for improved solution approaches has captivated mathematicians for centuries. The primary motivation behind the development of the AOA stems from its application of arithmetic in solving mathematical problems.

MOAOA: Multi-objective Arithmetic Optimization Algorithm

In this section, we focus on extending the recent algorithm of the single objective AOA to solve the multi-objective optimization problems. In this context, a multi-objective strategy based on the equilibrium between exploration and exploitation properties. Precisely, a population archive was incorporated into this algorithm for leading the main population towards the approximate Pareto set of a multi-objective optimization problem(MOP). The optimization process in the proposed MOAOA starts with an initial population(P0) of N candidate solutions (X) created at random for the multi-objective problem. Then, the algorithm assesses each individual from the initial population according to M objective functions.

Subsequently, the external archive population is populated by the non-dominated solutions from the initial population. As stated before, this archive is employed as a repository for storing the nondominated solutions found so far. Also, the leader solution is selected from this archive to lead the main population to converge towards the Pareto front optimal. After the initialization phase, the MOAOA uses the four strategies based on the Arithmetic operators in math (Multiplication, Division, Subtraction, and Addition) to explore the space search of MOP. Over the series of iterations, each solution updates its position using the best (leader) position and Math Optimizer Accelerated (MOA) or Math Optimizer probability (MOP) functions.

During this optimization stage, the exploration search strategies(Division (D) and Multiplication (M)) were used to boost the other step of the exploitation of the search space by improved coordination between them. In this context, the exploration phase is controlled by the Math Optimizer accelerated (MOA) using random values. It is worth pointing out that the stochastic scaling coefficient is used to explore more promising regions in the search space and prevent stagnation in the local solutions. The updating of position for each individual of the population is performed using simple rules that imitate the behaviours of the Arithmetic operator. the following sections provide more details on this behavior.

Exploration phase

The MOAOA employs exploration operators that dynamically analyze various segments of the target region to improve solutions. This process relies on two primary search techniques, denoted as 'D' (Division) and 'M' (Multiplication) as outlined in Equation (1), to update the positions of solutions (Zheng, Jia, Abualigah, Liu, & Wang, 2021).

$$x_{i,j}(t+1) = \begin{cases} best\ (x_j) \div MOP \times ((UB_j - LB_j) \times \mu + LB_j), & r2 < 0.5 \\ best\ (x_j) \times MOP \times ((UB_j - LB_j) \times \mu + LB_j), & Otherwise \end{cases} \quad (1)$$

Where $x_i(t+1)$ is the i^{th} new solution in the upcoming iteration, $x_{i,j}(t)$ is the j^{th} position of the i^{th} solution, and $best(x_j)$ is the j^{th} best position so far. UB_j and LB_j are upper and bound values, respectively. μ is a tuning parameter adjusted to 0.5. MOP is the suggested Math Optimizer probability calculated using Equation (2).

$$MOP(t) = 1 - \frac{t^{1/\alpha}}{F\_t^{1/\alpha}} \quad (2)$$

Where t and F_t are the current and total number of iteration, respectively. α is a tuning parameter adjusted to 5. In this context, the exploration phase is controlled by the Math Optimizer accelerated (MOA) presented in the equation (3)

$$MOA(t) = Min + t \times (\frac{Max - Min}{F\_t}) \quad (3)$$

Where $MOA(t)$ is the function value at the t^{th} iteration, t indicates the current iteration, F_t denotes the maximum number of iterations. Min, and Max represent the lowest and maximum values of the MOA function, respectively.

Exploitation phase

The exploitation stage of MOAOA is based on Subtraction (S) or Addition (A) operators (Abualigah & Diabat, 2021). The equation (4) elucidates the utilization of these two search techniques in the exploitation step, emphasizing improved search communication.

$$x_{i,j}(t+1) = \begin{cases} best\ (x_j) - MOP \times ((UB_j - LB_j) \times \mu + LB_j), & r2 < 0.5 \\ best\ (x_j) + MOP \times ((UB_j - LB_j) \times \mu + LB_j), & Otherwise \end{cases} \quad (4)$$

The pseudo-code and the flowchart of the proposed MOAOA are presented in Algorithm 1 and Figure 1, respectively.

Algorithm 1: Pseudo-code of MOAOA algorithm

Begin

Initialize the population $(P0_i)$ *at random* $(i = 1, 2, \ldots N)$
Calculate the fitness value for each individual from $P0$
Initialize the Archive (Ar) *by Non – dominated solutions of* $P0$

While $(t < F\_t)$ **Do**

Calculate (MOP) and (MOA) using Eq. 2 and 3, repectively
Select the leader solution from (Ar) *population*

IF $rand() < MOA$ **Then** $/ * Exploration\ Phase * /$

IF $rand() < 0.5$ **Then**
Perform (D) *operator using the first part of Eq.*1
Else
Perform (M) *operator using the second part of Eq.*1

Else $/ * Exploitation\ Phase * /$
IF $rand() < 0.5$ **Then**
Perform (S) *operator using the first part of Eq.*2
Else
Perform (A) *operator using the second part of Eq.*2
EndIF

Update the (Ar) *population*
Adjust the size of (Ar) *population*

End While

Generate the Pareto Front

End

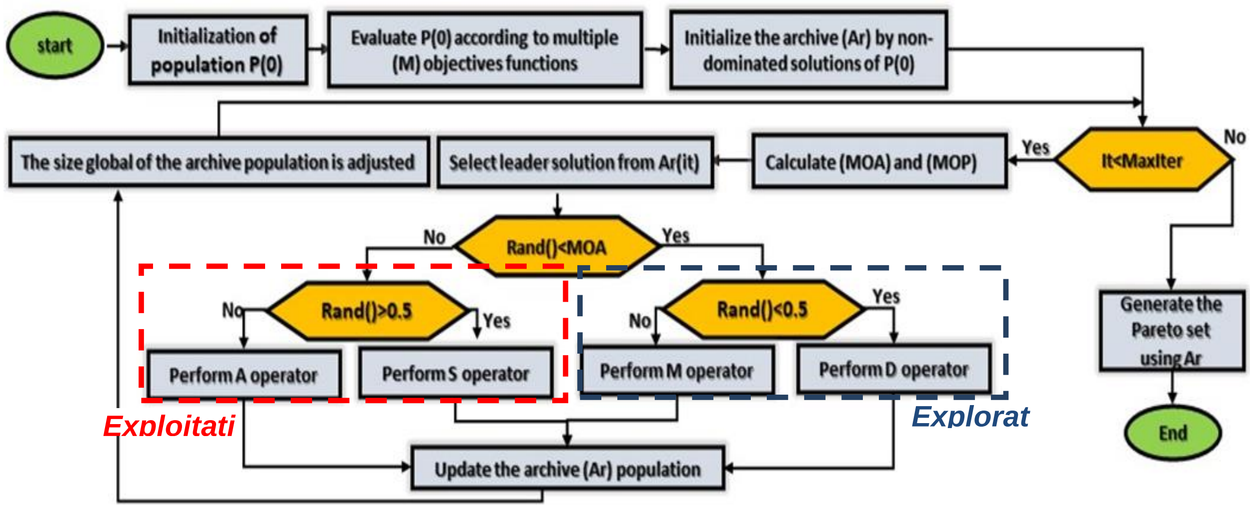

Fig. 1. Flowchart of the exploration and exploitation properties of the proposed MOAOA

Results and Discussion (Findings)

The proposed MOAOA is analyzed and compared with other well established state-of-the-art methods such as Multi-Objective Grey Wolf Optimizer (MOGWO) (Mirjalili et al., 2016), Multi-

Objective evolutionary algorithm based on decomposition (MOEAD) (Zhang & Li, 2007), and Multi-Objective Salp Swarm Algorithm (MSSA) (Mirjalili, Gandomi, et al., 2017) using the ZDT1 multi-objective problem taken from the ZDT-series (Zitzler, Deb, & Thiele, 2000).

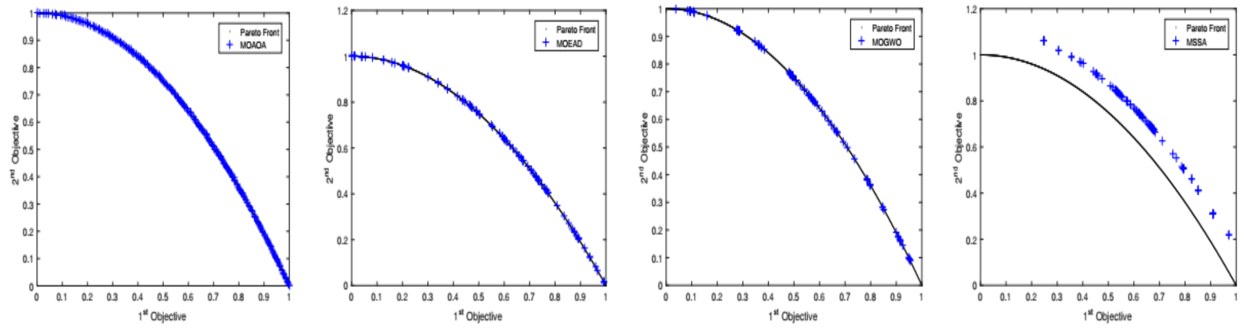

Fig. 2. Pareto fronts generated by MOAOA, MOEAD, MSSA, and MOGWO

Conclusion

In this study, we have employed three strategies to strike a balance between exploration and exploitation properties in order to extend the standard AOA to its multi-objective version (MOAOA). Firstly, a population archive serves as a repository to store and retrieve the non-dominated solutions obtained throughout the optimization process. Secondly, a leader's solution is utilized to guide the main population towards promising regions within the search space. Lastly, a density estimator, based on both crowding distance and epsilon dominance, is employed to ensure comprehensive coverage of the search space. The comparison results obtained using well-known metrics in the field of multiobjective optimization have demonstrated the efficiency of our proposed MOAOA in terms of superior convergence and diversity compared to other algorithms.

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Customised learning: Techniques and standards for adaptive e-learning

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Abstract

The future of education is likely to be significantly impacted by adaptive e-learning. It can transform education at all levels by providing tailored, meaningful and integrated learning experiences. Incorporating personalised learning enables learners to play an active role in their learning, supports their diverse individual needs, develops their skills, and improves their engagement and academic performance, in addition to increasing their potential for success. Educational institutions and platforms can also create a learner-centred environment that fosters engagement, motivation and significant learning outcomes, besides optimising resources and meeting the diverse requirements of learners in a rapidly evolving digital environment. The primary aim of this paper is to examine and provide insight into some adaptive e-learning systems with a focus on the key features and benefits of customised learning along with the role of artificial intelligence in this area, as well as highlighting adaptive e-learning techniques and showcasing its standards while outlining some of the challenges and limitations of adaptive e-learning.

Keywords: *Educational system, E-learning system, Customised learning, Adaptive e-learning techniques, Adaptive e-learning standards.*

Introduction

The evolution of adaptive e-learning technologies has witnessed significant advances and transformations over time. Originally, e-learning relied primarily on static content delivery and limited interactivity. However, with the emergence of adaptive e-learning technologies, the learning experience has become more personalised, responsive and effective (Alam, 2022).

Customised learning, or personalised learning, refers to an educational approach that tailors instructional methods, content, pace and learning experiences to meet the specific needs, preferences and capabilities of individual learners. It involves adapting teaching strategies and resources to accommodate different learning styles, interests and abilities, allowing learners to progress at their own pace and to focus on areas that require additional attention or exploration. It emphasises learner autonomy, engagement and meaningful learning experiences, aiming to optimise learning outcomes and foster lifelong learning (Shemshack & Spector, 2020). It plays a crucial role in e-learning, where its importance in online learning lies in its ability to optimise learner engagement, promote individualised mastery, facilitate targeted support, promote learner independence and create inclusive learning environments. By leveraging technology and pedagogical approaches, personalised learning enhances the effectiveness and efficiency of e-learning experiences by meeting the unique needs of each learner (Ingkavara et al., 2022).

This paper gives an overview of customised learning and its significance in e-learning. First, the authors present some adaptive e-learning systems. Then, they describe the adaptation techniques for adaptivee-learning, along with its standards, highlight the role of artificial intelligence in this field, as well as identify the main features and benefits of personalised learning, followed by its possible challenges and limitations.

Literature Survey

Adaptive learning systems underscore the significance of personal variation in the construction of an optimal e-learning experience. The recognition and accommodation of individual learners' distinct requisites and aptitudes are pivotal for achieving proficiency in delivering adaptive e-learning systems. These competencies are imperative for adaptive educational systems to offer appropriate learning modalities and content to their users (Benkhalfallah & Bourougaa, 2022). To gain a better knowledge and comprehension of adaptive e-learning systems, this section offers a concise overview of relevant research and studies associated with adaptive e-learning.

The study conducted by (Pitchford, 2023) examined the obstacles faced in tackling the worldwide learning crisis, specifically in sub-Saharan nations, and proposed solutions to overcome them. It emphasizes the utilization of tailored e-learning platforms as a means to enhance accessibility, quality, and fairness in education. However, the article also acknowledges the difficulties in implementing effective solutions in challenging environments. The author underscores the significance of evidence-based practices and policy decisions, as well as the necessity for effective communication and consistent terminology among cross-sector partners. Overall, the article sheds light on the intricate challenges involved in education within sub-Saharan countries and the transformative potential of technology.

The focus of the study (El-Sabagh, 2021) is on examining the influence of adaptive online learning environments on student engagement. It delves into the advantages of tailored instruction and its potential to enhance learning results. Through a quasi-experimental research design, it explores the effectiveness of adaptive online learning environments in fostering student engagement. The findings indicate that these environments have a substantial positive impact on both student engagement and learning outcomes. Furthermore, the article explores the development of adaptive e-learning environments tailored to individual learning styles and preferences. Ultimately, the study emphasizes the capacity of adaptive e-learning environments to augment student engagement and improve learning outcomes.

According to (Kolekar et al., 2019), a new method has been introduced for delivering adaptive user interfaces (AUIs) in e-learning systems, drawing on the Felder-Silverman Learning Style Model (FSLSM). The approach put forward aims to deliver personalized learning resources and interfaces by incorporating AUI components that align with individual learning styles. The system includes a user interface component in the form of a learning path on the portal, assisting new learners in navigating the system. Through an experiment conducted on engineering students, positive outcomes were observed, indicating the effectiveness of the proposed approach in enhancing the learning process. Generally, this paper makes a valuable contribution to the field of e-learning by presenting a universal approach for generating and providing adaptive user interface components with adaptable content to learners.

The paper (Colchester et al., 2017) examines the utilisation of artificial intelligence techniques in adaptive educational systems implemented in e-learning platforms. It emphasizes the significance of constructing precise student profiles and models to establish an adaptive learning environment. Various AI techniques employed in adaptive educational systems are reviewed, focusing on their benefits in improving learning outcomes. Furthermore, the article underscores the importance of addressing uncertainty and fostering a conducive context for effective learning and teaching. In summary, the article offers valuable perspectives on the contribution of AI in the creation of personalized learning experiences for students.

The author (Truong, 2016) presented an extensive examination of the integration of learning styles and adaptive e-learning systems. The literature review provides a comprehensive overview of the methodologies, constructs, advancements, and applications explored in this research area. The study thoroughly investigates the integration process, encompassing various aspects such as measuring learning styles in e-learning systems and employing learning styles in e-learning applications. The findings reveal a complex landscape within the research field, showcasing promising results and expanding applications, while also highlighting several unresolved issues. The most widely utilized theory in e-learning systems is the Felder-Silverman model, although there are multiple variables employed for

measurement purposes. Additionally, the review uncovers that while adaptive learning content and strategies dominate the application focus, there has been an expansion of learning style applications to other domains such as assessment, educational games, and media choices. The study encompasses a range of relevant research on the integration of learning styles and adaptive learning systems gathered from three search platforms: Google Scholar, Scopus, and Science Direct. The comprehensive compilation of individual keywords results in an extensive collection of potential keyword combinations. The quality of the research is contingent upon the efficiency of the search engines utilized. Ultimately, the study provides valuable recommendations for future research endeavours in this field.
The research study (Ruiz et al., 2008) explores the conceptualisation and implementation of adaptive e-learning systems that specifically take into account the cognitive attributes of students. The paper encompasses various technical and pedagogical elements of adaptation, including the incorporation of learning styles to inform the design of educational content. The authors draw upon numerous studies and references to bolster their claims, providing a significant overview of the current landscape of e-learning systems. Lastly, it provides a comprehensive summary of the barriers and opportunities associated with cognitive adaptation in the realm of e-learning.

Adaptation Techniques For Adaptive E-Learning

Adaptive techniques are an essential component of adaptive e-learning systems. These techniques work together to allow the system to dynamically adjust the learning experience according to the learner's characteristics, performance and progress, ensuring that learners receive an optimised and engaging learning experience that meets their specific needs (Premlatha & Geetha, 2015). Here are some common adaptation techniques used in adaptive e-learning illustrated in **Fig. 1**.

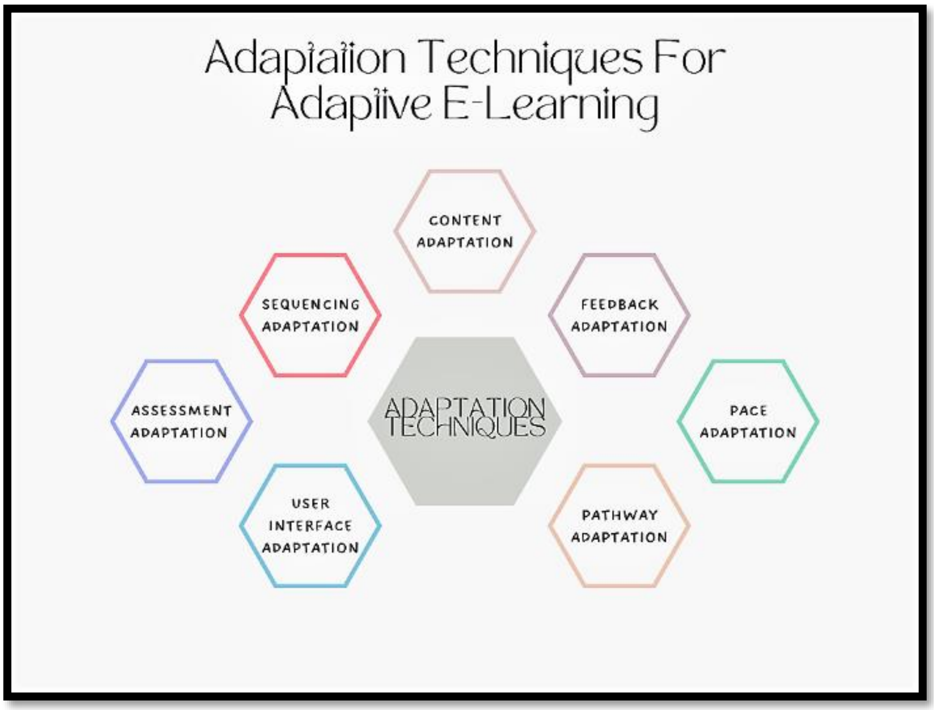

Fig. 1. Some common adaptation techniques for adaptive e-learning.

1. **Content adaptation**
   Adaptive e-learning systems adapt the content to match the learner's needs and abilities. This may involve adjusting the difficulty level of the content, selecting relevant examples or case studies, or providing alternative explanations or representations to cater to different learning styles. Content adaptation ensures that the learner receives material that is appropriately challenging and engaging (Kolekar et al., 2019).

2. **Sequencing adaptation**
   The sequence of learning activities and modules can be adapted based on the learner's progress and performance. The system can reorder or skip certain topics depending on the learner's mastery of prerequisite concepts, or provide additional reinforcement before moving on to more advanced material. Adapting the sequence ensures a coherent and personalised learning progression (Premlatha & Geetha, 2015).

3. **Feedback adaptation**
   They provide personalised feedback that addresses the learner's specific requirements. Feedback can be tailored to highlight strengths and weaknesses, suggest improvements or provide additional resources for further exploration. Tailoring feedback ensures that the learner receives timely and relevant guidance to enhance their learning (Premlatha & Geetha, 2015).
4. **Assessment adaptation**
   Assessments play a crucial role in adaptive e-learning systems. Adaptive assessments dynamically adjust the difficulty and type of assessment items based on the learner's performance. The system can offer more difficult questions if the learner performs well, or offer remedial questions and support if the learner is struggling. In addition, assessment adaptation ensures that evaluations accurately measure the learner's knowledge and provide an appropriate level of difficulty (Kolekar et al., 2019).
5. **Pace adaptation**
   Adaptive e-learning systems can adapt the pace of learning to suit the learner's individual needs. Some learners may require more time to grasp certain concepts, while others may progress more quickly. The system can adjust the speed of content delivery, the frequency of assessments or the availability of additional learning resources to match the learner's preferred pace (El-Sabagh, 2021).
6. **User interface adaptation**
   The user interface of adaptive e-learning systems can be adjusted to accommodate learners with different preferences or requirements. This may include customisable settings for text size, colour schemes or language options. Adapting the user interface guarantees that learners have a comfortable and accessible learning environment (Kolekar et al., 2019).
7. **Pathway adaptation**
   They offer customised learning pathways based on the learner's goals and interests. The system can recommend specific learning paths or suggest alternative routes to explore related topics. Pathway adaptation allows learners to have a tailored learning experience that fits their individual preferences and aspirations (Premlatha & Geetha, 2015).

Standards For Adaptive E-Learning

It is important to note that the field of adaptive e-learning is evolving rapidly, although there are no universally accepted standards specifically dedicated to it, there are several established standards and frameworks in the e-learning domain that can be applied to adaptive learning environments to address specific aspects (Abdullah & Ali, 2016). The most prominent of these is shown in **Fig. 2**.

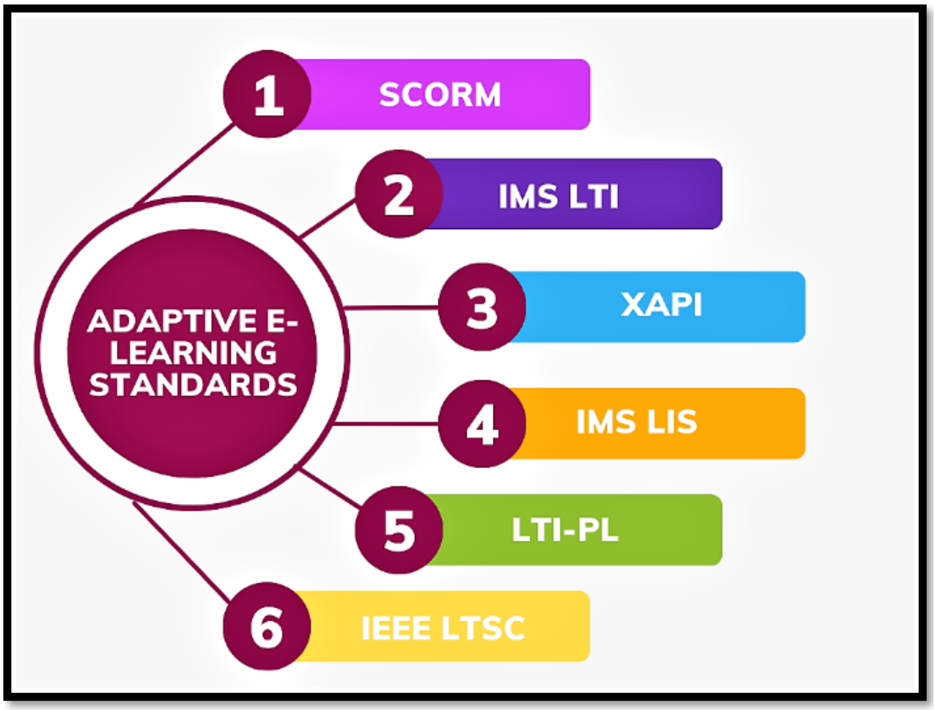

Fig. 2. The most prominent standards for adaptive e-learning.

1. **SCORM (Sharable Content Object Reference Model)**

   SCORM is a widely adopted standard for the development and delivery of e-learning content. Although it does not specifically address adaptivity, SCORM-compliant content can be integrated into adaptive e-learning platforms. It provides guidelines for creating interoperable e-learning content that can be tracked and managed in Learning Management Systems (LMS) (Abdullah & Ali, 2016).

2. **IMS Learning Tools Interoperability (LTI)**

   LTI is a standard developed by the IMS Global Learning Consortium that enables integration and interoperability between learning tools and learning platforms. Adaptive e-learning systems can use the LTI standard to seamlessly integrate with Learning Management Systems (LMS) and other learning platforms, allowing the exchange of data, content and learner activities (Abdullah & Ali, 2016).

3. **xAPI (Experience API) or Tin Can API**

   xAPI is a specification that enables the collection and tracking of learner data and experiences across different learning activities and platforms. It allows adaptive e-learning systems to capture and analyse data on learner interactions, preferences and progress, facilitating personalised and adaptive learning experiences (Abdullah & Ali, 2016).

4. **IMS Learning Information Services (LIS)**

   LIS is a global IMS specification that defines a standardised framework for exchanging learner-related information between systems, such as learner profiles, enrolment details and assessment results. Adaptive e-learning systems can use LIS to exchange learner data with other systems and provide seamless integration into the learning ecosystem (Abdullah & Ali, 2016).

5. **Learning Tools Interoperability Personalized Learning (LTI-PL)**

   LTI-PL is an extension of the LTI standard that focuses specifically on personalised and adaptive learning. It provides additional capabilities for adaptive learning scenarios, such as launching personalised learning activities, exchanging learner-specific data and receiving recommendations from external tools or platforms (Abdullah & Ali, 2016).

6. **IEEE Learning Technology Standards Committee (LTSC)**

   The LTSC develops a range of standards related to e-learning, including those covering areas such as learning analytics, learning object metadata and learner information profiles. These standards can contribute to the development of adaptive e-learning systems and ensure compatibility and interoperability with other learning technologies (Abdullah & Ali, 2016).

The Role Of Artificial Intelligence In Personalised Learning

Artificial intelligence (AI), including machine learning and deep learning, plays a pivotal role in advancing customised learning. By harnessing the power of AI, customised learning becomes more precise, efficient and engaging. It revolutionises personalised learning by tailoring teaching, user profiling, content and resource recommendations to individual learners. It enables a more tailored educational experience, ultimately leading to improved learning outcomes for each learner. However, it's important to note that ethical considerations, including data privacy and algorithmic fairness, should be carefully addressed in the implementation of AI-driven personalised learning systems (Benkhalfallah & Laouar, 2023).

Key Features And Benefits Of Customised Learning

Customised learning recognises the diversity of learners and adapts teaching to their requirements. It promotes greater independence, engagement and deeper learning, ultimately enhancing educational outcomes and preparing students for success throughout their lives (Darling-Hammond et al., 2020; Shemshack & Spector, 2020). Here are some of its key benefits:

- Individualised instruction: Personalised learning allows students to learn at their own pace and in a way that suits their learning style. It recognises that each student is unique and may require different strategies or approaches to grasp concepts effectively. By adjusting the instruction to match individual needs, personalized learning can enhance student engagement and understanding (Kem, 2022).
- Targeted support: It enables educators to identify and address specific areas of strength and weakness for each student. It allows for targeted interventions and additional support where needed, helping students overcome challenges and achieve mastery in particular subjects or skills (Linden, 2022).
- Increased motivation and engagement: When students have a sense of ownership and control over their learning, they are more likely to be motivated and engaged. Personalised learning allows students to pursue their interests, set learning goals and make choices about the content and activities they undertake. This autonomy and relevance can enhance intrinsic motivation and deepen engagement in the learning process (Jayalath & Esichaikul, 2022).
- Flexibility and adaptability: It provides flexibility in terms of time, place and mode of learning. It helps students to learn at their preferred pace, explore topics of interest, and choose from various resources and materials. Customised learning can also adapt to accommodate different learning styles, preferences and abilities, ensuring that students receive an education that aligns with their individual needs (Pitchford, 2023).
- Mastery and competency-based learning: It focuses on mastery rather than simply completing tasks or achieving grades. It concentrates on the development of core competencies and skills, allowing students to progress once they have demonstrated

proficiency in a particular area. This approach encourages deeper understanding and long-term retention of knowledge and competencies (Camacho & Legare, 2016).

- Enhanced collaboration and communication: Customised learning often incorporates collaborative activities and opportunities for peer interaction. Students can engage in group projects, discussions and peer feedback, encouraging communication and teamwork. By working with others, students can learn from different perspectives and build important social and interpersonal skills (El-Sabagh, 2021).
- Data-driven decision-making: It leverages data and analytics to track student progress, performance and learning patterns. Educators can use this data to make informed decisions about teaching strategies, interventions and resource allocation. Data-driven insights enable educators to continuously refine and improve the learning experience for individual students and the overall pedagogical approach (Mandinach, 2012).
- Preparation for the future: It highlights skills such as critical thinking, problem-solving, collaboration and self-directed learning which are essential for success in the 21st-century workforce. By nurturing these skills, personalised learning equips students with the tools and mindset needed to navigate an ever-changing, knowledge-driven world (Truong, 2016).

Challenges And Limitations Of Adaptive E-Learning

Adaptive e-learning offers many benefits, but it also faces certain challenges and limitations that ongoing research, technological advancements and best practices are constantly striving to address and work towards more effective and inclusive adaptive e-learning solutions (Alam, 2022; Truong, 2016). Here are some of the main challenges associated with it:

- Data Privacy and Security: Adaptive e-learning relies heavily on collecting and analysing learner data to personalise the learning experience. This raises concerns about data privacy and security. Safeguarding sensitive learner information and ensuring compliance with privacy regulations can be challenging for institutions and organisations implementing adaptive e-learning systems (Alam, 2022).
- Technical Infrastructure and Integration: Implementing adaptive e-learning may require robust technical infrastructure and integration with existing learning management systems (LMS) or educational platforms. Ensuring compatibility, scalability and seamless integration with various technologies and systems can be complex and time-consuming (Alam, 2022).
- Quality of Data and Algorithms: It strongly depends on accurate and high-quality learner data to make effective adaptations. However, data quality issues, such as incomplete or inaccurate data, can hinder the system's ability to personalise the learning experience. Similarly, the effectiveness of adaptive algorithms in accurately identifying learner needs and providing appropriate adaptations depends on their design and implementation (Truong, 2016).
- Content Development and Adaptation: Creating and adapting content for adaptive e-learning can be resource-intensive. Developing adaptive content requires careful consideration of different learning pathways, varying levels of difficulty and diverse learning preferences. Additional effort may be required to create adaptive learning materials that effectively engage learners and meet their individual needs (Premlatha & Geetha, 2015).
- Instructor Training and Support: Adaptive e-learning systems can impact the role of instructors. Teachers and instructors may need training and support to effectively use and navigate adaptive e-learning platforms. Understanding how to interpret and use the data provided by adaptive systems can be challenging, as can effectively guiding and supporting learners in personalised learning environments (Truong, 2016).

- Learner Engagement and Motivation: While adaptive e-learning aims to increase learner engagement, individual motivation and persistence can still be a challenge. Maintaining learners' interest and motivation in personalised learning pathways can be a complex task. Particular attention must be paid to instructional design, user experience and ongoing support to ensure that learners remain engaged and motivated throughout the adaptive learning journey (El-Sabagh, 2021).
- Equity and Accessibility: Ensuring equitable access to adaptive e-learning for all learners, regardless of their socio-economic background, technological access or disabilities, is a significant challenge. Addressing the issues of accessibility, digital divide and inclusive design becomes crucial to ensure that adaptive e-learning is accessible and beneficial to all learners (Al Zahrani et al., 2021).
- Ethical Considerations: There are ethical considerations surrounding the use of adaptive e-learning. Balancing personalisation with the potential risks of algorithmic bias, unintended tracking or narrowing of perspectives requires careful attention. Ethical guidelines and considerations must be taken into account to guarantee responsible and fair use of adaptive e-learning systems (Blaga & others, 2019).

Conclusion

Customised learning, powered by adaptive e-learning techniques and standards, holds immense promise for transforming education. By tailoring teaching, content and learning experiences to individual learners, it promotes engagement, motivation and improved learning outcomes. Techniques such as personalised learning paths, intelligent content recommendation, adaptive assessments and feedback empower learners to take ownership of their education and progress at their own pace. These techniques, supported by standards like IMS LTI, xAPI and SCORM, facilitate interoperability, data exchange and the development of adaptive e-learning systems. While challenges exist, including data privacy, technical infrastructure and instructor training, the potential impact of personalised learning on the future of education is considerable. It offers personalised, accessible and efficient teaching that meets the diverse needs of learners, prepares them for lifelong learning and drives continuous improvement in the field of education. As customised learning continues to evolve and mature, its impact on the future of education is extremely promising, it holds the power to revolutionise the field and transform learning experiences, unlocking the full potential of every learner and paving the way for a more personalised, inclusive and effective learning landscape.

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Fine-tuning CNNs for automated diagnosis of pneumonia from Chest X-rays

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Abstract

Pneumonia is a medical condition characterized by inflammation and infection of the lungs. It is commonly caused by bacteria, viruses, or other drugs. In children under the age of five, pneumonia associated with infections accounts for 14% of all pediatric fatalities. Chest x-ray is the most commonly used imaging approach for pneumonia detection, but there is a growing interest in using artificial intelligence (AI) and deep learning techniques for automated diagnosis. This paper proposes eight fine-tuned Convolutional neural networks to detect and classify pneumonia from chest X-ray images, including VGG16, VGG19, MobileNet, InceptionV3, InceptionResNetV2, Xception, ResNet50, and ResNet50V2. These models achieved accuracy rates surpassing 90%. The modified VGG19 model showed the greatest results, with a test accuracy of 99.15% for binary classification.

Keywords: *Image classification, Fine-Tuning, Convolutional neural network, Pneumonia Detection, Chest X-ray Images.*

Introduction

Pneumonia is the inflammation of one or both lungs of a person. It affects the lungs' alveoli (air sacs). It usually caused by infection with viruses, bacteria, fungi, or certain microorganisms. According to the World Health Organisation, pneumonia accounts for 14% of all deaths among children under the age of 5 years, Approximately 740,180 children lost their lives in the year 2019(WHO). It is the third most common cause of death from infectious diseases worldwide(Kuo, Jackson, Campbell, & Grayston, 1995). Diagnosis is usually by chest X-ray (CXR) and clinical signs. However, the chest X-ray is widely recognized as the most available, well-known, and accessible imaging dataset for pneumonia detection. In the last few years, there has been a growing interest to introduce an automated framework to address the issue at hand of pneumonia diagnosis with artificial intelligence (AI), several researchers have suggested diverse techniques involving Deep Learning for chest X-ray analysis, which has proven effective in numerous medical image tasks, including pneumonia detection. In general, the detection of pneumonia presents a major challenge for experts to classify CXR as healthy and unhealthy with the highest accuracy.

In this work, we present fine-tuned CNNs models to detect and classify pneumonia from Chest X-ray to normal or pneumonia. Our work aims to analyse the performance of fine-tuning CNN architecture for pneumonia diagnosis on a limited dataset

The remainder of the paper is organized as follows: Section 2 describes a brief overview of pneumonia detection from CXR. Section 3 presents the proposed methodology in detail, including dataset information, data pre-processing, and performances evaluation metrics. Followed by experimental results, and discussions in Section 4. And finally, Section 5 concludes this paper.

Related work

In the present time, several researchers have used convolutional neural networks which are the most widely used for pneumonia detection. There is a considerable amount of literature and various approaches have been proposed to solve this issue.

P.Rajpurkar et al.(Rajpurkar et al., 2017) presented a CNN architecture with 121 layers called ChexNet, they trained their algorithm on the Chest X-ray14 dataset (Wang et al., 2017)which contains more than 100,000 frontal-view chest X-rays of 14 diseases including pneumonia obtained from 32,717 patients. They achieved an F1 score of 0.43 (95% CI 0.387, 0.481).

S. Thakur et al.(Thakur, Goplani, Arora, Upadhyay, & Sharma, 2021) proposed a fine-tuned VGG16 for pneumonia diagnosis, the authors trained their models on a dataset(Kermany et al., 2018) of 5863 chest X-ray images and achieved an accuracy of 90.54% with 87.69% precision and 98.71% recall.

Harshvardha GM. (GM, Gourisaria, Rautaray, & Pandey, 2021) trained 15 different CNN models on the CXR dataset and Compared their performances to select the best model with an area under the curve(AUC) of 95.82%.

Another study was presented by Abhir Bhandary et al.(Bhandary et al., 2020), they proposed a Modified AlexNet (MAN) for identifying cancer in Lung CT images of LIDC-IDRI and pneumonia in CXR. The MAN achieved an accuracy of 96.8% using the Support Vector Machine (SVM) classifier for pneumonia detection, and this result was compared to MAN-softmax, AlexNet, VGG16, VGG19, and ResNet.

The authors (Sarkar, Hazra, Sadhu, & Ghosh, 2020) achieved an accuracy of 98.28% and an AUROC score of 0.99726 for pneumonia detection on CRXs(Kermany et al., 2018) using the DL model with pre-processing methods, bilateral filtering for noise reduction, the CLAHE algorithm for image enhancement.

The method of(Hashmi, Katiyar, Keskar, Bokde, & Geem, 2020) is based on a weighted classifier for the diagnosis of pneumonia. The authors combine the weighted predictions from five deep learning models (ResNet18, Xception, inception3, DenseNet121, and MobileNetV3) after increasing the training dataset by data augmentation techniques. The experimental results indicated an accuracy of 98.43% of the proposed weighted model.

The authors (Al Mamlook, Chen, & Bzizi, 2020) conducted a comparative study to evaluate the effectiveness of a convolutional neural network (comprising two convolutional layers) against six machine learning methods, namely Decision Tree, Random Forest, K-nearest neighbor (KNN), Adaboost, Gradient Boost, and XGBoost, for detecting pneumonia in chest X-rays. The evaluation was performed after applying various pre-processing techniques, including dimension reduction, image cropping, and image resizing. Their CNN achieved an overall accuracy of 98.46%.

KH.T.Islam et al.(Islam, Wijewickrema, Collins, & O'Leary, 2020)achieved an accuracy of 0.9899 by using two pre-trained convolutional neural networks (SqueezeNet(Iandola et al., 2016) and Inception-v3(Szegedy, Ioffe, Vanhoucke, & Alemi, 2016))for feature extraction of images and an artificial neural network for pneumonia classification comparing with support vector machine (SVM), k-nearest neighbors(KNN), and stacked auto-encoders(SAE).

In summary, these studies collectively demonstrate the effectiveness of deep learning, particularly convolutional neural networks, in pneumonia detection from medical images. However, the choice of model architecture, dataset size, preprocessing steps, and evaluation metrics can significantly impact results and should be considered carefully in future research and clinical applications.

Materials and Methods

Fine-tuned models

Deep learning has achieved considerable success in the past few years with object detection, pattern recognition, and image processing. Convolutional neural networks (CNN) achieved excellent performance on Image classification in many fields including video and audio processing, robotics, computer vision finance, and analyses of medical data.

In this study, we used eight pre-trained CNN models for pneumonia detection from the chest X-ray images VGG16, VGG19, ResNet, ResNetV2, Xception, MobileNet, InceptionV3, and InceptionResNetV2.

VGG architecture had been introduced by the Visual Geometry Group at Oxford University (Simonyan & Zisserman, 2014). Their deep model VGG16 consists of 13 convolutional layers with small filters of size 3x3 and 3 fully connected layers. Whereas, VGG19 has 26 layers including 19 weight layers, 16 convolutional layers, and 3 fully connected layers(Simonyan & Zisserman, 2014). Kaiming et al.(He, Zhang, Ren, & Sun, 2016) have proposed Residual Networks (ResNet) from Microsoft and won ImageNet Large Scale Visual Recognition Challenge (ILSVRC) (Russakovsky et al., 2015) in 2015, they used a network with 152 layers with building blocks of residual learning and shortcut connections (He et al., 2016). MobileNet architecture was introduced by Howard et al. in 2017 (Howard et al., 2017), MobileNet depends on depthwise separable, a factorized convolution technique that breaks down a standard convolution into two distinct parts: a depthwise convolution and a pointwise convolution with a kernel size of 1x1 (Howard et al., 2017). GoogleNet architecture was proposed by Szegedy et al.(Szegedy et al., 2015) from Google and won ILSVRC 2014. GoogleNet invented the idea of an inception module that uses the Network in Network approach(Lin, Chen, & Yan, 2013). The inceptionV3 model was proposed in 2016(Szegedy, Vanhoucke, Ioffe, Shlens, & Wojna, 2016) with 48 layers, which is an improved version of the GoogleNet architecture. Xception is another architecture proposed by Chollet from Google in 2017(Chollet, 2017). The main idea in Xception is the use of an extreme version of the inception module, based on using depthwise convolutional layers, followed by pointwise convolutional layers. In 2016, Szegedy et al. have proposed a combined architecture which is Inception-ResNetV2(Szegedy, Ioffe, et al., 2016),this model uses the idea of inception blocks and residuel layers together. This architecture consists of 164 layers, they used residual connections to reduce the training time and to skip the degradation problem causes by deep networks.

In this study, we modified the last layers in each model by removing the top layers of these models and adding new layers including the Global Average Pooling layer, a fully connected layer with Dropout to reduce the overfitting problem, and softmax activation for predictions.

Figure 1 shows the modified VGG19 which is one of the models used in our work.

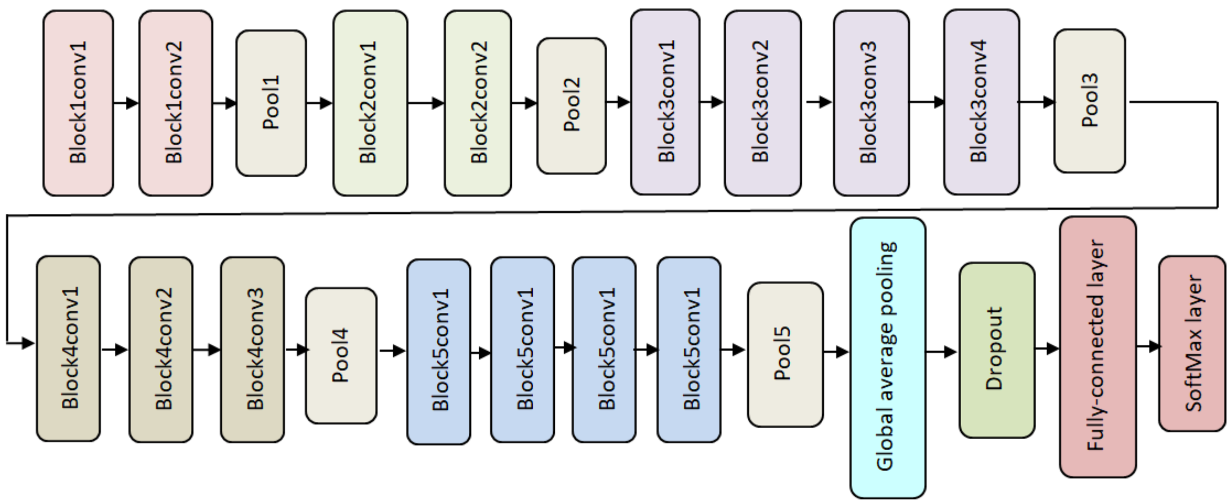

Fig. 3. Fine-tuned VGG19 architecture

Data set and data pre-processing

In this study, we utilized the chest X-ray dataset obtained from (Kaggle) to train and test our model. This dataset comprises 5856 images categorized into two classes: normal and pneumonia. To ensure proper evaluation, we randomly reorganized the dataset, allocating 80% for training, 10% for validation, and another 10% for testing. As shown in Table 1, the normal category consists of 1267 training images, 158 validation images, and 158 test images. Figure 2 illustrates some samples of the chest X-ray of the two classes.

Tab. 1. Categorizing of chest X-ray image dataset

Class	Training data	Validation data	Test data
Pneumonia	3419	427	427
Normal	1267	158	158
Total	4686	585	585

(a) (b) (c)

Fig. 4. Examples of chest X-ray images. (a) Normal,(b) bacterial pneumonia,(c) Viral Pneumonia

Each sample had a different size and was in the JPEG format, we scaled the images into 115x115, the pixel values were normalized to be between 0 and 1. We used data augmentation and early stopping to reduce overfitting issues of the pre-trained models, we performed examples with a rotation range of 45, a vertical Shift of 0.2, and horizontal shift of 0.2. Figure 3 shows the images after following the application of different augmentation techniques.

Horizontal shift Rotation vertical shift

Fig. 5. Images after using different augmentation techniques.

To evaluate the performance of the classification of the modified models, we relied on essential measures such as true-positive (TP), true-negative (TN), false-positive (FP), and false-negative (FN). These measures are commonly used to assess the accuracy and effectiveness of the classification task. With these parameters, it can be calculated many essential metrics, such as accuracy, recall, F1 score, and precision:

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \quad (1)$$

$$Recall = \frac{TP}{TP + FN} \quad (2)$$

$$Precision = \frac{TP}{TP + FP} \quad (3)$$

$$F1 - score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (4)$$

Results and Discussion

As may be seen below, we calculated the 8 confusion matrix to evaluate the performance of each fine-tuned model

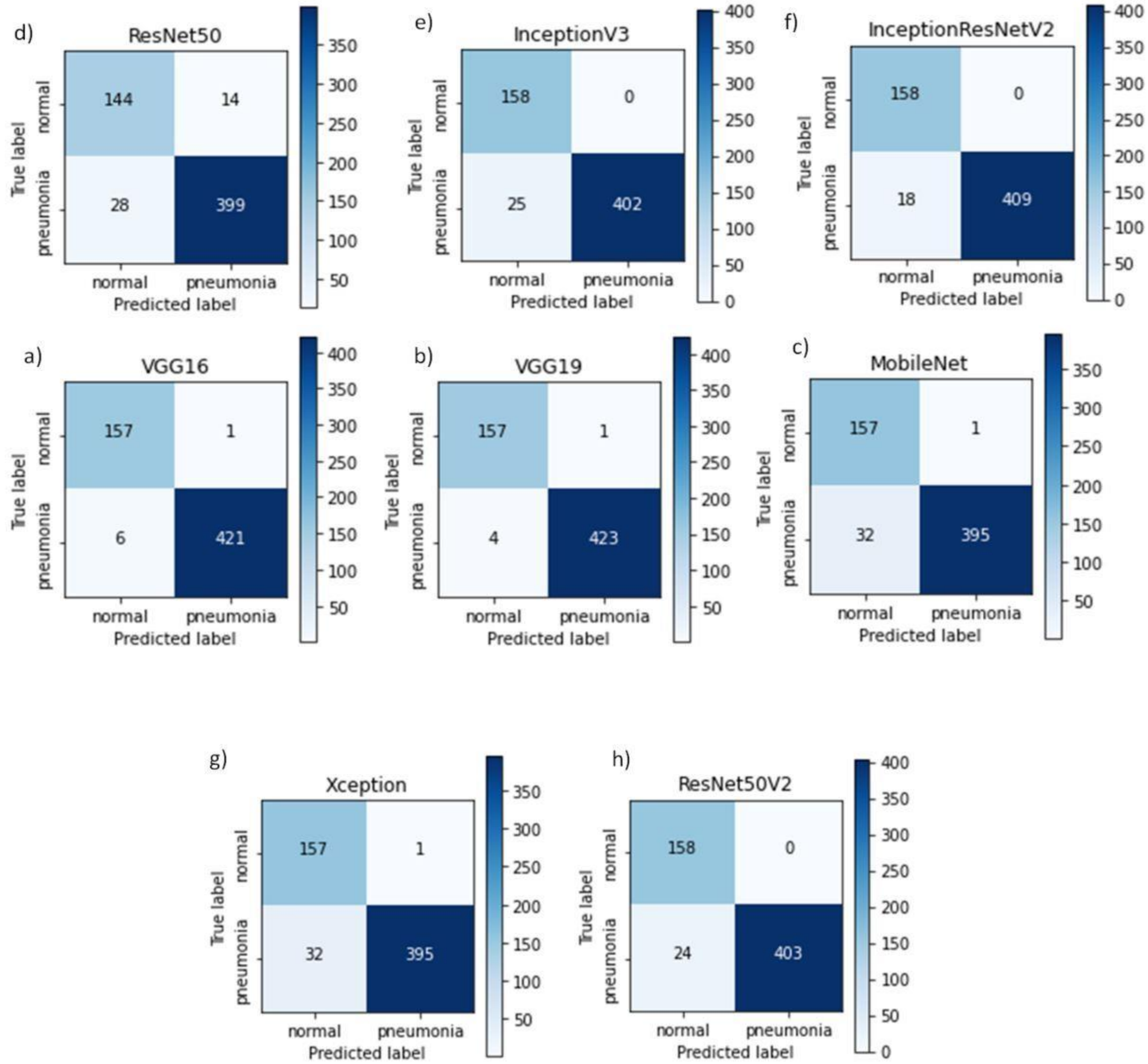

Fig. 6. Confusion matrix of fine-tuned models, (a) Visual Geometry Group(VGG)-16, (b)VGG-19, (c) MobileNet, (d) ResNet, (e) InceptionV3, (f) InceptionResNetV2, (g) Xception, and (h) ResNet50V2.

As demonstrated in Table 2 below Four different performance measures, including accuracy, precision, recall, and F1 score were calculated from the values given (in the confusion matrix) in Figure 3 and the equations (1), (2), (3), and (4) to analyse the classification performance of the proposed fine-tuned models. The visualization of the four classification performances is illustrated in Figures 4, 5, 6, and 7.

Tab. 2. Performance measure

MODELS	ACCURACY	PRECISION	RECALL	F1-SCORE
VGG16	0,9880	0,9976	0,9859	0,9918
VGG19	**0,9915**	0,9976	**0,9906**	**0,9941**
INCEPTIONRESNETV2	0,9692	1,0000	0,9578	0,9785
INCEPTIONV3	0,9573	1,0000	0,9415	0,9698
RESNETV2	0,9590	1,0000	0,9438	0,9711
XCEPTION	0,9436	0,9975	0,9251	0,9599
RESNET	0,9282	0,9661	0,9344	0,9500
MOBILENET	0,9436	0,9975	0,9251	0,9599

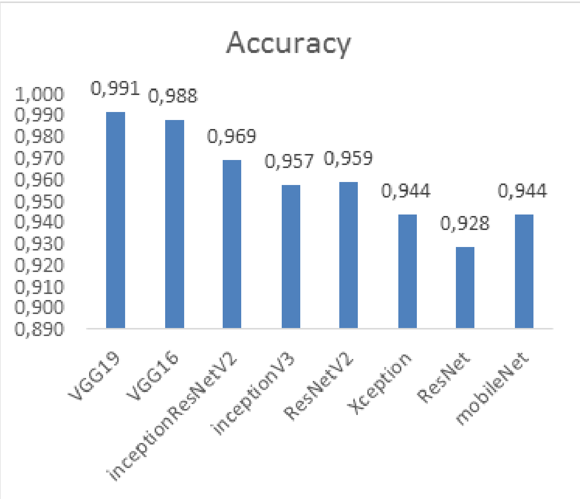

Fig. 7. Accuracy comparison

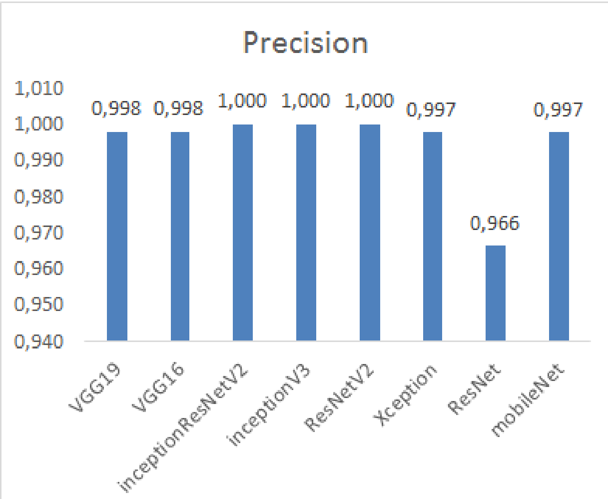

Fig. 8. Precision comparison

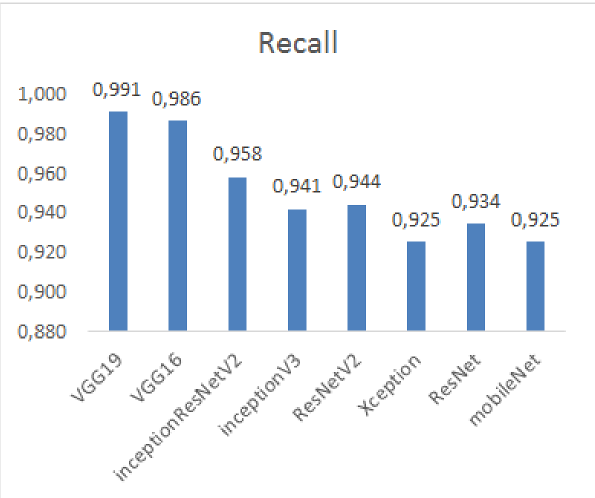

Fig. 9. Recall comparison

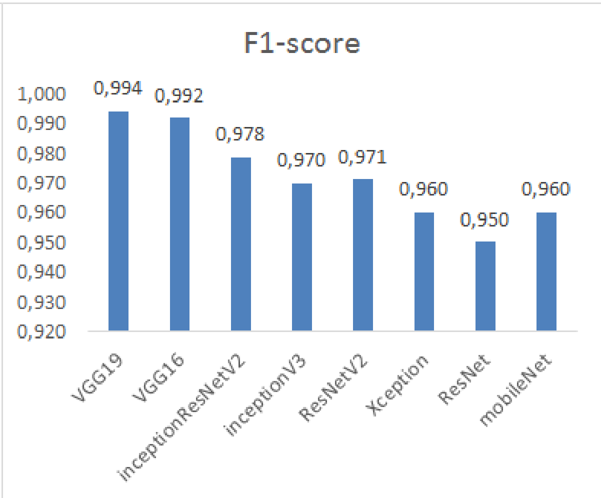

Fig. 10. F1-Score comparison

It observed from Table 2 that the modified VGG19 achieved the highest classification performance for pneumonia detection with 99.15% test accuracy when compared with the other fine-tuned models which provide remarkable results with accuracy greater than 90 %. Moreover, the modified VGG19 model performs better than the other models in terms of recall with 99.06% and F1-score with 99.41%. Which succeed in correctly detecting the most positive pneumonia case, and a low false negative case.

The performance of different recent methods of pneumonia detection is summarized in Table 3:

Tab. 3. Comparison of the proposed finetuned model with different existing DL methods.

Reference	Accuracy (%)	Precision (%)	Recall (%)	F1score (%)
S.Thakur et al.(Thakur et al., 2021)	90.54	87.7	98.7	92.9
Abhir Bhandary et al. (Bhandary et al., 2020)	96.80	96.58	96.57	96.78
M.F. Hashmi el al.(Hashmi et al., 2020)	98.43	98.26	99.00	98.63
KH.T.Islam et al.(Islam et al., 2020)	98.99	99.18	98.80	98.99
Our study (modified VGG19	**99.15**	**99.76**	**99.06**	**99.41**

Our results shows that our fine-tuned VGG19 architecture performs better compared to other state-of-the-art CNN architectures and it can make the correct pneumonia diagnosis with an accuracy of 99.15%, precision of 99.76%, recall (sensitivity)of 99.06%, and F1-Score of 99.41%.

Conclusion

In this paper, we have proposed eight fine-tuned models to classify and detect pneumonia from chest X-ray images by using pre-trained convolutional neural networks such as VGG16, VGG19, MobileNet, InceptionV3, InceptionResNetV2, Xception, ResNet50, and ResNet50V2. All fine-tuned models have achieved good results on chest X-rays with an accuracy high than 90%. Comparing all proposed models, it appears that the modified VGG19 performs better and was able to provide binary classification with a test accuracy of 99.15.

Based on the results, it can be concluded that the proposed model has been very successful in diagnosing pneumonia automatically. Furthermore, the proposed modified VGG19 could be readily applied to identify unhealthy persons from the healthy based on the chest X-ray. The most important limitation is due size of the dataset which contains a few numbers of images and an unbalanced dataset problem.

The future research could potentially lead to the development of a tool that could aid in the diagnosis of COVID-19, which could be particularly useful in areas where access to medical professionals or testing is limited.

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Anticipating Student Dropout in MOOCs based on Classification Predictive Model

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Abstract

In the last few years, MOOCs have emerged as a transformative trend in education due to their advantages, such as accessibility, flexibility, and affordability offered to students. Despite the massive number of enrolments attracted by MOOCs, one persistent issue plaguing them is the high dropout rate among students. However, the big educational data generated from student activities on online platforms offered opportunities for research in the Big Data analytics field to improve educational outcomes. This research exploits and compares advanced analytical techniques, such as machine learning (ML) and deep learning (DL), to forecast student dropout from MOOCs. Therefore, this study employed five different models using DT, RF, LR, SVM, MLP,and LSTM algorithms to forecast attrition in MOOCs of the Open University using the clickstreamdata from the VLE. In this study, the RF and DT models predict student attrition better than the other models. However, the remaining models perform well.

Keywords: Big Data analytics, MOOC, Machine learning (ML), Deep learning (DL), Student dropout.

Introduction

Education is one of the most substantial factors in socioeconomic development. That is why weneed to develop and solve the various problems that the educational field suffers from, such as dropping out of educational institutions, a critical issue that can occur at all learning levels, suchas primary and secondary school and higher education. Online education also suffers from student dropout, and it is much worse than traditional education, as statistics indicate (Nadar and Kamatchi 2018). Massive Open Online Courses (MOOCs) have received enormous attentionover the last decade, attracting tens of thousands of students due to their flexibility andcontribution to removing many obstacles, such as geographical and financial barriers for students. Moreover, the new Coronavirus pandemic (COVID-19) forced Universities and institutes to adapt their education systems toward online learning.

However, student retention has been identified as a critical concern in MOOCs because of the high dropout rate, which is much higher than campus-based students and can easily reach 90 %attrition rates (Medina-Labrador et al. 2022; Chanaa et al. 2022).

The dropout phenomenon has been addressed in the fields of Educational Data Mining (EDM) and Learning Analytics (LA), the two multidisciplinary fields of study that involve researchers from various research communities attempting to improve education quality by analyzing educationaldata and extracting relevant information for academics using diverse statistics and machine learning methodologies (Aljohani, Fayoumi, and Hassan (2019)

The subsequent sections of this paper are structured in the following manner. Section 2 providesa comprehensive review of prior scholarly articles relevant to classification techniques in education and the prediction of student dropout in Massive Open Online Courses (MOOCs).

Section 3 provides a concise overview of the academic disciplines relevant to predicting studentattrition. Section 4 delineates the methodology employed in the prediction of student attrition within the scope of this study. The results and discussion will be presented in Section 4, while the conclusion of this paper and future research directions will be outlined in Section 5.

Background

This section presents some key concepts related to student dropout in MOOCs mentioned in thispaper and links between them, which can be illustrated in figure 1.

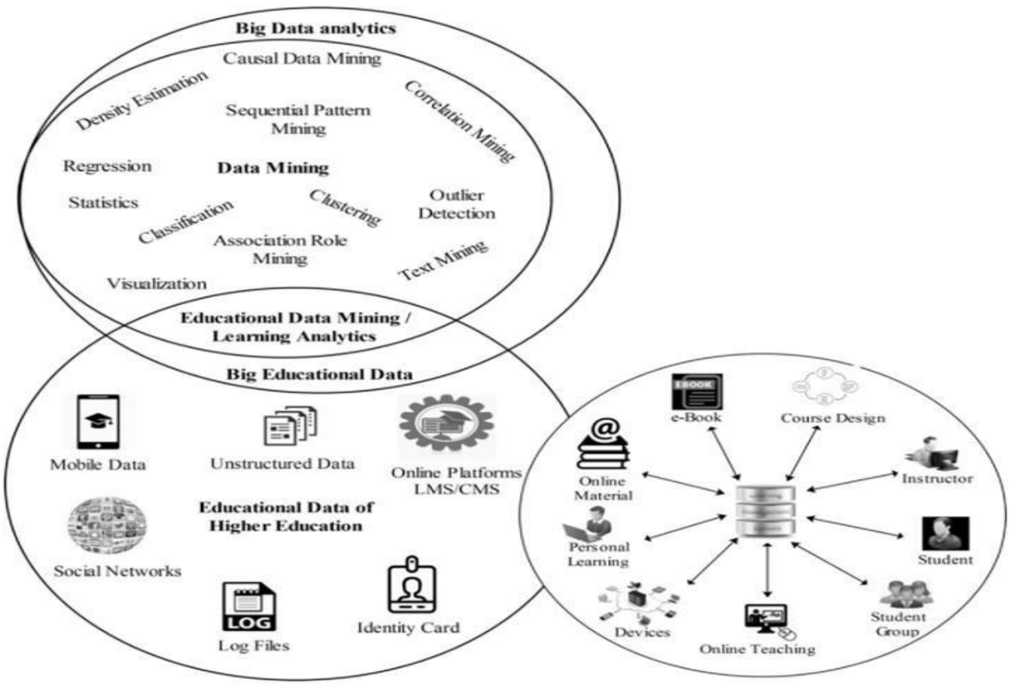

Fig. 1. An illustration of EDM, LA, and Big data links and uses in higher education (*Aldowah, Al-Samarraie, and Fauzy, 2019*)

Massive Open Online Courses (MOOCs) have undoubtedly led an education revolution since their launch in 2008, bringing together global educational resources and reshaping the learning environment. However, despite their momentum, student dropout is a major problem in MOOCs.This problem has been addressed by the two fields of research, Education data mining and Learning analytics, which can be defined as follows:

EDM refers to the application of machine learning and data-mining methodologies for examiningeducational data primarily produced by students and instructors within educational environments(Bakhshinategh, Zaiane, ElAtia, and Ipperciel 2018). While Learning Analytics, according to the call of the First International Conference on Learning Analytics and Knowledge (LAK), can be defined as:

*"The measurement, collection, analysis, and reporting of data about learners and their contexts for understanding and optimizing learning and the environments in which it occurs" (*Calvet Liñánand Juan Pérez 2015*).*

Since MOOC platforms include a wealth of educational data generated through student interactions with the platform, assessments, forum posts, and online tools, these valuable resources led to constructing "big data" related to education coming from data from thousands of students (Piety, Hickey, and Bishop 2014).

Big data analytics is applying analytics techniques to massive amounts of data to extract insightsand uncover hidden patterns (Russom et al. (2011)). As a result, applying analytics on big educational data in higher education has garnered the interest of researchers from various research backgrounds and disciplines to address dropout and other education issues.

Related Work

Numerous studies address the issue of student dropouts from MOOC platforms. So far, most ofthese studies are based on ML and DL classification techniques, which have been one of the most feasible ways to enhance MOOC completion rates through early dropout prediction models.This section reviews the state-of-the-art approaches in previous research on dropout predictions.

(Muthukumar and Bhalaji 2020) present "MOOCVERSITY," a deep learning model based on neural networks and learners' log data for predicting dropout rates in MOOCs. The proposed approach offers a reliable method for identifying at-risk students in MOOCs and outperforms Decision Trees and Logistic Regression.

In their study, (Hassan et al. 2019) utilise the Long short-term memory (LSTM) deep-learning model to forecast student attrition within a virtual learning environment (VLE) using data from theOpen University Learning Analytics (OULA) dataset. The proposed system provides insights intothe early identification of at-risk students and potential interventions to improve retention rates.

(Queiroga et al. 2020) Proposed a learning analytics approach to identify at-risk students of dropout in a technical distance education course. This study presents a genetic algorithm basedon Darwin's theory of natural selection for hyper-parameter tuning for early student dropout prediction, using only students' interactions with the virtual learning environment of distance education.

(Mubarak, Cao, and Hezam, 2021) propose a deep analytic model that combines the Convolutional neural network and LSTM to analyse student data and predict dropout behaviour.The presented method outperforms the conventional model, such as SVM and logistic regressionin early identification students show dropout behaviour, allowing preventive action.

The authors (Waheed et al., 2020) trained a deep Artificial neural networks (ANNs) on handcrafted attributes from online class log data to predict course student dropouts. The presented method outperforms baseline machine learning algorithms in identifying at-risk students, demonstrating deep learning models' potential in accurately predicting student performance based on VLE data.

Methodology

A. Research Design

This study aims to predict student dropout, which represents the process used to identify at-risk students illustrated in figure 2 and is part of the Knowledge Discovery and Data Mining processes (Calvet Liñán and Juan Pérez 2015).

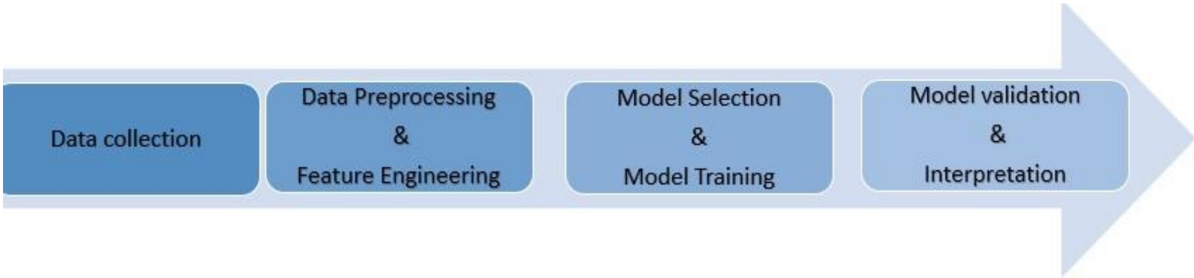

Fig. 2: student dropout prediction workflow

Several classification techniques were employed and trained using data from the OULA datasetto build predictive models for early identifying at-risk students to prevent them from dropping outof the courses.

B. Data

The Open University Learning Analytics dataset (OULAD)[1] was used in this investigation. This data includes demographic, performance, and clickstream data from 22 courses and 32,593 students. The daily summaries of student clicks (10,655,280 entries) in Open University's virtual learning environment (VLE) produce the clickstream data.

Table 1: Description of the OULA dataset activities used as features

N°	Activity	Description
1	DataPlus	Interaction with supplementary information and views on videos, audio, and websites.
2	DualPane	Interaction with the site's information and associated activity
3	External Quiz	interaction with the external quiz
4	Folder	Interaction with course-related materials in public folders
5	Forumng	Participation the discussion forum
6	Glossary	Interaction with the course-related glossary of essential terms.
7	HomePage	Interaction with the course homepage
8	HtmlActivity	Interaction with the dynamic HTML page
9	Oucollaborate	Interaction with online video discussion forums
10	Oucontent	Interaction with the assignment's contents
11	Ouelluminate	Interaction with the online learning sessions
12	Ouwiki	Interaction with the Wikipedia content
13	Page	Interaction with the course-related information.
14	Questionnaire	Interaction with the course-related questionnaires.
15	Quiz	Interaction with the course quiz link.
16	RepeatActivity	Interaction with course material from prior sessions.

17	Resource	Downloads pdf documents, such as books.
18	SharedSub Page	Broadcast the knowledge between courses and faculty
19	SubPage	Interaction with the additional websites that are accessible within the course.
20	Url	Interaction with hyperlinks leading to audio and video materials.

C. Preprocessing

This research examined student interaction with the VLE as a representation of student behaviour on the MOOCs platform. This latter dataset included 10,655,280 entries, each representing students' daily clickstream activity through 20 different activities.

Since the Open University (OU) data is not directly applicable as inputs in the machine learning (ML) classification model.

The input features utilised in this study were initially obtained from various tables and required fusion into a unified table. Various preprocessing steps were conducted on the data, where the clickstream data log of each student was transformed into a weekly format by aggregatingdaily records into a weekly activity record.

D. Used Techniques

The present study aims to evaluate the overall efficacy of identifying early dropout by comparing various conventional classification models commonly employed in the existing literature for predicting student dropout at an early stage.

- **Logistic Regression (LR):** It is a linear model with a sigmoid activation function that outputs the probability of the positive class. It's used for binary classification tasks (Hassan et al. 2019).
- **Decision Tree (DT):** is a classification and regression algorithm. Named for its tree-like structure. Root, internal, and leaf nodes make up a tree structure. Recursively partitioning data by feature values to make predictions (Queiroga et al. 2020).
- **Random Forest (RF):** combines multiple decision trees to make predictions by aggregating their outputs. Random subsets of data and features for each tree increase forecast accuracy and prevent overfitting (Queiroga et al., 2020).
- **Support Vector Machine (SVM**): It is a supervised machine learning algorithm for classification and regression. It works for linear and non-linear data by finding an ideal hyperplane that maximum separates classes or matches the data with the largest margin (Waheed et al. 2020).
- **Multilayer Perceptron (MLP):** an artificial neural network commonly used for various machine learning tasks. It consists of multiple layers of interconnected nodes, including input, hidden, and output layers (Muthukumar and Bhalaji 2020).
- **Long Short-Term Memory (LSTM):** is a recurrent neural network (RNN) architecture that mitigates the vanishing gradient problem to handle sequence data. Natural language processing and time series analysis use LSTMs to capture long-term data dependencies (Hassan et al. 2019).

E. Used Metrics

In order to evaluate the effectiveness of the models in accurately predicting student attrition, it is imperative to carry out an assessment. The selected evaluation metrics for this study canbe interpreted in the following manner:

- **Accuracy:** single numeric measuring the proportion of correctly predicted instances over the total number of instances

$$Accuracy = \frac{\text{Number of correct predictions}}{\text{Total prediction number}}$$

- **F1 Score**: It takes into account both the model's ability to correctly identify positive instances (precision) and its ability to capture all positive instances (recall), providing a balanced performance measure.

$$F1\ score = 2 \times \frac{\text{precision} \times \text{recall}}{precion + recall}$$

- **Area Under the Curve (AUC):** It is a widely employed evaluation metric in binary classification tasks, quantifying the effectiveness of a model's prediction probabilities (Bowers and Zhou, 2019).

Results and Discussion

The subsequent section examines the empirical findings derived from our experimental investigations.

The primary objective of this study was to create, execute, and assess machine learning modelsto forecast students' dropout based on Virtual Learning Environment (VLE) logs about their studybehaviours.

During the training process, the data from each week is concatenated with the data from the previous weeks to construct sequence data and then inputted into the classification model to predict at-risk students early. Thus, preventive action can be taken to prevent dropout.

The algorithms employed in this study address a binary classification task, where the positive class represents student continuation, and the negative class represents student dropout.

The empirical findings were compared based on efficiency metrics, including accuracy, F1-Score,and AUC, as presented in table 2.

Table 2: The experimental results regarding ML classification performance

Weeks	10 Weeks			20 Weeks			30 Weeks		
Metrics	**Accuracy**	**F1 Score**	**AUC**	**Accuracy**	**F1 Score**	**AUC**	**Accuracy**	**F1 Score**	**AUC**
LSTM	82,65%	78,08%	81,88%	89,96%	87,22%	89,39%	93,87%	93,87%	93,87%
LR	81,14%	78,06%	81,79%	89,06%	86,96%	89,61%	94,52%	93,27%	94,79%
MLP	85,44%	**81,24%**	**84,45%**	90,75%	88,37%	90,43%	95,57%	94,41%	95,39%
DT	85,55%	79,77%	83,22%	**93,95%**	**92,04%**	**93,00%**	97,10%	96,25%	**96,60%**
SVM	83,26%	78,05%	81,88%	91,12%	88,74%	90,66%	95,36%	94,12%	95,12%
RF	**86,09%**	79,98%	83,35%	93,29%	90,99%	91,97%	**97,12%**	**96,27%**	96,59%

Figure 3 illustrates the prediction summary obtained from employing various machine learning algorithms, namely DT, RF, MLP, SVM, LR and LSTM, on the given dataset. The graphs presented in this study illustrate the specific results of the predictions made at intervals of 10, 20,and 30 weeks regarding accuracy, F1 score, and AUC metrics.

The range from the 10th week to the 30th was selected because, in the first weeks, there is difficulty in determining the behaviour of the dropouts due to the limited availability of information. At the same time, after the 30th week, as the end of the course approaches, interaction and dropout rates are rare after this period.

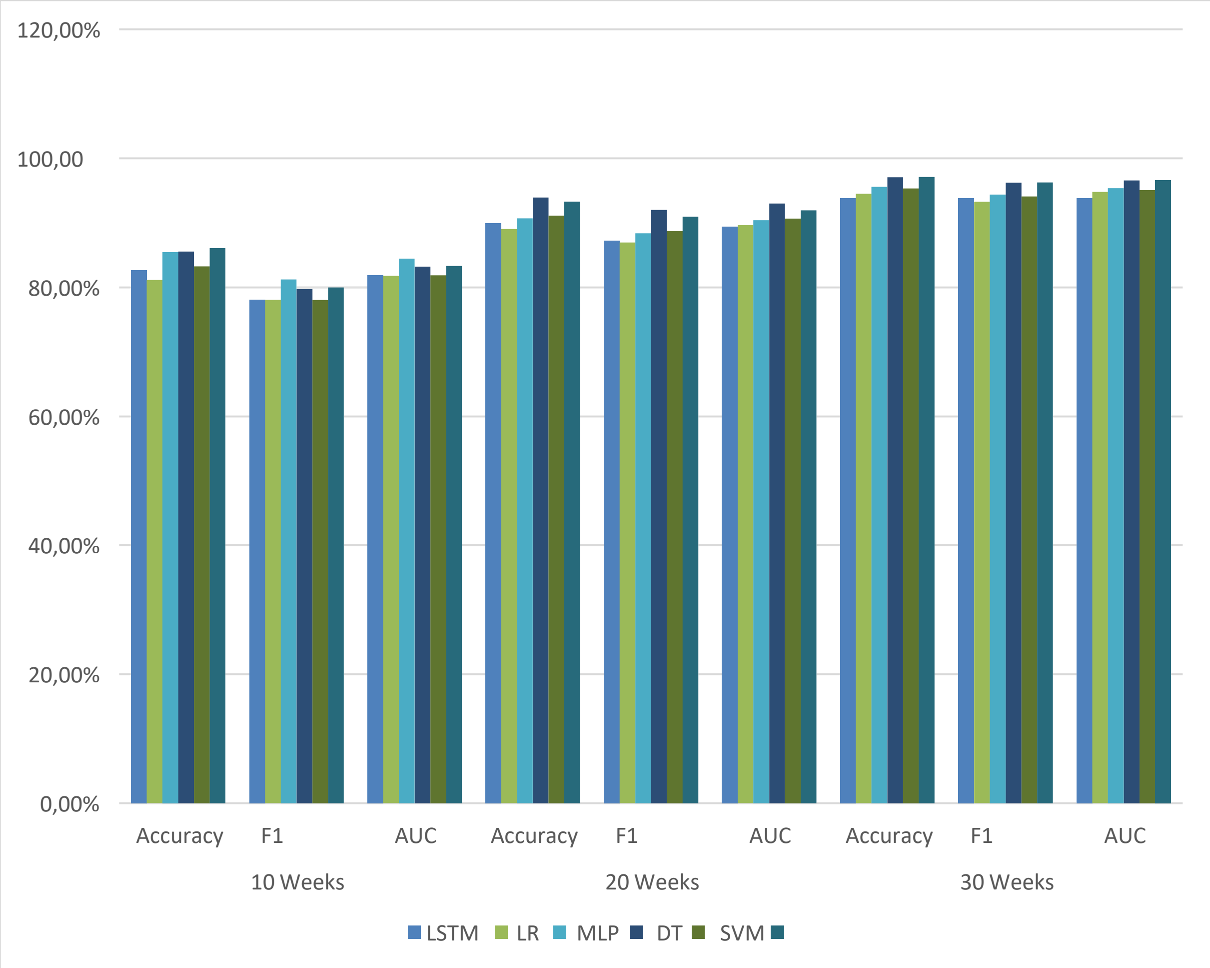

Fig 3: A Comparison of ML classification algorithms according to the accuracy, F1-score, and AUC over the weeks.

The findings indicate that the DT and RF models exhibit the highest level of accuracy in forecasting student attrition (dropout). Where accuracy rates exhibit a range of 86.09% during the 10th first weeks, reaching a peak accuracy of 97.12% in the 30th week for the Random Forest(RF) algorithm. Similarly, the Decision Tree (DT) algorithm demonstrates accuracy rates ranging from 85.55% to 97.10%. On the other hand, the alternative model demonstrates satisfactory performance as well. These results demonstrated the capability of these models in predicting at-risk students.

Conclusion and Future work

Implementing dropout prediction in (MOOCs) can be achieved by utilizing classification techniques. The study determined that the prediction model using RF and DT algorithms exhibited superior performance compared to other models, including LR, SVM, MLP, and LSTM, regarding the accuracy, AUC, and F measure. Nevertheless, from a statistical standpoint, it is evident that the remaining models also exhibit satisfactory performance, thereby substantiating the predictive ability of this particular model in forecasting student attrition.

This study has the potential for expansion by enhancing its accuracy and identifying the factors contributing to dropout rates. This knowledge can inform the development of targeted preventivemeasures to mitigate attrition before it occurs.

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LSTM deep learning model for wind speed forecasting in the region of Adrar

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Abstract

The significance of precise wind speed forecasting cannot be overstated, especially in the context of renewable energy generation. Wind turbines generate power by relying on the availability of wind, and precise wind speed forecasts are critical for maximizing their performance and assuring maximum energy output. Besides that, wind speed prediction is crucial for grid operators to manage wind energy integration into the electrical grid and ensure system stability. This work presents a deep learning long short-term memory LSTM model for wind speed forecasting at three-time scales: one hour ahead, three hours ahead, and six hours ahead in the Algerian Adrar region. Meteorological data is used to train and evaluate the model, and its forecasting ability is measured using the RMSE, MAE, and MAPE error metrics. The results indicate that the suggested LSTM model is useful for forecasting wind speed at various time scales, with respectable levels of accuracy for all three assessment measures. The suggested LSTM model can assist increase wind speed forecast accuracy as well as the efficiency and reliability of wind energy generation.

Keywords: *Renewable energy, Forecasting, Wind speed, Long short term memory, Artificial intelligence*

1. Introduction

It is widely recognised that the world's electrical energy consumption is rapidly increasing, owing largely to a growth in global population and, secondly, to the growing energy demands of industrialized civilizations. Yet, as fossil fuel storage capacity continues to diminish, the energy crisis becomes more severe than ever (Lindemann et al. 2021). As a result, legislative changes in the nation’s policies favouring the usage of renewable energy have been encouraged internationally in order to alleviate the energy crisis. Each renewable energy source is used differently in each country depending on its geographic location.

Wind energy has received a lot of attention among renewable energy sources because of its benefits in mitigating climate change, minimizing environmental pollution, reducing energy reliance, and encouraging the sustainable development of many nations (Lindemann et al. 2021). Wind energy may be regarded as one of the least expensive kinds of energy in several fields. According to the Global Wind Energy Council (GWEC), new wind projects will add 93.6 GW of capacity globally in 2021, just 1.8% less than the record year of 2020. This

brings the total installed wind capacity to 837 GW, a 12.4% increase over 2020 (Global Wind Report 2022 - Global Wind Energy Council).

Because wind power is unpredictable and intermittent, it presents several technological and economic obstacles, such as managing and planning energy production (Zhong et al. 2020).

Consequently, understanding wind energy forecasts is critical to tackling the issues. A number of tactics, including physical approaches, statistical models, artificial intelligence-based techniques, and their hybrid forms, have been proposed in the literature to create realistic renewable energy estimates over various time scales (Lindemann et al. 2021).

To represent the on-site circumstances at the given location, physical forecasting systems use numerical weather prediction (NWP). Furthermore, in order to carry out numerical weather forecasting, these approaches require a range of meteorological and geographic parameters, such as temperature, pressure, and orography. Physical techniques do not work well with short-term forecast timeframes (Z. Liu and Sullivan 2019). Statistical strategies are significantly simpler than physical procedures in that they model the wind speed signal using historical time series data from a given location to produce forecasting (Zhong et al. 2020). Based on the theory of random processes and probability, these techniques typically employ recursive linear models such as the autoregressive moving average, the Kalman filter, the Bayesian approach, the autoregressive moving average, the autoregressive integrated moving average, etc (Cassola and Burlando 2012)(Jiang, Song, and Kusiak 2013)(Torres et al. 2005). Because of their potential data mining and feature extraction capabilities, AI-based forecasting systems always outperform the first two approaches (Rajaee, Ebrahimi, and Nourani 2019). To address the nonlinear connection between input and output via error reduction, fuzzy logic, artificial neural networks (NNs), support vector machines (SVM), wavelet transformation deep learning method, and evolutionary computing techniques were commonly utilized (Yadav and Chandel 2017)(Zheng et al. 2023)(Khelil, Berrezzek, and Bouadjila 2021). Many hybrid techniques have been developed in the literature to increase forecast efficiency and accuracy (Zhu, Wang, and Yu 2022)(Q. Liu et al. 2022). These methods combine several intelligence algorithms with physical and statistical methodologies to get the best forecasting performance. In this study, Long Short-Term Memory (LSTM) will be used to forecast wind speed in the Adrar region of Algeria. LSTM is a form of recurrent neural network (RNN) that has demonstrated success in time-series forecasting (Yan et al. 2022). It can detect long-term dependencies in the input sequence and process input sequences of varying lengths. This makes LSTM appropriate for wind speed forecasting, a time-series forecasting task with input sequences of variable length. The proposed LSTM-based model for forecasting wind speed is trained using historical wind speed data from the Adrar region. The model is then utilized to forecast wind speed for a particular time horizon. Using RMSE, MAE, and MAPE, the performance of the model is evaluated by comparing the forecasted wind speed values to the actual wind speed values.

The remainder of the work is structured as follows. The second section provides the theoretical foundation for the LSTM evolutionary algorithm. In section 3, we describe the dataset used and the proposed model configuration. Section 4 presents the obtained simulation results using the proposed method. Finally, the conclusion is then provided.

2. Materials and Methods

2.1. Long Short-Term Memory (LSTM)

RNNs are a type of neural network that are particularly effective for sequential data analysis. In traditional neural networks, data is fed forward through the network and processed, with each layer only being able to access information from the previous layer (Z. Liu and Sullivan 2019) . LSTM is a type of Recurrent Neural Network that is designed to handle the problem of long-term dependencies in sequential data. The basic structure of an LSTM consists of three gates - an input gate, an output gate, and a forget gate and a memory cell. These gates control the flow of information into and out of the memory cell, allowing the LSTM to selectively retain or forget information from previous time steps (X. Liu, Lin, and Feng 2021). The input gate i_t determines which information from the current time step should be added to the memory cell, while the forget gate f_t determines which information from the previous time step should be forgotten. The output gate O_t controls the amount of information that is output from the memory cell C_t at the current time step the memory cell is the internal state of the LSTM, and it can be thought of as a "conveyor belt" that runs through the network. Information flows through the memory cell from one time step to the next $\acute{C}_t$, with the gates controlling which information is added or forgotten at each step one of the key advantages of LSTMs over traditional RNNs is their ability to handle vanishing gradients, which can occur when gradients become too small to be propagated back through the network during training. The gating mechanism in LSTMs allows the network to selectively retain or forget information, which helps to prevent the gradients from vanishing. LSTMs have been used successfully in a wide range of applications, including natural language processing (Kasthuri and Balaji 2021), speech recognition (D. Bukhari, Wang, and Wang 2017), and time-series forecasting (Lindemann et al. 2021). They have been particularly effective for tasks that require the model to capture long-term dependencies in the data, such as forecasting stock prices (A. H. Bukhari et al. 2020) or weather patterns.

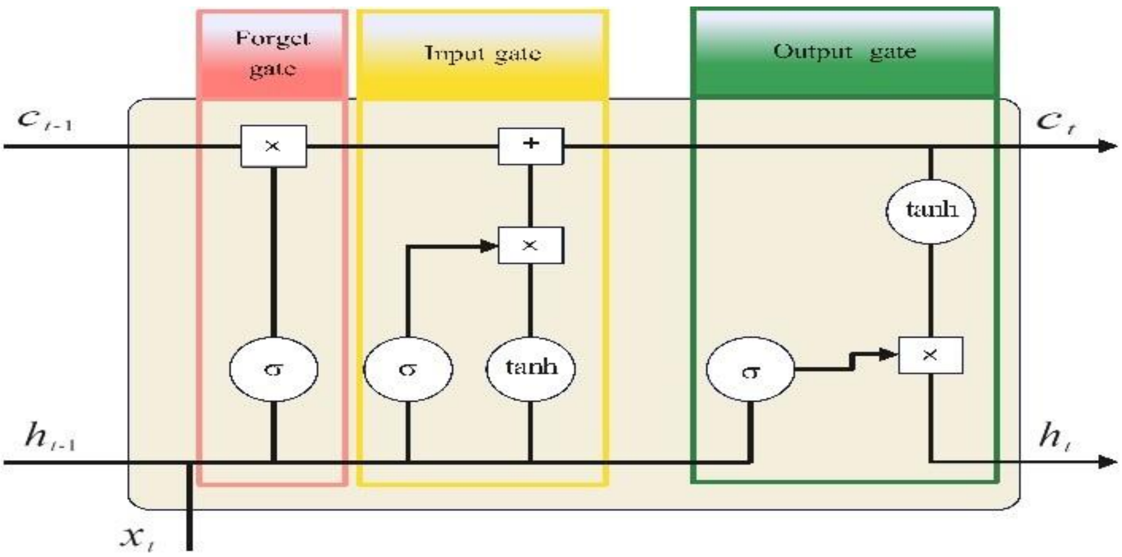

Fig. 1. Structure of Short-Term Long Memory

$$f_t = \sigma(w_f.[h_{t-1}, X_t] + b_f) \quad (2) \qquad \sigma(X) = \frac{1}{1-e^{-x}} \quad (3)$$

$$i_t = \sigma(w_i.[h_{t-1}, X_t] + b_i) \quad (4) \qquad \acute{C}_t = \tanh(w_c[h_{t-1}, X_t] + b_c) \quad (5)$$

$$\tanh(X) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \quad (6) \qquad C_t = f_t \bullet C_{t-1} + i_t \bullet \acute{C}_t \quad (7)$$

$$O_t = \sigma(w_o \cdot [h_{t-1}, X_t] + b_o) \quad (8) \qquad h_t = O_t \cdot \tanh(C_t) \quad (9)$$

where σ stands for the sigmoid activation function which is defined as in equation 3 and tanh is the hyperbolic tangent function that is defined as in equation 6 (Shen et al. 2022).

2.2. Evaluation index

- The root mean square error (RMSE) is one of the most used metrics for assessing the accuracy of time series forecasts. Calculated by computing the residual (the difference between forecasting and actual value) for each data point, averaging the residual values, and taking the square root of the mean, RMSE indicates how much forecasting results deviate from actual values (Xu and Wei 2022).

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(y_t - \hat{y}_t)^2} \quad (10)$$

- The mean absolute error (MAE) is a common metric calculated by adding up all the absolute errors and dividing them by the number of errors (Xu and Wei 2022).

$$MAE = \frac{1}{N}\sum_{t=1}^{N}(y_t - \hat{y}_t) \quad (11)$$

- The mean absolute percentage error (MAPE) is a metric that calculates the percentage difference between the forecasted and actual values, and it is often used to evaluate models with varying scales of data. It represents the average absolute percentage difference between the forecasted and actual values. A lower MAPE implies better forecasting accuracy, with zero indicating perfect forecasts (Bashir et al. 2022).

$$MAPE = \left(\frac{1}{N}\sum_{t=1}^{N}\frac{(y_t - \hat{y}_t)}{y_t}\right) \times 100 \quad (12)$$

3. Dataset and experiments

3.1 Dataset

The effectiveness of the LSTM forecasting model was evaluated in this study, using datasets collected by NASA from the Adrar Ouled Ahmed Timmi wind farm in 2013. These datasets consist of hourly measurements of wind speed (in meters per second) at 50 meters, air pressure, temperature, and wind speed (in meters per second) at 10 meters, over a period of almost seven years (2015-2022) with 70128 values for each feature the description of the datasets in table 1.

Table.1. Detailed description of dataset.

Columns	Count	Mean	std	min	max
Wind speed at 50 m (m/s)	70128	6.64	2.63	0.03	18.37
Pressure (PA)	70128	23.76	15.58	2.31	98.00
Temperature (C°)	70128	25.80	10.80	0.29	49.05
Wind speed at 10 m (m/s)	70128	25.80	1.97	0.02	15.33

3.2. Model setup

The model setup for the article paper involves the following steps as shown in figure 2.

Data Pre-processing: The dataset is pre-processed to prepare it for analysis. This involve cleaning and normalizing the data using MinMaxscaler Method to ensure that it is suitable for the deep learning algorithm.

Train-Test Split: The pre-processed dataset is split into three parts: a training set, Validation set, and a testing set. In this case, 5 years of the data is assigned to the training set, one year for the validation and one year assigned to the testing set.

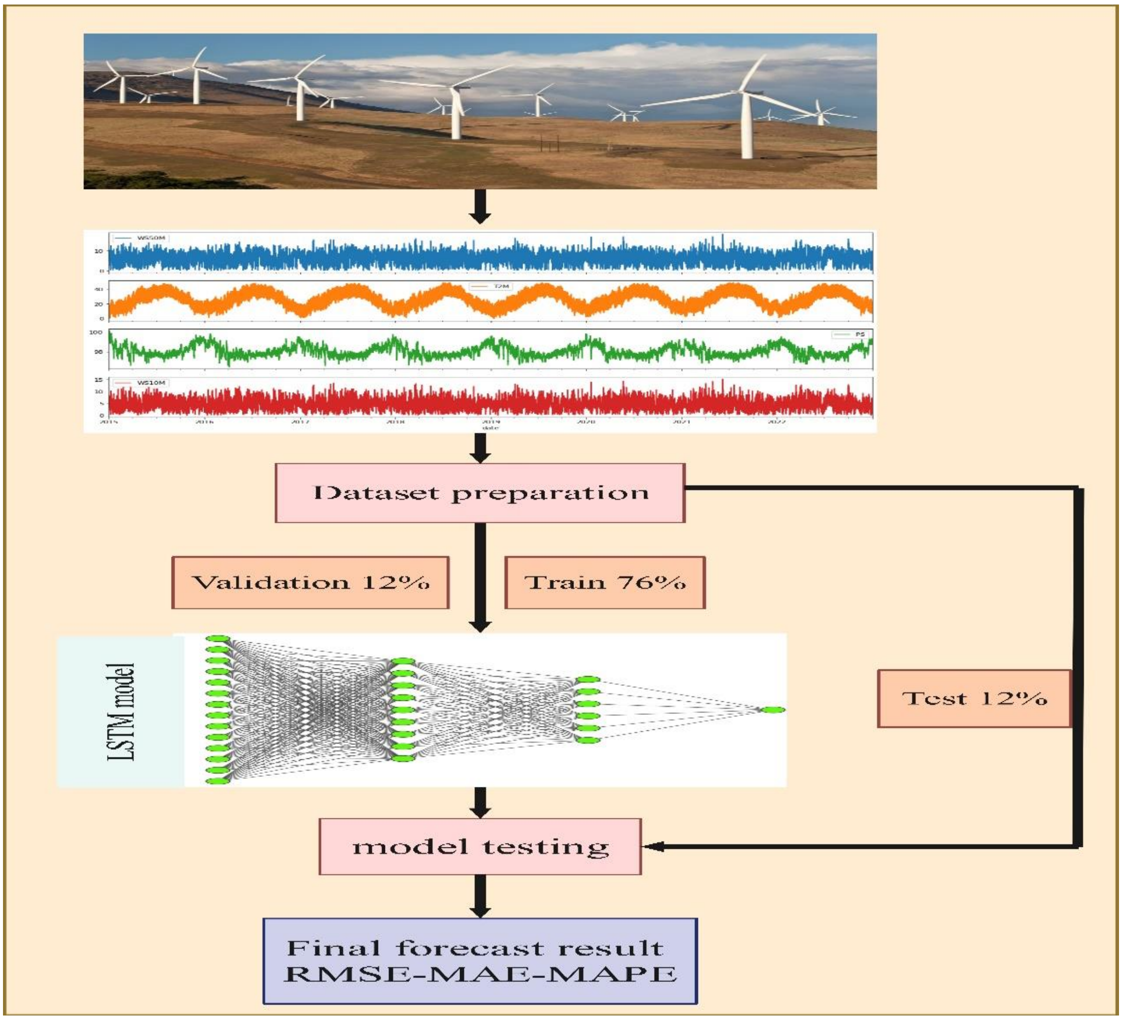

Fig. 1. Model setup

Model Architecture, the model is configured to utilize 10 hours as the number of steps and four input features, which are wind speed at 50 m, air pressure, temperature, and wind speed at 10 m.

LSTM Model Training, To obtain wind speed forecast results, the suggested model LSTM is trained with the following parameters: a learning rate of 0.001, a batch size of 250, and 250 epochs. LSTM has shown in figure 3 a good model fitting between train and validation, which is a good sign for forecasting wind speed.

Results Analysis, Once the model is trained, it is evaluated on the testing dataset to determine its accuracy. The results are then analyzed to determine the effectiveness of the model in forecasting wind speed.

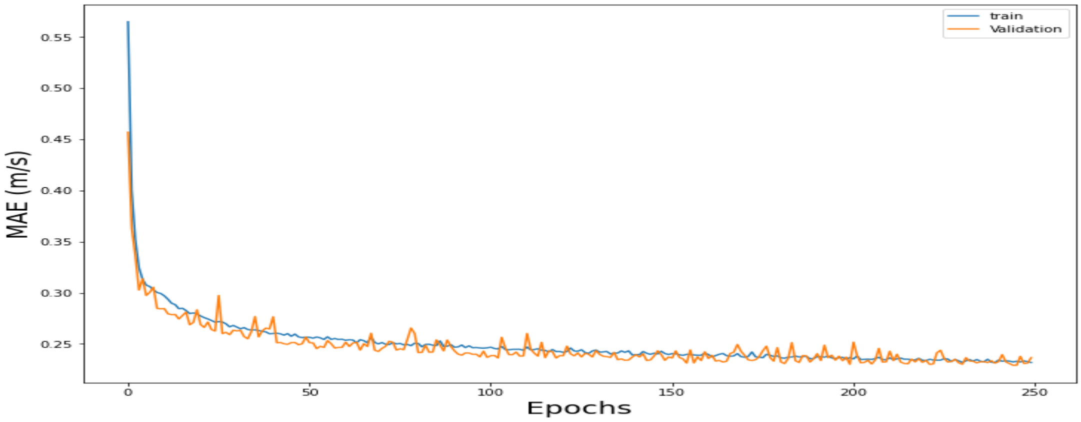

Fig. 3. model fitting train and validation loss minimization for the LSTM network

4. Results and Discussion

To evaluate the accuracy of the proposed LSTM model for wind speed forecasting, we calculated three metrics Root Mean Squared Error, Mean Absolute Error and Mean Absolute Percentage Error. We used these metrics to assess the performance of the model for forecasting wind speeds at three different time scales: 1 hour ahead, 3 hours ahead, and 6 hours ahead as showing in table 2.

p

Table 2. Evaluation results for the LSTM model at different time scale.

Evaluation index	1 hour ahead	3 hours ahead	6 hours ahead
MAE	0.248	0.637	0.929
RMSE	0.498	0.798	0.964
MAPE	5.12%	13.65%	21.56%

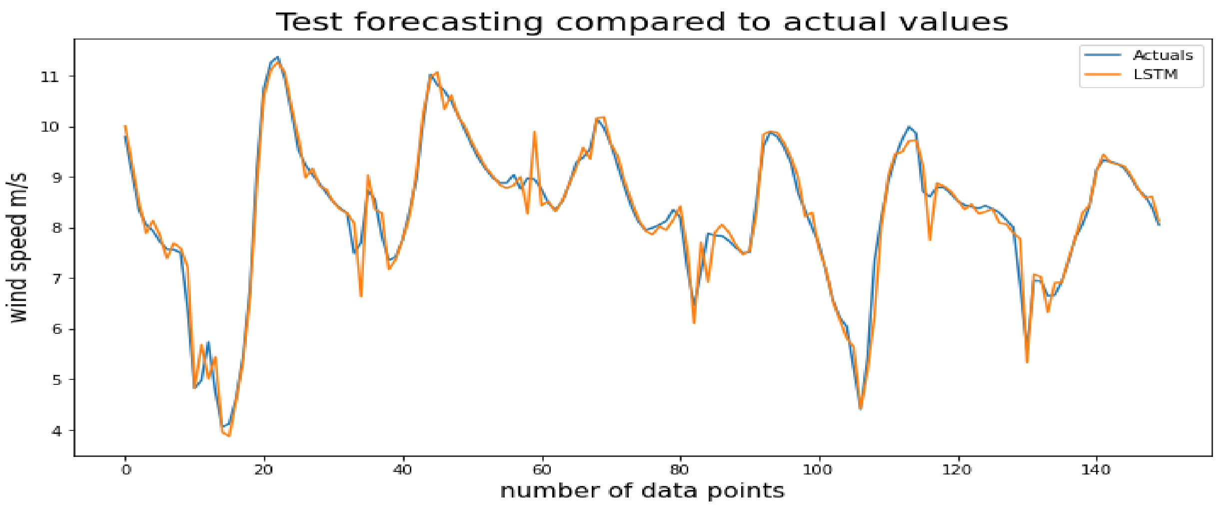

Fig. 4. Forecasting results of LSTM for 1 hour ahead

The results of our study show that the proposed LSTM model is acceptable for wind speed forecasting at different time scales over the Adrar site. The evaluation metrics indicate that the model performs reasonably well, with MAE values of 0.248, 0.637, and 0.929 for 1 hour, 3 hours, and 6 hours ahead forecasts respectively.

The RMSE values of 0.498, 0.798, and 0.964 indicate that the model's forecasts are slightly less accurate than the MAE values, but still within reasonable limits. The MAPE values of 5.12%, 13.65%, and 21.56% show that the model's forecasts have a reasonable level of accuracy, but there is some room for improvement, particularly for longer forecasting horizons.

Overall, these results suggest that the proposed LSTM model can be a useful tool for wind speed forecasting at the Adrar site, particularly for shorter forecasting horizons. However, future studies should focus on improving the accuracy of the model for longer forecasting horizons, which may

require the use of more advanced modelling techniques or the inclusion of additional meteorological variables in the modelling process. In addition, it would be useful to compare the performance of the proposed LSTM model with other state-of-the-art forecasting methods to determine its relative performance and identify potential areas for improvement.

5. Conclusion

This study proposes an LSTM model for forecasting wind speed at the Adrar site. The model was trained and evaluated using meteorological data collected over a seven-year period, and its forecasting performance was evaluated using three metrics: RMSE, MAE, and MAPE. The results of this analysis demonstrated that the proposed LSTM model is acceptable for forecasting wind speed at various time scales, with reasonable levels of accuracy for all three evaluation metrics. While there is still opportunity for enhancement, especially for extended forecasting horizons, the results indicate that the model may be a valuable tool for wind speed forecasting in the Adrar region. Future research should continue to investigate the viability of advanced machine learning techniques for wind speed forecasting and their applicability in other geographic regions.

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Large-Step GRU-DQN: A deep Reinforcement Learning Approach for Dynamic Vehicle Control in Intersections

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Abstract

This research introduces the "Large-Step GRU-DQN," an innovative extension of the Deep Q Network (DQN) algorithm for lateral control of autonomous cars in challenging intersection environments. The LS-GRU-DQN is an off-policy strategy that improves the precision of RL policies while decreasing learning time. It accurately tackles dynamic obstacles by interacting with the environment and recording temporal relationships using a single-layer Gated Recurrent Unit (GRU). The gym toolkit was used for training and evaluating the algorithm on a simulation environment. The experimental findings show that the LS-GRU-DQN outperforms other DQN algorithm variations in terms of accuracy, making it a potential technique for navigating intersection situations.

Keywords: *Reinforcement Learning, Q Learning, Deep Learning, Autonomous Driving.*

Introduction

Vehicle control system is one of the basic systems of autonomous vehicles adding to the perception system and execution system (Bagloee 2016), where perception components are tasked with detecting, tracking and providing location of objects in the autonomous vehicle and its surroundings, based on these information the control system decides the best route to take and the appropriate actions including accelerating, braking, turning…etc can lead to accomplish this root, then the execution system is responsible of running the decisions taken by the control system.

Hand-crafted supervised learning was adopted by researchers to handle systems control in which predefined knowledge was necessary for agents to function well, but this approach is limited by the complexity of tasks (Bacha 2008, Kendall 2019). An alternative approach was used being the RL algorithms (Matthew 2019,Rais 2020) in which autonomous agents learn the desired behavior through continuous interactions with environments. Two modes of learning exist for the RL approach being model free and model based learning (Nicole,2006).

In the model based learning mode a prior learned model is exploited by the autono-mous vehicle agent to reach the desired goal, at the opposite of model free learning approach in which trial-error method is used to upgrade performance in time.

Q learning is the most popular approach in reinforcement learning where actions are linked to values that estimate the preciseness of each action. Due to complex driving environments, agents need to adapt to many states and many actions possibilities to take, therefore, Deep Learning(Zouaidia 2021, Rais 2022) was adopted to handle the representation of multiple combinations of environments states and actions. Approximating the Q values using neural networks gave prominent results and was the focus of researchers to solve decision making problems.

The first successful deep reinforcement learning model was proposed by Mnih V et al in (Mnih 2013) where high-dimensional input were used to learn control policies and estimate future rewards. In (Abhik 2019), Abhik Singla et al proposed a memory-based deep reinforcement learning algorithm to handle navigation of UAVs while avoiding obstacles, results showed that obstacle avoidance goal was achieved while having high inference rate than other prior works and the power wastage was reduced for UAVs. In (Chu 2015), Chu et al achieved an intelligent and autonomous navigation for robots while avoiding collision with dynamic and static obstacles using a reinforcement learning algo-rithm. In (Xia 2014), Xia et al tackled the issue of obstacle avoidance for industrial robots and were able to handle the navigation in an effective way using Q learning approach. Zheng et al in (Zheng, 2013) used the least-squares policy iteration approach as the base of a decision making method to handle controlling autonomous vehicle in simple traffic scenarios. Carl-Johan Hoel et al applied in (Hoel 2018) the Deep Q network method to reach tactical decisions for autonomous vehicle in highway scenarios. Huang et al (Huang 2018) proposed an approach for static and dynamic obstacles avoidance to let a robot navigate from a starting point to a desired location without colliding with its environment, they adapted the learning policy of Q learning algorithm to achieve better results in shorter period of time. The main contributions of this paper are:

- Developing a model capable of handling decision making in an intersection scenario that represent a difficult task (the autonomous agent needs to interact with multiple vehicles headed in different directions).

- Proposing a novel adapted extension of the popular Q learning algorithm with an upgraded actions selection policy that improves balance in exploration, and provides preciseness in selecting actions in various states.

- Reducing the time consumed during learning using the GRU network without decreasing the performance.

Simulation

For simulation purpose we adopted a gym toolkit intersection simulator developed for testing and upgrading reinforcement learning algorithm. In figure 1 below an example of the environment used is illustrated.

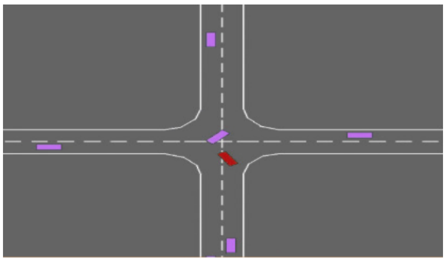

Fig1. Example of Intersection scenario treated

Using data provided by the simulator, the deep reinforcement learning agent updates its policy of selecting actions at each situation to avoid colliding with other vehicles in the road and to navigate successfully the intersection. To create more realistic scenarios, 15 cars were added to the road with random velocities to allow the agent to learn how to adapt to various situations while travelling intersections. Information provided by the simulator comprise the position and the velocity of each car in the map including the self-driving car. these information are received through the kinematics observation that represents a table where each line is related to a single vehicle. Actions available to the autonomous agent through the reinforcement learning algorithm are related to lateral control where longitude control was left to the agent itself. A discrete actions space was used that includes five actions available to agents: accelerate, decelerate, turn left, turn right, and stay in line.

Rewards giving to reinforcement learning agents are related to velocity and collision avoidance with other vehicles and are calculated through the formula below:

$$R(s,a) = a * \frac{(V - Vmin)}{(Vmax - Vmin)} - b * collision$$

Episodes of training can take endless period if the process of learning for the autonomous agent is focused on avoiding collisions, therefore, we defined a max duration of each episode equal to 12 seconds to have an efficient learning attitude.

Methodology

Before we explain the novel extension a brief introduction on Deep Q Network method that was the base of our proposed method is presented: Based on the popular reinforcement learning algorithm "Q Network" in which agents tend to maximize a reward notion related to action, state pairs in order to learn a policy that let them behave more efficiently, at each action selected in a specific state a Q value is given and saved in a table and will be updated in next runs. However, vehicle control in more complicated situations make it hard to save all actions in all states in a single table that is why neural network approach was adopted. In DQN, we output each action-state value of each action through a deep neural network while adding a weight parameter that will be updated at each state, to help in reducing error between real and estimated action value. Instead of a predefined table an experience replay memory is used to fit the model and reach the optimal policy.

Large-Step GRU DQN

In this novel extension we updated the actions selection policy of DQN algorithm and proposed a novel policy to add more balance to the exploration of the possible decisions at each state. We took advantage of the GRU network that can handle multiple constraints with continuous data and offer a less complicated structure to reduce Q values estimation time. The GRU structure is similar to the usual Recurrent Neural Networks (RNN) while the main difference is the operation and gates related to the GRU units. Each unit contains two gates named: update gate and reset gate for the purpose of solving the gradient descent problem that RNN faces. Through a hidden state the update gate determines the amount of information transferred to the next state and information that will be deleted, while the reset gate is used to specify the pervious information that will be ignored.

The general equations and structure of GRU cell used in our model are shown in equations below:

$$z_t = \sigma_g(W_z x_t + U_z h_{t-1} + b_z)$$
$$r_t = \sigma_g(W_r x_t + U_r h_{t-1} + b_r)$$
$$\hat{h}_t = \varphi_h(W_h x_t + U_h(r_t \odot h_{t-1}) + b_h)$$
$$h_t = (1 - z_t) \odot h_{t-1} + z_t \odot \hat{h}_t$$

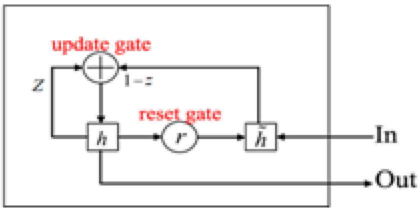

Fig2. GRU Cell Structure.

The instructions for the action policy are as follow:

-A random number between 0 and 1 is set, and test if it is less than epsilon (control value) then a random action is selected else the next instructions are used in the action selection.
-A model prediction is run of the current state to get the q value of each action that can be executed.

- From the list of q values the index of the biggest q value and the second biggest q value are determined. Using these values the best action and the second best action for the current state are selected.
-If the difference between both q values is larger than a predefined value that depends on the rewards of the environment, we select the first action to be executed, or else we return the second option to allow more possibilities in upcoming states.

Below is the pseudo code of the action selection policy of Large-Step GRU DQN:

```
Algorithm 1: Action Selection Policy (Parameter1: Current State)

Calculation of random number np.
If np < epsilon Then
        Return a random action
Else
        Save "Model.Predict" in a list of q values
         Declare two variables: bestQ, SecondBestQ
        Initialize the two variables from the list of Q values
         Calculate difference of bestQ and SecondBestQ.
         if (difference > 0.2):
              return the action corresponding to bestQ.
         Else
        |     return the action corresponding to SecondBestQ.
```

In the pseudo code below details about the process of learning for the proposed algorithm are explained.

```
Algorithm 2: Process of Learning
Repeat in each episode:
     Initialization of replay memory.
    Get initial data from simulator.
    While Not Done:
        Select an action using the novel selection policy.
        Apply the action.
        Observe reward r and the new state of the simulator.
        Save data in the replay memory.
         Train neural network model using batches of replay memory.
```

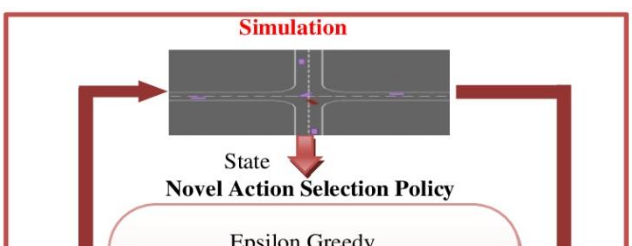

Fig3. Learning Framework of Large-Step GRU-DQN.

Results and Discussion

To prove the efficiency of the proposed extension we compared it to multiple variations of DQN algorithm being: the base deep Q network, Double Deep Q Network, and Dueling Deep Q Network, using several metrics being: accuracy of the model, rewards achieved in the period of training, and time consumed in each episode. Each algorithm was trained for a total of 200 episodes to provide enough time to reach max performance.

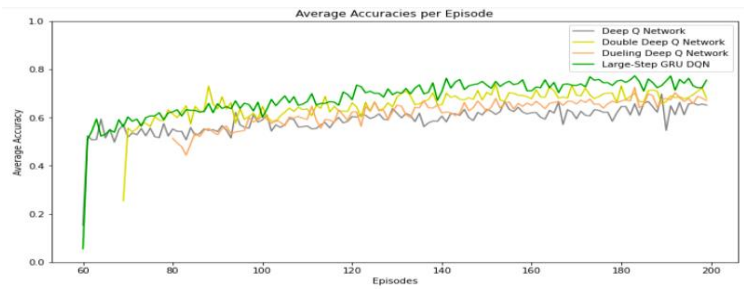

Fig4. Accuracy Values Comparison during Training.

Episodes / **Algorithms**	100 - 150	150 - 200
DQN	0.59128	0.62852
Double DQN	0.651708	0.69307798

Dueling DQN	0.6165422	0.6639039
LS-GRU DQN	**0.695904**	**0.73989**

Table1. Average Accuracy Reached Results

From figure 4 and table 1, we can see that the proposed extension provided the agent with more accuracy in selecting actions in all episodes of training where it could surpass 70% accuracy in the last 50 episodes of training and achieved an average of 0.73989. The DQN accuracy remained close to 60%, while both double DQN and dueling DQN gave better performance but not comparable to the proposed algorithm.

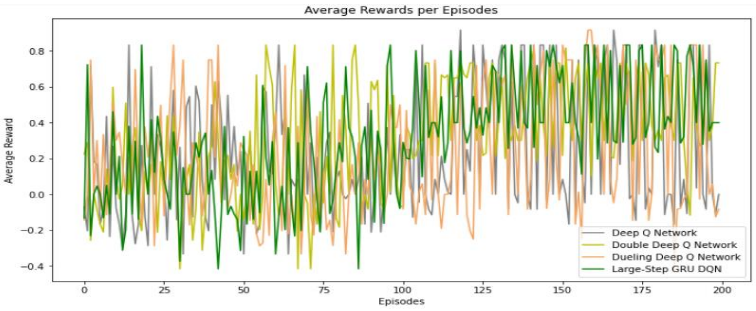

Fig5. Average Rewards Values Comparison during Training

Episodes Algorithms	0 - 50	50 - 100	100 - 150	150 - 200
DQN	0.14118	0.11796	0.3385	0.3277
Double DQN	0.08163	**0.22298**	0.47222	0.48047
Dueling DQN	**0.22834**	0.0694	0.26469	0.39102
LS-GRU-DQN	0.07494	0.16469	**0.50044**	**0.52903**

Table2. Average Rewards Reached Results

Figure 5 and table 2, confirm the effectiveness of the new actions selection policy, where we can notice that after episode 100 the new algorithm outperformed all benchmark algorithms in most episodes and achieved 0.8 as average rewards per episode, while maintaining average 5results over 0.5 through all the training process. We can notice also the stability of the values range at the opposite of the rest of the benchmark algorithms. Double DQN gave the closest performance achieving 0.47222 and 0.48047 in episodes 100-150 and 150-200 respectively.

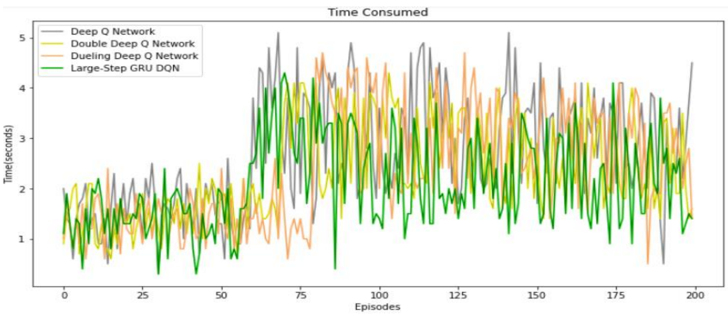

Fig6. Time Consumed during Training Comparison

Episodes Algorithms	0 - 50	50- 100	100 - 150	150-200
DQN	1.554	2.89	3.169	2.961
Double DQN	1.442	2.5479	2.872	2.496
Dueling DQN	**1.343**	**2.346**	2.932	2.804
LS-GRU-DQN	1.376	2.62	**2.208**	**2.146**

Table3. Average Time Consumed Results

In nearly all episodes of training and while using the novel LS-GRU-DQN algorithm we were able to reduce the time necessary for training compared to all the benchmark algorithms, while still outperforming them in all the aspects used for the comparison purpose, we can see from figure 6 and table 3 that before episode 100 all algorithms gave close performance, while after it we can notice the effectiveness of the changes in the structure of our proposed model that permitted to the agent to reach the desired goal faster and smoother than other benchmark algorithms.

Episodes Algorithms	0 - 50	50 - 100	100 - 150	150 - 200
DQN	8.24	7.96	8.52	8.69
Double DQN	**8.75**	8.98	9.82	9.92
Dueling DQN	8.62	8.42	9.9	9.76
LS-GRU DQN	8.65	**9.25**	**10.12**	**10.66**

Table4. Average Max Duration Reached Results

Knowing that max duration of one episode over training for the intersection environment is 12 steps, results of comparison according to this metric are shown in table 4.

At the start of training we can see that all algorithms gave close performance because they are still exploring different states using same policy. After episode 50 we notice a positive update for the proposed algorithm results where other models maintained close results to previous episodes. From 100 to 150 episodes all algorithms showed improvements while the proposed model gave the best results reaching above 10 steps in average. At the last phase of training, we were able to get close from 11 steps in average where the best benchmark models remained under 10 steps in average.

In table 5 below more detailed results related to previous plots were gathered.

Algorithms	Deep Q Network	Double DQN	Dueling DQN	LS-GRU-DQN
Best Accuracy	0.6972916	0.73859374	0.7246875	**0.77291666**
Total Reward	46.272303	62.8659200728	47.67509402	**63.4558258915**
Time Consumed	528.8	466.9	471.2999999	**418.399999999**

Table5. Results of various metrics comparison

From table 5, we can confirm that LS-GRU-DQN outperformed DQN, Double DQN and Dueling DQN in all of the adopted metrics, achieving 0.77291666, 63.4558258915, and 418.399999999 as best accuracy, total reward during training, and total time consumed respectively. The proposed algorithm provided acceptable action selection behavior while reducing dramatically the time consumed for training.

Conclusion

In this paper, a novel extension of the popular deep reinforcement learning algorithm DQN was proposed named Large-Step GRU DQN for dynamic obstacle avoidance and vehicle control in intersections. In this new extension we focused on updating the action policy to enhance decision making concept. The proposed algorithm was trained in a simulator and compared to several varia-tions of DQN algorithm being: the deep Q network, Double Deep Q Network, and Dueling Deep Q Network, using several metrics (accuracy of the model, rewards achieved in the period of training, and time consumed in each episode). Results of comparison proved the efficiency and superiority of the proposed model and the good capacity of handling control in intersections for autonomous vehicles. In further works we will focus on handling multiple situations while upgrading stability of the algorithm, add more balance between exploration and exploitation and provide more accuracy.

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Multimodal 3D MRI Segmentation using dResU-Net for the detection of Brain Tumor

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Abstract

Segmenting brain tumors from 3D images stands as a critical and challenging endeavor in medical image processing. Manual human-assisted classification is prone to errors, especially with copious data. The diversity of brain tumor appearances and their resemblance to normal tissues complicates MRI-based tumor region extraction. To address this, we propose a modified U-Net architecture, "dResU-Net," that integrates residual networks with periodic shuffling in the encoder and sub-pixel convolution in the decoder. Our method focuses on detecting and segmenting brain tumors in multimodal 3D MRI images. The evaluation employs genuine images from the BRATS 2020 dataset, resulting in an impressive test accuracy of 99.41%. Comparative analysis with other approaches reveals that our U-Net-based model outperforms alternative deep learning-based methods. This innovation contributes to improved brain tumor detection and segmentation in complex medical image scenarios.

Keywords: *Brain tumor segmentation, U-Net, BraTS 2020, Multimodal MRI, Deep Learning*

Introduction

Brain tumors result from an accumulation of abnormal cells within the human brain, capable of harming the nervous system and adjacent healthy brain tissue. These tumors can significantly disrupt overall brain function and are recognized as one of the most perilous human afflictions. They are categorized as primary or secondary, with gliomas constituting a prevalent primary type. Gliomas are further subdivided into low-grade (Grade I and II) and high-grade (Grade III and IV) cases based on their growth speed and aggressiveness. Detecting gliomas poses a challenge for radiologists due to their diverse sizes and locations. Accurate treatment hinges on precise tumor identification, which necessitates tumor segmentation based on its location, type, and grade. For diagnosing brain tumors, MRI is the foremost modality. T1-weighted (T1w), T1-weighted contrast-enhanced (T1ce), Fluid-Attenuated Inversion Recovery (FLAIR), and T2-weighted (T2w) images are the primary modalities used. Each offers distinct insights, with T1w measuring healthy tissue, T2w highlighting tumor regions, and T1ce outlining tumor borders. The FLAIR scan aids in distinguishing edema from cerebrospinal fluid (CSF).(Bauer, Wiest, Nolte, & Reyes, 2013). Precise and prompt segmentation of brain tumors through these imaging techniques can provide medical practitioners with a safe framework for tumor treatment, particularly during surgeries, to preserve unaffected brain regions. The implementation of automated brain tumor segmentation (BTS) from MRI scans can accelerate the diagnostic process and ensure uniform outcomes. Nonetheless, automating the segmentation of brain tumors and their sub-regions presents a formidable undertaking due to the potential occurrence of tumorous cells across diverse locations within brain tissue, characterized by fluctuations in size, visual attributes, and contours (Baid et al., 2020).

Recent years have seen the emergence of solutions for automatic brain tumor segmentation (BTS) from MRI images. Semantic segmentation classifies each pixel into respective labels or masks, which means it assigns a particular class to all pixels in an image. Deep learning approaches have recently become the norm for various medical image processing applications. Deep learning models like U-Net, designed for biomedical image segmentation, autonomously capture local and global information, enhancing accuracy. Ranneberger et al. introduced U-Net as a prominent and effective choice for addressing the complexities of BTS

(Ronneberger, Fischer, & Brox, 2015). Training 3D models faces challenges due to extensive network parameters and memory constraints. A multi-path CNN was proposed for brain tumor region segmentation using 2D sliced MRI inputs. Additionally, they adopted dual training phases to address disparate input data classifications effectively (Havaei et al., 2017). Additionally, a segmentation methodology is presented, which combines CNN and FCN in a cascaded manner for detecting brain tumors (Meng, Fan, Zhao, & Su, 2018). 2D convolutions inadequately harness the spatial content within medical images, while 3D convolutions demand extensive memory and computational resources. To tackle this challenge, a separable 3D U-Net model utilizes distinct 3D convolutions to mitigate memory demands (Chen, Liu, Peng, Sun, & Qiao, 2019). Each 3D convolution was replaced with two consecutive layers: a 2D convolution layer for spatial feature learning and a 1D convolution layer for temporal feature acquisition. This model exploited the complete 3D brain volume through subdivided 3D convolutions across three branches. The authors introduced separable temporal convolution within the residual inception model, training their proposal individually for axial, sagittal, and coronal views. A multi-view fusion technique amalgamated the convolutional outputs for enhanced performance, resulting in notable efficiency on the BraTS 2018 test dataset.

In segmentation tasks, local and global features are pivotal for decision-making, yet as depth increases, gradients of low-level features (containing boundary, edge, line, or dot information) tend to vanish. Wang et al. proposed a TransBTS architecture that effectively integrated transformers into a 3D deep CNN model with an encode-decoder framework (Wang et al., 2021). The initial 3D CNN extracted local and spatial information, subsequently fed into a transformer for global feature capture. During the up-sampling process, the decoder combined these local and global features, yielding segmentation results. Experiments on the BraTS 2019 and 2020 datasets demonstrated comparable outcomes, albeit with a relatively higher demand for computational resources and memory in their approach.

Various studies in the literature have also demonstrated a significant enhancement in segmentation outcomes by altering the architecture of the U-Net model instead of using the original design. To address these challenges identified in previous research, the proposed approach in this study employs a combination of a residual network and a 3D U-Net model. This approach preserves low-level features and conveys them to the corresponding decoder level through adaptive skip connections, resulting in a smoother and faster training process. Furthermore, the proposed framework capitalizes on the advantages of the 3D volume and utilizes complete contextual information from multimodal MRI by employing 3D convolution. The constructed deep learning architecture has been employed to train the model using the BRATS 2020 dataset for predictive purposes. The proposed model successfully predicted four distinct brain tumor types, and these predictions were validated against the ground truth data. This trained model now provides the capability to classify and detect the presence of brain tumors effectively.

The organization of this study is as follows: Section 2 outlines the materials and techniques employed. In Section 3, we present the experimental setup, results, along with a concise juxtaposition against prior research. Finally, Section 4 offers a conclusion of the findings, and their relevance.

Materials and Methods

This section provides comprehensive information regarding the dataset, preprocessing procedures, and the implementation specifics of the proposed approach. Additionally, it delves into the details of the deep U-Net architecture introduced in this study. An overview of the proposed methodology's sequential steps is visually presented in Figure 1.

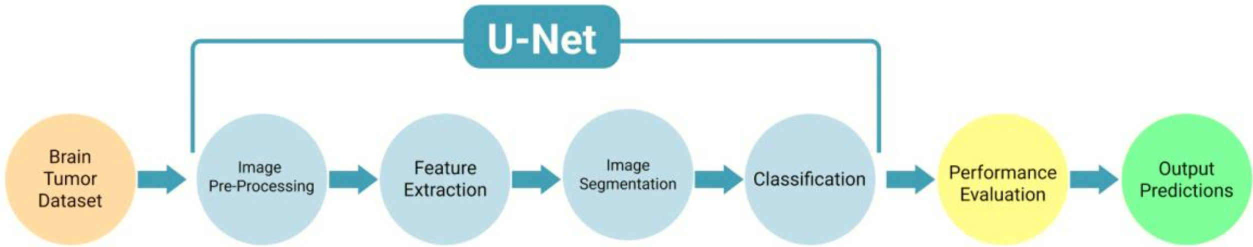


Fig. 11. Schematic representation of the suggested methodology

Dataset

The proposed U-Net model is both trained and assessed using the publicly accessible benchmark dataset from the BraTS 2020 challenge*. This dataset originates from the "Medical Image Computing and Computer-Assisted Intervention (MICCAI) Multimodal Brain Tumor Segmentation Challenge (BraTS) 2020" and was compiled by medical experts associated with the "University of Pennsylvania and UPenn's Center for Biomedical Image Computing and Analysis (CBICA)". Comprising 3D MRI brain scans from 369 glioma patients, the dataset comprises 76 patients with low-grade gliomas (LGG) and the remaining images pertain to high-grade glioma (HGG) patients. Each image possesses dimensions of 240 × 240, and within each 3D scan, there are a total of 155 slices. Each patient's MRI data consists of four distinct modalities: T2, T1ce, T1, and FLAIR. To visually illustrate, Figure 2 showcases sample subjects from the BraTS 2020 dataset, encompassing all four modalities alongside the ground truth.

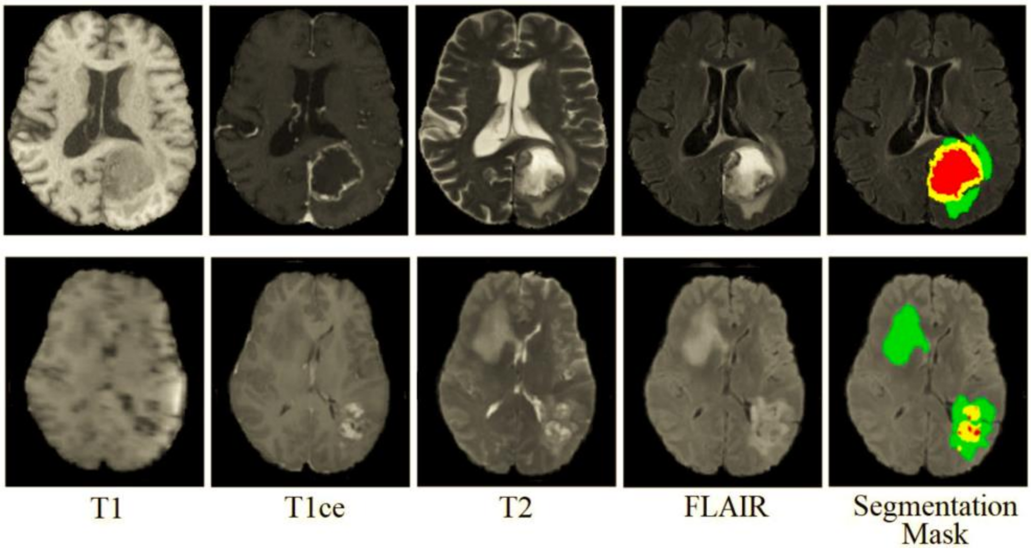


Fig. 12. MRI images and their ground truth with all four modalities.

Pre-Processing

The dataset (BraTS 2020) has undergone various preprocessing stages by the competition organizers before its public release. These measures encompass co-registration, skull-stripping, alignment into a common space, and the achievement of isotropic resolution. Notably, MRI images might contain variations in intensity due to differing magnetic field characteristics across scanners. Hence, preprocessing is essential to enhance segmentation outcomes during model training. Standardization and normalization were applied to all MR images by subtracting the mean value from each voxel and dividing by their standard deviation.

* https://www.med.upenn.edu/cbica/brats2020/

This procedure ensures a zero mean and unit variance within each brain image, commonly referred to as Z-score normalization(Chen et al., 2019).

Implementation process

The implementation process involved several steps. Once the BRATS dataset was collected, the images underwent preprocessing, followed by segmentation into distinct classes such as no tumor, edema, necrotic/core, and enhancing tumor. During the training phase, features were extracted pertaining to the tumor and subsequently classified. The model then made predictions based on these outcomes, which were stored for future evaluation and comparative analysis. The Process flow diagram depicted in Figure 3 visually illustrates the complete journey of implementing the paper, spanning from the initial stages to the final results.

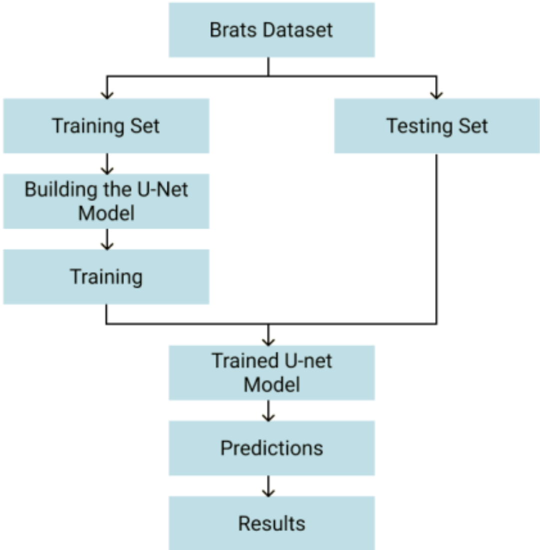


Fig. 13. Implementation process

U-Net Architecture

The U-Net architecture is widely acclaimed for biomedical semantic image segmentation, excelling in local and global feature extraction across various scales. Its effectiveness arises from transferring feature maps between encoder and decoder levels through skip connections, enabling the classifier to consider both low-level (boundary and edge information) and high-level (object and shape details) features when creating segmentation masks. Despite U-Net's success, certain complexities in training persist. Low-level features play a vital role in accurate segmentation by capturing boundary, edge, and tumor region location details. However, as the network deepens, richer features dominate over low-level ones during down-sampling, causing loss of local and location specifics due to convolution and non-linearity operations.

To retain low-level features, the proposed model incorporates residual blocks within the encoder section of the U-Net architecture. The dResU-Net structure mirrors that of a 3D U-Net pattern, featuring both contracting (encoder) and expanding (decoder) segments interconnected via skip connections. The contracting path is divided into five levels, indicating the network's depth. Within the encoder part of the proposed model, the first four levels include residual blocks (depicted in yellow) for effective feature extraction. The input to the encoder path is a 128 × 128 × 128 volume containing a stack of four modalities (T1, T2, T1ce, Flair). Each level comprises a residual block followed by a 3D max pool with a pool size of (2, 2, 2), stride of (2, 2, 2), and dropout. A residual block consists of three components with identity mapping. Components 1 and 2 employ batch normalization and ReLU activation after the conv3D layers. Component 3 is analogous but omits the ReLU activation. This architecture is preented in Figure 4. (Raza, Ijaz Bajwa, Mehmood, Waqas Anwar, & Hassan Jamal, 2023). To enhance the performance of this architecture, we introduced an additional level comprising both residual and convolutional blocks, each containing 512 neurons. This addition is aimed at further refining the model's ability to extract intricate features and patterns from the input data. Residual blocks facilitate the preservation of important low-level details, while convolutional blocks contribute to higher-level feature extraction through their specialized filtering operations. By incorporating these components at this particular level, we strive to bolster the model's capacity to capture and process complex information, ultimately leading to improved overall performance.

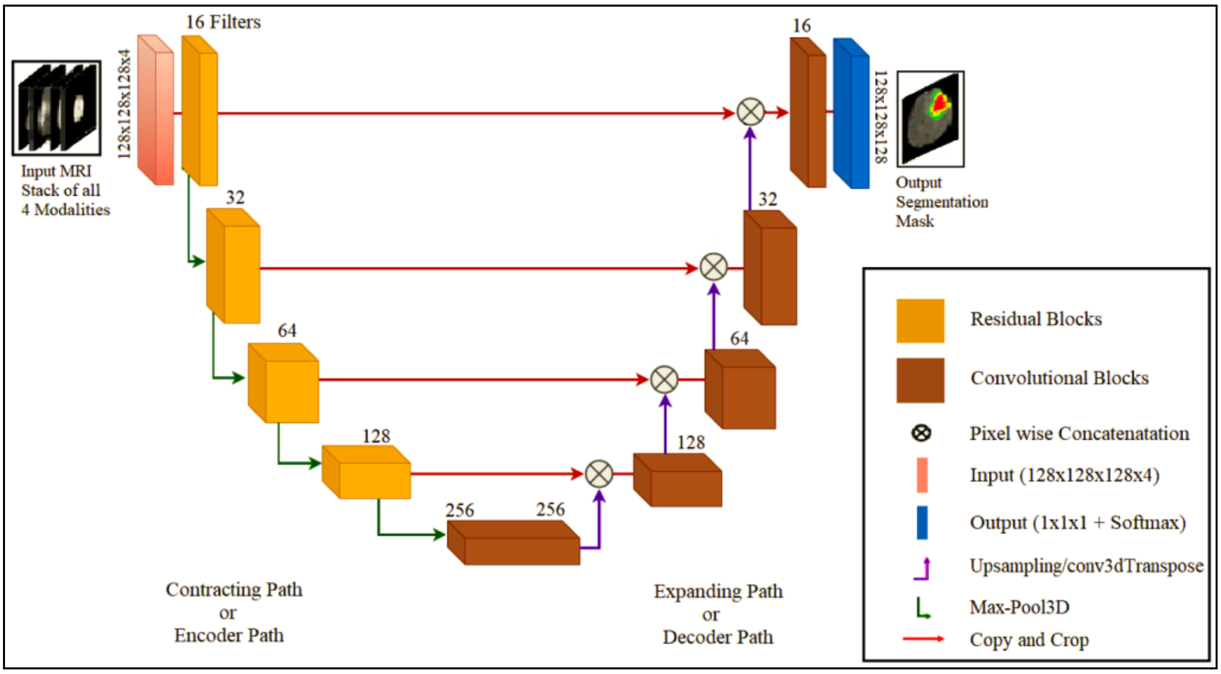


Fig. 14. Architecture of 3D dResU-Net *(Raza et al., 2023)*

The effectiveness and proficiency of a deep learning model are influenced not solely by its architecture, but also by the choice of the loss function. In our case, we opted for the Multiclass Soft Dice loss(Lin, Goyal, Girshick, He, & Dollár, 2020). This particular loss function plays a crucial role in guiding the training process by quantifying the dissimilarity between predicted and actual segmentation outcomes. By employing the Multiclass Soft Dice loss, our objective is to optimize the model's parameters to achieve accurate segmentation results across multiple classes, thereby contributing to enhanced performance and robustness.

Implementation detail

The Python programming language was harnessed to implement the dResU-Net model, which was seamlessly integrated with the Keras library, powered by TensorFlow as its backend framework. Leveraging the computational prowess of a GPU and the memory resources furnished by Google Colab, the model's training process unfolded. Employing the ReLU activation function in conjunction with batch normalization imparted stability and normalization benefits across the network's layers.

Results and Discussion

Evaluation measure

The evaluation of the model encompassed a multifaceted analysis, employing a range of distinct metrics to gauge its performance comprehensively. These metrics played a pivotal role in assessing various aspects of the model's predictions and generalization capabilities.

Accuracy: This metric quantified the proportion of correctly predicted instances out of the total instances. It offered an overall understanding of the model's correctness in its predictions.

Loss: The loss function represented the quantification of the disparity between predicted and actual values. A lower loss indicated a better alignment between predictions and ground truth.

Dice Coefficient: The Dice coefficient gauged the similarity between predicted and actual segments by considering their overlap. It was particularly relevant in segmentation tasks, providing insight into the model's ability to accurately segment objects.

Mean Intersection over Union (IOU): IOU measured the extent of overlap between predicted and true segments. A higher IOU score indicated improved segmentation accuracy and alignment.

Precision: Precision characterized the model's capability to correctly identify positive instances among all instances that it labeled as positive. It offered insights into the model's ability to avoid false positives.

Sensitivity (Recall): Sensitivity depicted the model's aptitude to correctly identify positive instances among all actual positive instances. It assessed the model's ability to avoid false negatives.

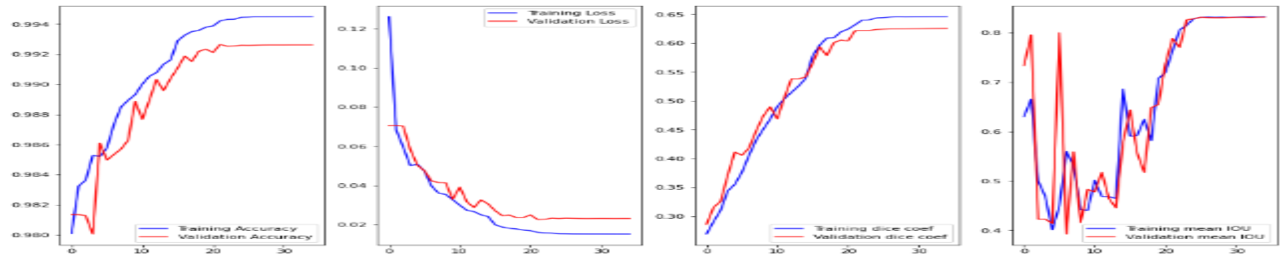
Specificity: Specificity evaluated the model's proficiency in correctly identifying negative instances among all actual negative instances. It provided an indication of the model's ability to avoid false positives in the negative class.

By utilizing this diverse array of metrics, the evaluation process acquired a multi-dimensional perspective, enabling a thorough analysis of the model's strengths and potential areas for improvement across various performance dimensions.

Training

Over a span of 45 epochs, the model underwent rigorous training, with a batch size of 100 chosen to accommodate the substantial volume of executions. In the realm of experimentation, the BraTS 2020 benchmark dataset played a pivotal role, with 80% of its data allocated for model training, 10% for rigorous testing, and another 10% for meticulous validation. Multiple iterations of experimentation were embarked upon, systematically probing the proposed method to unearth the most optimal amalgamation of hyperparameters. This iterative process aimed to fine-tune the model's performance and refine its predictive capabilities.

Throughout the model training phase, a comprehensive collection of metrics was diligently retained for every epoch. Subsequently, the preserved model was retrieved and employed to generate graphical representations of the training and validation metrics. In Figure 5, the presented graphs vividly portray the training metrics, where the blue line denotes the training metric's trajectory and the red line traces the evolution of the validation metric. The y-axis is representative of the epoch count, while the x-axis quantifies the metric score, thus offering a visual depiction of the training and validation progress.



(a) (b) (c) (d)

Fig. 15. Graph describing (a) the accuracy, (b) loss, (c) the Dice Coefficient, and (d) Mean IOU for each epoch

Predictions

The model was trained to predict brain tumor presence and classify types. Visualizations showcased original MRI, ground truth, and predicted classes. Random images validated accurate predictions in Figure 6 , confirming alignment with ground truth. These visual results underscore the model's proficiency in tumor identification and classification, vital for clinical applications.

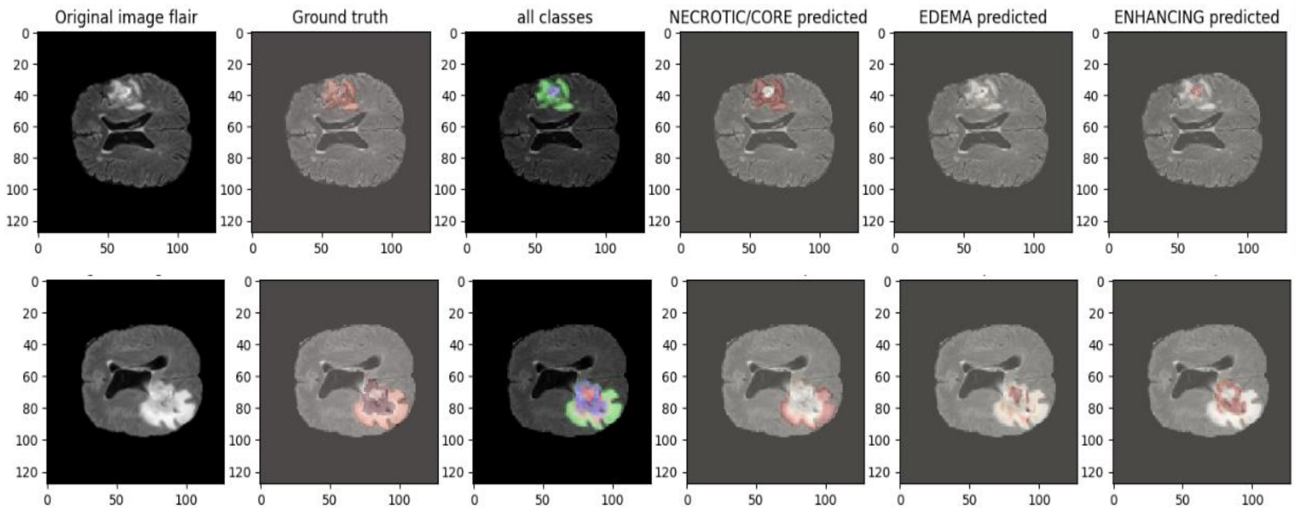


Fig. 16. The Model qualitative study. Three different colours are used to depict three different sub regions of tumours: Necrosis/core, edoema and an enhancing tumour.

To vividly illustrate the advancement facilitated by the proposed U-Net Architecture in comparison to various established techniques for brain tumor detection, a methodical comparative investigation was undertaken. This involved employing the same dataset to compute performance metrics for alternative algorithms. The ensuing results are

systematically presented in Table 1, furnishing a comprehensive and organized depiction of the contrasting performance levels among the different approaches. This comparative analysis not only quantifies the superior capabilities of the U-Net Architecture but also provides valuable insights into its efficacy and potential to outperform existing methodologies in the domain of brain tumor detection.

Table 1. Comparative analysis

Model	Data	Ref	Acc.	Loss	Dice	Mean IOU	Prec.	Sensit.	Spec.
VGG16	BraTS 2020	(Toğaçar, Cömert, & Ergen, 2020)	98.69	04.33	34.56	68.17	99.22	98.17	99.73
ResNet50	BraTS 2020	(Lei et al., 2021)	97.18	09.85	34.02	37.56	98.14	96.78	99.39
U-Net	BraTS 2020	(Sangui, Iqbal, Chandra, Ghosh, & Ghosh, 2023)	99.39	01.71	65.67	83.26	99.41	99.27	99.80
ResNet34	BraTS 2018	(Pedada et al., 2023)	92.80	/	/	/	/	89.50	82.20
dResU-Net	BraTS 2020	proposed	99.41	01.59	66.56	84.05	99.45	99.30	99.83

Conclusion

This study addresses the task of brain tumor segmentation (BTS) in multimodal 3D MRI images. We introduce a novel approach, the 3D Deep dResU-Net, designed to enhance brain tumor segmentation performance in MRI images. Our proposed model seamlessly integrates residual blocks with identity mapping into the encoder segment of the U-Net architecture. This integration enriches the learning process by retaining local feature responses and conveying them across encoder-to-decoder stages via skip connections. The model's architecture aims to improve overall training efficiency and overcome segmentation challenges. Performance assessment utilizes the BraTS 2020 dataset, revealing that our method outperforms existing models with remarkable accuracy of 99.41. Notably, these achievements are realized without relying on data augmentation or extensive post-processing techniques.

In the future, advancements in the performance of the proposed method could be achieved through the adoption of diverse augmentation techniques or by leveraging a more extensive benchmark dataset. Additionally, augmenting the dataset using synthetic data generation techniques could further expand its size. The exploration of additional 3D-based architectures, with careful consideration of computational efficiency while maximizing contextual information, holds promise. Furthermore, refining the selected models' performance might involve addressing false positive rates through the implementation of post-processing techniques. Expanding the scope of this work could encompass tackling clinically intricate medical imaging challenges and extending the methodology to other segmentation applications, such as liver tumor segmentation, kidney tumor segmentation, and beyond. This ongoing exploration and adaptation could yield significant enhancements in both accuracy and applicability.

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Towards A Greener Future: The Power of Renewables in Intelligent Energy Management

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Abstract

Energy represents an essential requirement and a key element in sustainable economic and social development endeavors. Thus, humanity is facing an important evolutionary stage in its effort to shift from dependence on traditional energy sources, that are in danger of going extinct, to alternative energy sources, that are witnessing growth at a global level, as a result of the low cost of technologies and the necessity abating greenhouse gas emissions. Renewable energies have emerged as competitive energy sources, due to their variety, continuity, inexhaustibility, flexibility, efficiency, cleanliness, security, freedom from all forms of environmental pollution, and the creation of job opportunities. This paper aims to provide a comprehensive overview of the power of renewable energy sources in intelligent energy management, ensuring the continuity of future life and the preservation of its civilization, greenery, and prosperity. Furthermore, it explores the emerging trends and innovations that support and reinforce the adoption of this alternative energy.

Keywords: *Intelligent Energy Management, Renewable Energy, Clean Energy, Sustainable Energy, Green Power, Smart City, Artificial Intelligence, Internet of Things.*

Introduction

Renewable energy sources have emerged as a powerful force in revolutionizing intelligent energy management. As the world grapples with the challenges of climate change, energy security, and the necessity for sustainable development, renewable energy offers a compelling solution (Tabor et al., 2018). With their inherent environmental benefits, renewable sources such as solar, wind, hydro, and geothermal are reshaping the energy landscape by providing clean, abundant, and renewable alternatives to conventional fossil fuels (Yuan et al., 2022). Moreover, when combined with intelligent energy management systems, the true potential of renewables is unlocked, enabling optimized energy generation, distribution, and consumption (Qadir et al., 2021). This paper explores the role of renewable energy sources in intelligent energy management and different aspects related to the most important technologies and advanced models utilized in this context, such as (Bedi et al., 2022), (Şerban & Lytras, 2020), (Mostafa et al., 2022), and (Xiaoyi et al., 2021). This study aims to offer an in-depth comprehension of the potency exhibited by renewable energy sources in the realm of intelligent energy management. Thereby eliciting their transformative influence in forging a more ecologically conscious, technologically advanced, and environmentally sustainable trajectory. This paper is structured as follows: it commences with an extensive survey encompassing pertinent literature, followed by an enumeration of paramount renewable energy sources. Subsequently, their characteristics are discussed, and the principal constituents of an intelligent renewable energy management system are identified. In the ensuing sections, a comprehensive analysis of the benefit conferred by these sources for smart energy management is expounded upon, along with an examination of the challenges that can be encountered during their implementation. Lastly, it concludes with future trends and projections.

Background

Smart Energy Management

Smart energy management (SEM) relies on control, monitoring, conservation, distribution, and rationalization of energy use, through advanced technologies, digital systems, cutting-edge devices, and intelligent solutions, as it benefits from innovations such as the Internet of Things, Artificial Intelligence, and Data Analytics, as well as the development of environmentally-friendly infrastructures. SEM improves energy efficiency, enhances grid reliability and sustainability (Bălășescu et al., 2022).

Renewable Energy Sources

Renewable energy sources, also known as alternative energy sources, are forms of energy derived from naturally replenishing resources that are virtually inexhaustible on a human timescale. These sources of energy are considered sustainable and have a significantly lower environmental impact compared to other energy types. Some common sources are listed and illustrated in

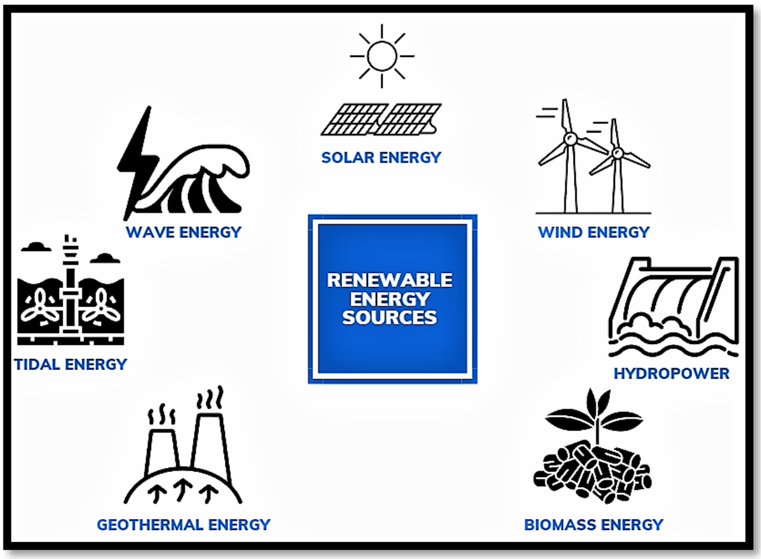

Fig. *17. Renewable Energy* Sourcesbelow (Kothari et al., 2021):

- Solar Energy: solar power is generated by capturing the energy from sunlight and converting it into electricity using photovoltaic (PV) cells or through solar thermal technologies.
- Wind Energy: wind power is generated by harnessing the kinetic energy of the wind to turn wind turbines, which then convert the energy into electricity.
- Hydropower: hydropower is generated by harnessing the energy of flowing or falling water. It is commonly produced through the use of dams and turbines in rivers, tidal streams, and ocean currents.
- Biomass Energy: biomass energy is derived from organic matter such as wood, agricultural residues, dedicated energy crops, and organic waste. It can be used for heat and electricity generation or converted into biogas or biofuels.
- Geothermal Energy: geothermal energy is derived from the heat within the Earth's crust. It involves extracting heat from geothermal reservoirs to generate electricity or for direct use in heating and cooling systems.

- Tidal Energy: tidal power is generated by capturing the kinetic energy of tidal movements caused by the gravitational pull of the moon and the sun. It usually involves using turbines in tidal barrages or tidal stream systems.
- Wave Energy: wave power is generated by harnessing the energy from ocean waves. Devices such as wave-buoys, oscillating water columns, or submerged pressure differential systems can convert wave motion into electricity.

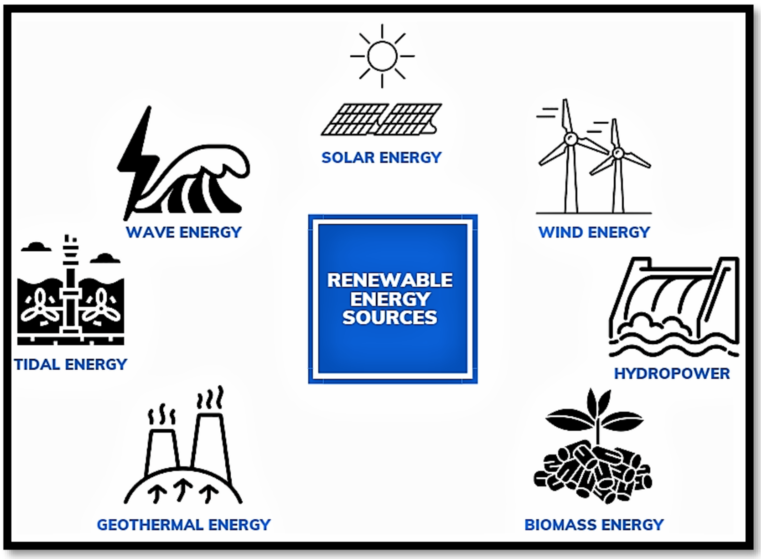

Fig. 17. Renewable Energy Sources

These renewable energy sources offer a sustainable and clean alternative to conventional fossil fuels, contributing to a reduction in greenhouse gas emissions and the mitigation of climate change, thereby powering our future (Yuan et al., 2022).

Renewable Energy Characteristics

Renewable energies possess several key characteristics that set them apart from conventional energy sources, including (Wu et al., 2022) (Xu et al., 2022) (Al Zou'bi, 2010):

- Sustainability: renewable energies are derived from sources that are naturally replenishing and virtually inexhaustible on human timescales. These sources, such as sunlight, wind, water, biomass, and geothermal heat, can be harnessed continuously without depleting the resource.
- Environmentally Friendly: it produces lower greenhouse gas emissions and has reduced environmental impacts compared to fossil fuels. They contribute to mitigating climate change, reducing air pollution, conserving water resources, and minimizing ecological disturbances.
- Diverse Resource Base: renewable energies are derived from a wide range of sources, allowing for diverse and distributed energy generation. This diversity includes solar radiation, wind patterns, water flows, organic matter, and geothermal heat. This enables a more resilient, decentralized energy system.
- Energy Security and Independence: it offers the potential for increased energy security and independence. By diversifying energy sources and reducing reliance on imported fossil fuels, countries can enhance their energy self-sufficiency and reduce exposure to geopolitical risks.
- Technological Advancements: the development of renewable energy technologies has led to continuous advancements, improving their efficiency, reliability, and cost-

effectiveness. Ongoing research and innovation contribute to the growth and maturation of renewable energy systems.

- Cost-competitiveness: the cost of renewable energy technologies has been declining in recent years, making them more cost-competitive with fossil fuels.
- Job Creation and Economic Opportunities: renewable energy sectors have the potential to create new employment opportunities, stimulate local economies, and foster innovation and entrepreneurship. Investments in renewable energies can lead to job growth in manufacturing, construction, operations, maintenance, and related industries.
- Scalability and Modularity: renewable energy systems can be designed and implemented at various scales, from small residential installations to large utility-scale projects. This scalability allows for tailored solutions to meet diverse energy needs and facilitates incremental deployment based on specific requirements.
- Energy Access and Rural Development: it has the potential to expand energy access, particularly in remote and underserved areas. Off-grid renewable energy systems can provide clean and reliable power, promoting rural development, improving quality of life, and supporting socioeconomic progress.

These characteristics highlight the advantages of renewable energies in promoting sustainability, environmental stewardship, energy resilience, and socioeconomic benefits (Ntanos et al., 2018). As these technologies continue to grow, they are likely to play an increasingly important role in meeting our energy needs, as well as creating a cleaner, more sustainable future and a healthier planet for future generations.

Literature Review

Several studies have been carried out into the use of various renewable energy sources in the intelligent energy management field. Most previous research has focused on the transition to clean, sustainable, and environmentally-friendly energy. This section provides a comprehensive overview of the relevant literature, including the following studies:
The authors (Gaitan et al., 2023) presented a comprehensive study on an intelligent energy management system (EMS) solution for multiple renewable energy sources. The proposed system is designed to optimize the use of renewable energy sources by employing advanced technologies and flexible control mechanisms. The study highlighted the benefits of using an EMS, including significant energy savings and reduced carbon emissions. The technical solution is presented in detail, including the materials and methods considered, discussions regarding the proposed solution were presented, and some limitations of this system have also been identified. The study (Hoang et al., 2021) delved into the integration of renewable energy sources into energy systems for smart cities, highlighting the importance of this strategy in achieving sustainable urban development. By employing an integrative literature methodology, the study collected and analyzed relevant publications. The analysis revealed the decisive roles of smart energy systems in reducing CO2 emissions, improving energy efficiency, and enhancing energy management. The study also explored the characteristics of integrated renewable energy systems based on solar, wind, geothermal, hydro, biomass, and waste sources, and identified existing problems and challenges for smart energy systems in the smart city. The study concludes that the deep and rapid penetration of renewable energy technologies can benefit modern society by creating a low-carbon economy and improving the quality of urban life. The paper (Bhattacharjee & Nandi, 2021), proposed a novel approach to efficiently manage energy from different sources and maintain a load-supply power balance in a renewable energy-based hybrid system. The proposed approach used a voting-based smart energy management system (VSEMS) that employs a rule-based energy management algorithm (EMA) to make decisions. The effectiveness of the proposed algorithm was verified through a case study analysis using a yearly usage profile, demonstrating its viability and effectiveness in energy management operations. It also emphasized the importance of

reducing greenhouse gas emissions from conventional power plants and highlighted the role of renewable energy-based hybrid systems in achieving global emissions targets. The proposed approach increases customer participation in decision-making related to their energy supply and controls the intermittency of renewable energy sources efficiently. The research study (Dincer & Acar, 2018) highlighted the importance of making our energy portfolio smarter and more sustainable, in line with the current trend of everything being requested to be smart. The authors discussed the need to cover the entire energy spectrum under five categories, namely energy fundamentals and concepts, energy materials, energy production, energy conversion, and energy management. They also emphasized the significance of recent initiatives such as the Hydrogen Council, which aims to foster the energy transition by promoting hydrogen as a clean energy source. This article further explored the potential of cutting-edge technologies and artificial intelligence applications in revolutionizing the way we deal with energy matters. Authors in (Zhang et al., 2015) explored the transition towards a smart energy network, which is driven by a variety of factors such as economic conditions, climate change, and government initiatives. The development of forecasting techniques is crucial in gaining the greatest value from the vast amount of available data, and the trend is towards multiple-model-based or combined forecasts that include both physical and statistical models. The future smart energy network is a computerized system with large deployments of information and communication technology (ICT), and fuel/electrolysis cells play a significant role in its development. They also discussed various technological perspectives that are being explored to support the transition toward a smart energy network. According to (Pawar et al., 2020), an innovative IoT-based Intelligent Smart Energy Management System (ISEMS) is introduced, which uses advanced machine learning techniques to efficiently manage renewable energy sources without compromising user comfort. This system employs a user-configurable dynamic priority assignment feature and an accurate prediction model based on several machine-learning techniques. The proposed architecture was evaluated in a laboratory-level experimental set-up, which demonstrates an advanced SEMS system with an optimized load strategy and reliable communication. The system outperformed other prediction models due to its PSO-based SVM regression model, which shows significant improvement in results compared to state-of-the-art methods. The ISEMS system is also designed to handle energy demand in a smart grid environment with deep penetration of renewables, highlighting the importance of developing accurate renewable energy prediction models to manage demand-side appliances efficiently.
The literature reviewed has been crucial to progress in the area of intelligent energy management, with a paramount focus on addressing numerous climate problems. These studies have resulted in the ability to efficaciously govern energy operations, ensure its preservation, expedite accessibility, and save costs by taking advantage of artificial intelligence strategies, methods, and techniques. These initiatives cover a broad range of energy-related issues and use many approaches and technologies to achieve their objectives. A comparison of this literature is presented in **Table 2:** Comparing works of literature.

Table 2: *Comparing works of literature*

		Renewable energy sources							
Study	**Strategy applied**	**Solar Energy**	**Wind Energy**	**Hydropower**	**Biomass Energy**	**Geothermal Energy**	**Tidal Energy**	**Wave Energy**	**Objectives**

(Gaitan et al., 2023)	Design, develop, and test an intelligent system that integrates multiple sources of renewable energy	✓	✓	✓					Achieve maximum efficiency in the energy management system
(Hoang et al., 2021)	Integrate renewable resources into the smart city energy system	✓	✓	✓	✓	✓		✓	Reducing CO2 emissions, improving energy efficiency, and enhancing its management Achieve more sustainable, smarter, and cleaner cities in the future
(Bhattacharjee & Nandi, 2021)	Propose the design of a voting-based smart energy management system (VSEMS)	✓	✓		✓				Efficiently manage energy from different sources Maintain a balance between energy supply and demand
(Dincer & Acar, 2018)	Transition to clean hydrogen energy as a smart energy solution	✓			✓	✓		✓	Reliable, efficient, and affordable power generation Foster the energy transition towards hydrogen as a clean energy source Focusing on a sustainable future
(Zhang et al., 2015)	Exploring the transition toward a smart energy network	✓	✓	✓	✓	✓			Developing a smarter and more sustainable energy grid in the future Reducing harmful gas emissions
(Pawar et al., 2020)	Propose an Intelligent Smart Energy Management System (ISEMS) architecture for demand-side energy management considering a renewable source	✓							Enhance real-time energy systems management Manage demand-side devices efficiently

Components of An Intelligent Renewable Energy Management System

An intelligent renewable energy management system typically comprises several key components that work together to optimize the generation, distribution, and consumption of renewable energy (Gherairi, 2023). While the specific components may vary depending on the system's complexity and application, some main components commonly found in such systems are (Mariano-Hernández et al., 2021) (Parvin et al., 2022):

- Renewable Energy Generation Infrastructure: this component encompasses the various technologies and infrastructure utilized to capture and convert renewable energy sources into usable forms. It includes solar panels, wind turbines, hydroelectric generators, biomass plants, geothermal systems, and other renewable energy systems.
- Sensors and Data Acquisition: sensors and meters are employed to collect data on energy generation and consumption, weather conditions, and other relevant parameters. This data acquisition component enables real-time monitoring and provides critical information for system optimization and decision-making.
- Energy Storage Systems: energy storage systems play a vital role in an intelligent renewable energy management system. They allow excess energy generated during periods of high production to be stored and used during periods of high demand or low generation. Battery systems, pumped hydro storage, compressed air energy storage, or thermal storage systems can be used for this purpose.
- Energy Management Software: this software component integrates various data sources, monitors system performance, and facilitates decision-making. It employs algorithms and control strategies to optimize energy production, storage, and distribution. It may include functions such as load forecasting, energy scheduling, demand response, and grid integration management.
- Communication and Control Infrastructure: an intelligent renewable energy management system relies on a robust communication and control infrastructure to enable data exchange, monitoring, and control of different components. This may involve wired or wireless networks, protocols, and automation systems that facilitate seamless communication and coordination between system elements.
- Demand-Side Management: this component focuses on managing and optimizing energy consumption on the demand side. It involves strategies such as load shifting, peak shaving, energy efficiency measures, and demand response programs to balance energy supply and demand and reduce overall energy consumption.
- Grid Integration and Interconnection: for renewable energy systems connected to the grid, grid integration components ensure smooth interaction with the existing power infrastructure. This may involve inverters, transformers, interconnection equipment, and smart grid technologies to facilitate bi-directional power flow and grid stability.
- Monitoring and Control Interfaces: these interfaces provide users, operators, and administrators with real-time information and control capabilities. They can include user-friendly dashboards, visualization tools, control panels, and mobile applications for monitoring energy generation, consumption patterns, and system performance and enabling manual or automated control actions.

The elements listed here provide a general overview, and the actual implementation and configuration of an intelligent renewable energy management system can vary based on specific project requirements and system design considerations.

Benefits of Renewable Energy for Smart Energy Management

Renewable energy can provide several benefits for smart energy management systems, contributing to more efficient, sustainable, and resilient energy systems. These benefits include (Renewable Energy Agency, 2017) (Maradin, 2021):

- Environmental Sustainability: diverse renewable energy sources produce little to no greenhouse gas emissions during operation, unlike fossil fuels. By integrating renewable energy into smart energy management systems, carbon emissions can be significantly reduced, leading to cleaner air, mitigating climate change, and promoting environmental sustainability.
- Energy Efficiency: smart energy management systems leverage advanced technologies and data-driven approaches to optimize energy production, distribution, and consumption. Such systems can enhance overall energy efficiency, minimize energy losses, and improve the utilization of renewable resources.
- Cost Savings: renewable energy costs have been decreasing over the years, making them increasingly cost-competitive with conventional energy sources. By utilizing renewable energy within smart energy management systems, energy costs can be reduced in the long term. Additionally, smart management techniques, such as load balancing, demand response, and energy storage optimization, can further enhance cost savings.
- Energy Independence and Security: incorporating renewable energy sources into smart energy management systems promotes energy independence by reducing reliance on imported fossil fuels. Diversifying the energy mix with renewables enhances energy security, as renewable resources are typically domestically available and less susceptible to price fluctuations and supply disruptions.
- Grid Resilience and Flexibility: smart energy management systems coupled with renewable energy enable enhanced grid resilience and flexibility. Distributed renewable generation, coupled with energy storage and advanced monitoring and control systems, can provide resilience against power outages and disruptions such as natural disasters or cyberattacks, improve grid stability, and enable the integration of intermittent renewable resources into the grid.
- Created jobs: the renewable energy industry is a growing sector that is creating jobs in manufacturing, installation, and maintenance. This can help boost economic development and create a more sustainable future.

As the world transitions to a clean energy future, renewable energy and smart energy management will play an increasingly important role. By working together, these technologies can help to create a more reliable, efficient, safe, and sustainable energy system (Cakir et al., 2022).

Challenges in Renewable Energy Management

Managing renewable energy presents many challenges that need to be addressed to ensure its efficient and effective integration into the energy system. Some of the most significant include (Meraj et al., 2023) (Tvaronavičienė, 2023) (Benkhalfallah et al., 2023):

- Intermittency and Variability: many renewable energy sources, such as solar and wind, are intermittent and variable in nature, meaning that they do not produce energy all the time. Their generation fluctuates with weather conditions and time of day, making it challenging to match supply with demand. Managing this intermittency requires careful balancing of energy sources, incorporating energy storage systems, and implementing advanced forecasting and scheduling techniques.
- Grid Integration: integrating renewable energy into the existing power grid can pose challenges. Renewable energy generation is often decentralized and dispersed,

requiring robust grid infrastructure and smart grid technologies to accommodate bidirectional power flows, maintain grid stability, and ensure the reliability of electricity supply.

- Energy Storage: the efficient and cost-effective storage of renewable energy is a significant challenge. Energy storage technologies are crucial for capturing excess energy during periods of high generation and supplying it during periods of low generation or high demand. Advancements in energy storage systems, such as batteries, pumped hydro storage, or other emerging technologies, are needed to address this challenge.
- Limited Grid Capacity: the integration of large-scale renewable energy projects may face limitations in grid capacity. Expanding the transmission and distribution infrastructure to accommodate increased renewable energy generation can be complex, time-consuming, and costly. Addressing grid capacity constraints requires careful planning, grid expansion, and coordination between renewable energy developers and grid operators.
- Cybersecurity: the increasing use of digital technologies in renewable energy systems makes them more vulnerable to cyberattacks.
- Policy and Regulatory Frameworks: the development and implementation of supportive policies and regulatory frameworks are critical for effective renewable energy management. Ambiguous or inconsistent regulations, insufficient incentives, and complex permitting processes can hinder the deployment of renewable energy projects. Establishing favorable policies, streamlined regulations, and supportive market mechanisms is essential to overcoming these challenges.
- Financial and Economic Factors: the upfront costs of renewable energy projects, especially for emerging technologies, can be significant. Financing renewable energy projects may require innovative financing models, access to affordable capital, and favorable market conditions. Ensuring a stable and attractive investment environment and reducing reliance on subsidies are essential for the long-term economic viability of renewable energy systems.
- Skill Development and Workforce Training: the growth of renewable energy technologies requires a skilled workforce capable of designing, installing, operating, and maintaining these systems. Ensuring the availability of a skilled workforce and providing adequate training programs is crucial for managing renewable energy effectively.
- Public Acceptance: it is vital for the successful management of renewable energy. Addressing concerns related to visual impacts, land use, noise, and potential environmental impacts is important for gaining public support and minimizing conflicts.

Despite these challenges, renewable energy is becoming increasingly important and effective as a way to reduce our reliance on fossil fuels and combat climate change. As technological advancements continue to improve and the cost of renewable energy continues to come down, these challenges are likely to be overcome, enabling efficient management of renewable energies and facilitating the transition to a more sustainable energy future (Rosen, 2021).

Conclusion and Future Trends

Embracing a sustainable future through the integration of renewable energy sources and smart energy management is a critical step toward achieving a cleaner, more efficient, and resilient energy system. In this respect, the current study has examined the role of renewable energy sources in intelligent energy management, as the increasing penetration of these sources, coupled with advancements in energy storage, data analytics, and connectivity, offers promising prospects for optimizing its generation, distribution, and consumption. By harnessing the power of renewable resources, we can mitigate climate change, reduce carbon emissions or other pollutants, and promote environmental sustainability. Smart energy management techniques, driven by advanced technologies and intelligent systems, empower us to optimize energy efficiency, balance supply and demand, and foster grid resilience. Adopting renewable energy and smart energy management not only offers economic benefits, such as cost savings and job creation, but also empowers individuals, communities, and nations to actively participate in the energy transition. By working together towards a sustainable future, we can unlock the full potential of renewable energy, creating a world where clean, reliable, and affordable energy is accessible to all while preserving our planet for future generations (Peake & others, 2018).

Renewable energy in smart energy management holds promising future trends and prospects. The continued growth and competitiveness of its sources, such as solar and wind, are expected to increase their penetration in the global energy mix (Li et al., 2022). Advancements in energy storage technologies, including batteries and hydrogen storage, will enable better integration of intermittent renewable sources, while advanced data analytics and artificial intelligence (AI) will enhance energy forecasting, optimization, and decision-making in its management. The proliferation of IoT devices and connectivity will enable real-time monitoring and control of renewable energy generation and consumption, while decentralization and peer-to-peer energy trading facilitated by blockchain technology will empower consumers to generate, store, and trade renewable energy directly. Moreover, grid-interactive buildings, microgrids, and the electrification of transportation, including electric vehicles (EVs), will further support renewable energy integration and grid resilience. These trends demonstrate the transformative potential of renewable energy in shaping a sustainable, resilient, and consumer-centric energy future (Metayer et al., 2015).

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Enhancing The Performance of A Hybrid OCDMA/OFDM Optical System Incorporating A New Spectral Coding Block Via FSO Channel

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Abstract

The goal of this paper is to propose an advanced hybrid system for wireless optical networks based on the optical code division multiple access (OCDMA) technique and orthogonal frequency division multiplexing (OFDM) modulation for bettering system performance in terms of bit error rate (BER) and signal to noise ratio (SNR). The proposed model adopts a one-dimensional spectral flexible weight (1D-SFW) code to successfully eliminate multiple access interferences (MAI). The mathematical model of the suggested system via free space optics (FSO) is elucidated. The SNR expression has been derived, and the numerical relationships of BER and error vector magnitude (EVM) have also been deduced. Our proposed system outperforms a similar system employing modified double weight (MDW), flexible cross-correlation (FCC), diagonal eigenvalue unity (DEU), and multi-diagonal (MD) codes, it can accommodate a high data rate reaching 4.3 Gbps and supporting more than 180 concurrent users.

Keywords: OCDMA, OFDM, BER, SNR, 1D-SFW

Introduction

Optical communications have steadily increased in prominence over the past few years due to the benefits it provides, such as the ability to communicate over vast distances and transfer information at high speeds (Rahmani, Cherifi, Sabri, Bouazza, & Karar, 2022). The majority of today's optical communication systems rely on multiple access technologies such as optical code division multiple access (OCDMA). Furthermore, OCDMA is implemented to assign each transmission block (user) an optical code that differs from other blocks (users), and this strategy allows for the simultaneous transmission of multiple users in the same transmission environment while utilizing the entire frequency band and any time (Rahmani, Cherifi, Karar, Naima Sabri, & Bouazza, 2022).

The OCDMA technique is split into two systems depending on the optical source: coherent OCDMA and incoherent OCDMA (Cherifi, Jellali, Najjar, Aljunid, & Bouazza, 2019). The first category allows for the construction of strictly orthogonal optical codes using bipolar bits (-1 and +1), which completely eliminates the problem of multiple access interferences (MAI) between users, whereas the second category permits for the production of non-strictly orthogonal optical codes using unipolar bits (0 and +1), which results in the creation of the MAI drawback due to the missing the property of orthogonality between codes (Alayedi et al., 2020). However, by preventing the overlapping of "1"s between the sequence of codes of several users, it is feasible to construct unipolar orthogonal codes, allowing the MAI to be controlled.

The basic issue regarding OCDMA multiplexing technology is excessive phase-induced intensity noise (PIIN), which is caused by multi-user chip interference and results in multi-user interference (MUI or MAI), which primarily impacts system performance (Alayedi, Cherifi, Hamida, Bouazza, & Aljunid, 2021). Further, spectral amplitude coding (SAC) is a popular coding technique in OCDMA systems for the purpose of optical codes production and MAI problem avoidance. For that, various one dimensional codes (1D) have been developed (Kakaee, Seyedzadeh, Adnan Fadhil, Barirah Ahmad Anas, & Mokhtar, 2014;Ahmed & Nisar, 2013;Rahmani, Cherifi, Sabri, et al., 2022;Panda, 2017) to mitigate PIIN noise and MAI effects.

To prevent these constraints, a good selection of codes with high orthogonality is one of the critical stages in determining overall system performance. In the area of OCDMA, this technical word (orthogonality) is known as the zero cross-correlation (ZCC) property.

OFDM (orthogonal frequency division multiplexing) is a sophisticated modulation format offering many advantages, including excellent spectral efficacy, resistance against multipath, and excellent performance in wireless channels (Singh et al., 2023;Kumari & Arya, 2022;Bhanja & Panda, 2020). As a result, combining OFDM modulation with SAC-OCDMA can provide good spectrum occupancy, enhanced transmission rate, and a large number of subcarriers, hence increasing the number of active users (Sarangal, Singh, Malhotra, & Thapar, 2021).

An optical transmission medium is used to exchange data between two entities in optical communication. In this context, optical systems are classified into two types based on their mode of communication: wired optical systems, which employ optical fiber as a data transmission channel, and wireless optical systems, which use wavelengths of light to transmit data via the air (El-Mottaleb et al., 2021). Free space optical communication (FSO) has become a very intriguing technology because of its benefits such as fast transmission speed, strong immunity against electromagnetic (EM) effect, and low power consumption. It can also be implemented in areas where optical fibers are facing a challenge to install (Ratna Kalos Zakiah Sahbudin, Kamarulzaman, Hitam, Mokhtar, & Anas, 2013).

Several studies have recently been performed in this regard. (Saw, Janyani, & Singh, 2023) established a coherent OFDM modulation through the FSO channel to improve signal-to-noise ratio (SNR) performance. (Sahoo, Panda, & Bhanja, 2023) investigate the OFDM-FSO system's performance. (Hacini & Aissaoui, 2023) evaluated the performance of an OCDMA system under fog conditions employing a distinct code via an FSO channel. (Abd El-Mottaleb et al., 2023) employ one-dimensional permutation vector (1D-PV) coding to examine the efficacy of OCDMA-FSO in various weather conditions.

A distinct hybrid SAC-OCDMA-OFDM system via the FSO channel was investigated in this study employing a one-dimensional spectral flexible weight (1D-SFW) code. The system that has been developed stands out for its simple design, low power consumption, high data rate, perfect spectrum occupancy, and outstanding immunity against electromagnetic influences. Further, the code used is distinguished by its short code length, exceptionally high multiplexing capacity, and zero cross-correlation (ZCC) property, which primarily eliminates PIIN noise and the MAI effect.

The next part of this paper is as follows. Section 2, proposes a novel one-dimensional code family (SFW). Section 3, describes our proposed hybrid 1D-SAC-OCDMA-OFDM system through the FSO channel. Section 4, our hybrid system's mathematical analysis. Section 5our system's simulation findings and their discussion. Section 6, provides a conclusion related to our system.

Establishment of a new spectral code (SFW)

The spectral flexible weight (SFW) code is created by combining three parameters (L, W, K), where "L" represents the spectral length of each sequence, "W" represents the number of "1" in each sequence, and "K" represents the number of users (number of codes). Hence, the stages of its construction are listed below:

1. Choose the number of users and the code weight (K, W).

2. Generate two matrices: even weight diagonal matrix (EWDM) and odd weight anti diagonal matrix (OWAM), where EWDM and OWAM are presented as follows:

$$EWDM = \begin{bmatrix} \overbrace{1 \dots 1}^{W\ even} & 0 & 0 \\ 0 & 1 \dots 1 & \vdots \\ \vdots & \vdots & 0 \\ 0 & 0 & 1 \dots 1 \end{bmatrix}_{K \times WK} ; OWAM = \begin{bmatrix} \overbrace{0}^{C_1} & \overbrace{0}^{C_i} & \overbrace{1}^{C_K} \\ 0 & \iddots & 0 \\ \underbrace{1}_{W\ odd} & 0 & 0 \end{bmatrix}_{K \times K} \quad i = 1,2, \dots, K \quad (1)$$

Note that if the code weight is even, only the EWDM matrix is used.

3. When the weight is odd, perform the superposition of the two matrices as follows:

$$SFW_{W(Odd)} = \begin{bmatrix} 1 & \overbrace{0}^{C_1} & 1 & 0 & \overbrace{0}^{C_2} & 0 & \cdots & \overbrace{1}^{C_K} & 0 \\ 0 & \vdots & 0 & 1 & \vdots & 1 & \cdots & 0 & \vdots \\ \vdots & \vdots & \vdots & 0 & 0 & 0 & \cdots & \vdots & \vdots \\ \vdots & 0 & \vdots & \vdots & 1 & \vdots & \cdots & \vdots & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 \end{bmatrix} \quad (2)$$

4. When the weight is even, only EWDM is used as follows:

$$SFW_{W(Even)} = \begin{bmatrix} \overbrace{1 \dots 1}^{W} & 0 & 0 \\ 0 & 1 \dots 1 & \vdots \\ \vdots & \vdots & 0 \\ 0 & 0 & 1 \dots 1 \end{bmatrix}_{K \times WK} \quad (3)$$

5. Using the following formulae, determine the length of the SFW code and its auto/cross correlation property:

$$\begin{cases} L = K \times W \\ \sum_{i=1}^{K} C_i C_l = \begin{cases} \lambda_a = W & if \quad i = j \\ \lambda_c = 0 & if \quad i \neq j \end{cases} \end{cases} \quad (4)$$

Here λ_a and λ_c are autocorrelation and cross correlation, respectively. C_i, C_j are two sequences of SFW code. Table 1 gives an example of a one-dimensional SFW code (1D-SFW) for K=3 and W=2 and 3, respectively.

Table 1. 1D-SFW spectral code for 3 users

	Even weight (K=3, W=2)
1D-SFW code	$\begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}$
	Odd weight (K=3, W=3)
1D-SFW code	$\begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 \end{bmatrix}$

Proposed hybrid system

The data on the electrical part of the OFDM signal is modulated using the quadrature amplitude modulation (QAM) pattern, as shown in Fig.1. The electrical signal is then passed through the inverse fast Fourier transform (IFFT) block, where the guard interval is added to the multipath channels to minimize interference between successive blocks and allow for further equalization. Following that, an electrical-to-optical modulator (EOM) modulates each OFDM symbol, transforming the electrical data bits into optical pulses. The modulated optical pulses are sent to Fiber Bragg gratings (FBGs) for spectral encoding using the SFW codeword assigned to each user.

The spectral encoder output signal is thereafter transmitted to the receiver through the wireless optical channel (FSO).

A spectrum decoder corresponding to the needed signal is employed on the receiver side, followed by a single photodiode (PD) for direct detection of the decoded signal, where the PD operates as a signal converter from optical to electrical form. Finally, the electrical signal is recovered by inverse operations such as OFDM demodulation, the FFT process, and other electrical processes.

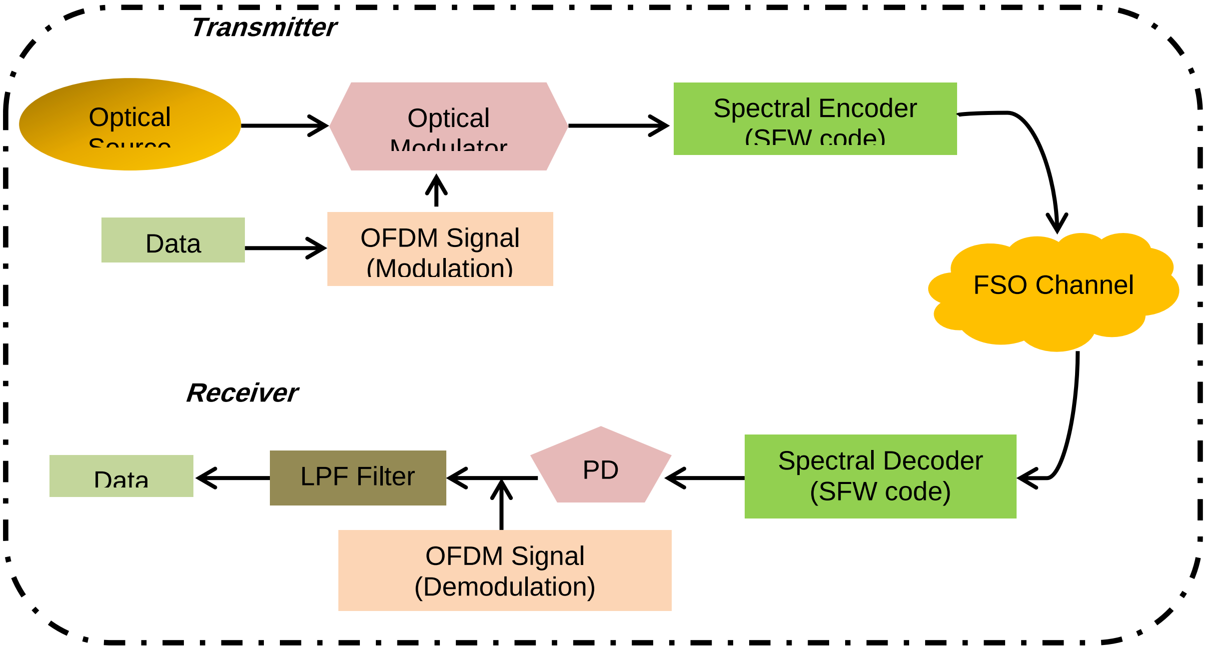

Fig.1. Hybrid OCDMA-OFDM system design via FSO channel

Mathematical examination

As seen in Fig. 1, the suggested hybrid architecture is studied by using only one photo-diode (PD) for direct detection at the receiver because of the ZCC feature. As a result, we consider thermal noise $< I_{th}^2 >$, and shot noise $< I_{sh}^2 >$, in our model to estimate the total noise variance produced by direct detection. Consequently, the photocurrent variance noise is stated as follows (Rahmani, Cherifi, Sabri, et al., 2022):

$$<I_{noise}^2 >=< I_{sh}^2 > +< I_{th}^2 >$$
$$= 2eB_r I_r + \frac{4K_b B_r T_n}{R_l} \quad (5)$$

Where e refers to the electron charge, B_r refers to the electrical bandwidth, I_r refers to the average photo direct current, K_b refers to Boltzmann's constant, T_n refers to the absolute temperature, and R_l refers to the load resistor,.

To facilitate system analysis, the following four assumptions are taken into account (Rahmani, Cherifi, Sabri, et al., 2022):

1. The light source is unpolarized ideally with a flat spectrum over $[v_0 - \frac{\Delta v}{2}, v_0 + \frac{\Delta v}{2}]$ where v_0 refers to the central optical frequency and Δv is the optical source bandwidth. They are estimated in Hertz.
2. All power spectral components have equal spectral widths.
3. All users have equal power on the receiver side.
4. Synchronization in bit streams of different transmitters.

The received signal's power spectral density (PSD) can be represented as (Rahmani, Cherifi, Sabri, et al., 2022):

$$r(v) = \frac{P_{sr}}{\Delta v}\sum_{k=1}^{K} d_k \sum_{i=1}^{L} C_K(i) C_l(i) \prod(v,i)\, dv \quad (6)$$

Where P_{sr} denotes the effective power of the source at receiver, K denotes the number of simultaneous users, L denotes the code length and d_k denotes the data bit of k^{th} user (i.e., ”0” or “1”). As well, $\prod(v,i)$ can be defined as (Rahmani, Cherifi, Sabri, et al., 2022):

$$\prod(v,i)\, dv = \left\{u\left[v - v_0 - \frac{\Delta v}{2L}(-L+2i)\right] - \left[v - v_0 - u\frac{\Delta v}{2L}(-L+2i+2)\right]\right\} \quad (7)$$

Where $u(v)$ is the unit step function, which is stated as follows:

$$u(v) = \begin{cases} 1 & v \geq 0 \\ 0 & else \end{cases} \quad (8)$$

The current out from PD can be mentioned as:

$$I_r = \Re \int_0^{\infty} r(v) dv$$

$$= \frac{\Re P_{sr}}{\Delta v}\left(1 \times W \times \frac{\Delta v}{L} + 1 \times 0 \times \frac{\Delta v}{L}\right) = \frac{\Re P_{sr} W}{L} \quad (9)$$

Where $\Re$ is the PD response expressed as: $\Re = \frac{\eta . e}{h . v_0}$, and W is code weight.

η, h, v_0 are denoted as the quantum efficiency, Plank’s constant, and central frequency of the broad-band optical pulse, respectively.

After employing OFDM demodulation at period T_s, I_r becomes as (Aldhaibani, Aljunid, Anuar, Arief, & Rashidi, 2015):

$$I_r = \frac{\Re P_{sr} W}{L} . \sum_{n=1}^{N} X_n e^{j2\pi f_n t} \quad (10)$$

Where X_n is a complex data bit at N subcarriers, $n = 1,2,\ldots,N$, and e is the signal waveform carrier. If the condition below is met, the orthogonality attribute is acquired (Rahmani, Cherifi, Sabri, et al., 2022),(Aldhaibani et al., 2015).

$$f_n = \frac{n-1}{N} \quad (11)$$

Depending on the methodology stated in (R.K.Z. Sahbudin, Abdullah, & Mokhtar, 2009), the $\sum_{n=1}^{N} X_n$ is approximated as follows:

$$\sum_{n=1}^{N} X_n \approx K . \frac{W}{L} \quad (12)$$

Based on FSO transmission, the effective source power is stated as a function of the transmitted power P_t as (Jangid & Sharma, 2020):

$$P_{sr} = P_t \times \frac{(d_r)^2}{[(d_t + (D \times \varphi_{div})]^2} \times (10)^{(-\alpha \times \frac{D}{10})} \quad (13)$$

Where d_t refers to the sender aperture diameter, d_r refers to recipient aperture diameter, D is transmission length, φ_{div} refers to beam divergence, and α is attenuation factor.

Thus, following the results of Eqs. (5) , (10), (12) and (13), the SNR performance can be provided as:

$$SNR = \frac{I_r^2}{<I_{noise}^2>} = \frac{\left[\frac{\Re P_{sr} W}{L}\sum_{n=1}^{N} X_n e^{j2\pi f_n t}\right]^2}{2eB_r \frac{\Re P_{sr} W}{L} + \frac{4K_b T_n B_r}{R_l}} \quad (14)$$

Considering that the probability of transmitting "0" and "1" is equal to (0.5), hence, Eq. (14) becomes:

$$SNR = \frac{\left[\frac{\Re P_{sr}W}{L} \times \sum_{n=1}^{N} X_n e^{j2\pi f_n t}\right]^2}{eB_r \frac{\Re P_{sr}w}{L} + \frac{4K_b T_n B_r}{R_l}} \tag{15}$$

The BER is determined from the SNR using the Gaussian approximation as follows:

$$BER = \frac{1}{2} erfc \sqrt{\frac{SNR}{8}}$$

$$= \frac{1}{2} erfc \sqrt{\frac{1}{8} \times \frac{\left[\frac{\Re P_{sr}W}{L} \times \sum_{n=1}^{N} X_n e^{j2\pi f_n t}\right]^2}{eB_r \frac{\Re P_{sr}w}{L} + \frac{4K_b T_n B_r}{R_l}}} \tag{16}$$

Numerical Simulation

This section discusses the evaluation of our proposed hybrid system via FSO channel using the SFW code under the influence of various parameters such as the number of users, effective power, and data rate on BER and SNR factors, as well as comparison to other systems using modified double-weight (MDW), flexible cross-correlation (FCC), diagonal eigenvalue unity (DEU), and multi diagonal (MD) codes that are studied in (Aljunid, Ismail, Ramli, Ali, & Abdullah, 2004;Rashidi et al., 2014;Ahmed & Nisar, 2013;Abd, Aljunid, Fadhil, Ahmad, & Saad, 2011) while taking both shot noise and thermal noise into account. Table 2 also contains the settings chosen for the simulation using the MATLAB software.

Table 2. Adopted parameters for numerical calculation

Parameters	Value
Photo detector responsivity ($\mathcal{R}$)	0.75
Data rate (R_b)	622 Mbps
Electric bandwidth (B_r)	$0.5 \times R_b$GHz
Receiver Load resistor (R_l)	1030Ω
Spectral width of light (∆v)	3.75 THz
transmission power (P_t)	12 dBm
Receiver noise Temperature (T_n)	300 K
Electron charge (e)	1.6×10^{-19}c
Boltzman's constant (K_b)	1.38×10^{-23}J/K
Transmission distance (D)	2.5 Km
Transmit aperture diameter (d_t)	5 cm
Receive aperture diameter (d_r)	20 cm
Beam divergence (φ_{div})	2 mrad
Rain attenuation (α_{rain})	0.42 dB/Km

The second figure (Fig.2) displays the BER variation as a function of the number of active users simultaneously of our hybrid system over the FSO channel at 622 Mbps and at 12 dBm of transmitter power. It demonstrates that our proposed hybrid system OCDMA-OFDM/SFW excels compared to other systems. Thus, our system can support 185 users at the BER threshold of 10^9, whereas MDW, FCC, DEU, and MD codes can support 143, 161, 168, and 176 users, respectively. Furthermore, when compared to OFDM-OCDMA/MDW, OFDM-OCDMA/FCC, OFDM-OCDMA/DEU, and OFDM-OCDMA/MD networks, system capacity has been raised by 1.29, 1.14, 1.10, and 1.05 times. As seen in equation (17), the cardinality of each system is given as:

$$C_{MDW/SFW} \frac{185-143}{143} \times 100 = 29.37\ \% \text{ , } C_{FCC/SFW} \frac{185-161}{161} \times 100 = 14.90\ \%$$

$$C_{DEU/SFW}\frac{185-168}{168}\times 100 = 10.11\ \%\ ,\ C_{MD/SFW}\frac{185-176}{176}\times 100 = 5.11\ \% \quad (17)$$

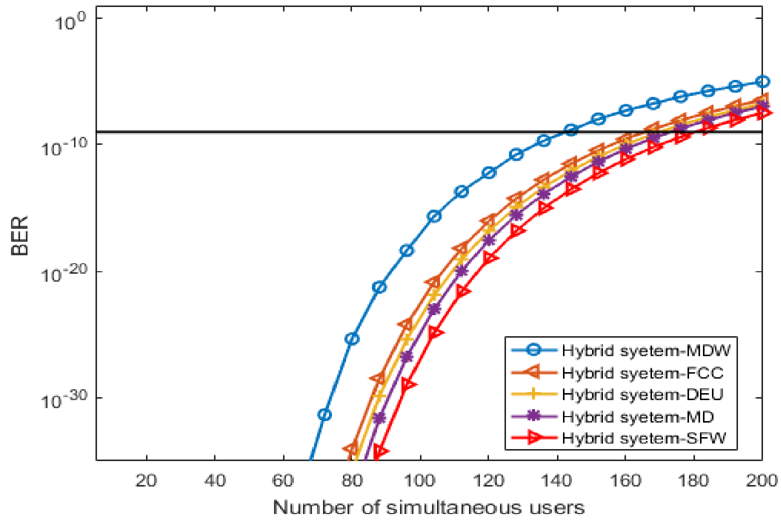

Fig.2 BER of hybrid system versus active users via FSO channel

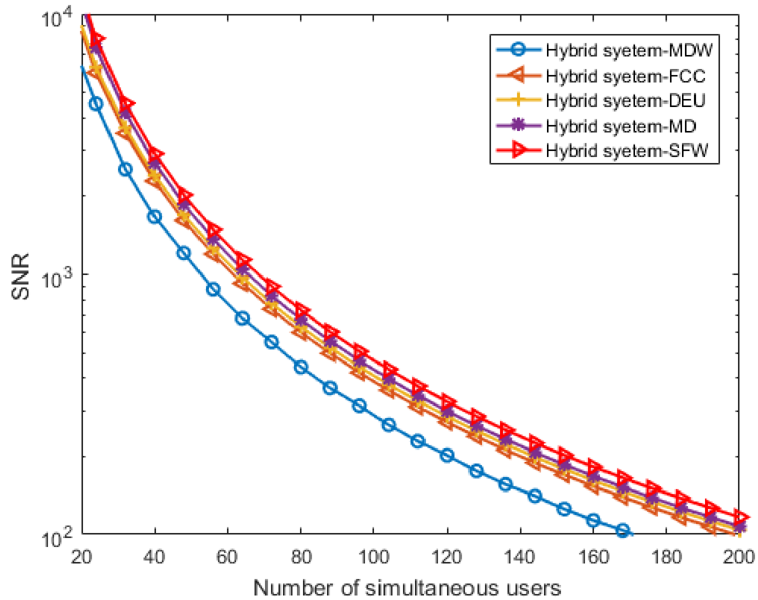

Fig.3 SNR of hybrid system versus active users via FSO channel

The third Figure (Fig.3) reveals the alteration in SNR with respect to the number of concurrent users at 622 Mbps and 12 dBm of throughput and emitter power, respectively. As assumed, implementing the SFW code in a hybrid system leads to higher levels of SNR as compared to the MDW, FCC, DEU, and MD codes. Thus, SNR values for OFDM-OCDMA systems based on MDW, FCC, DEU, MD, and SFW codes for 60 active users are 740, 851, 995, 1083, and 1300, respectively. These findings have been confirmed by a considerable increase in signal power versus noise power at the receiver as a result of PIIN noise removal.

The fourth figure (Fig. 4) depicts the BER variation as a function of data rate where the transmitter power and available users are set to 12 dBm and 50 active users, respectively. As previously stated, an OFDM-OCDMA system based on the SFW code supports a high data rate of 4.3 Gbps at a sufficient BER value (10^{9}), on the other hand, other systems based on the MDW, FCC, DEU, and MD codes can support a lower data rate of 1.87 Gbps, 2.5 Gbps, 2.85 Gbps, and 3.54 Gbps, respectively. As a result of the high data rate, our code achieves better levels of efficiency and improves the system's efficiency when considering the requirements of optical communication systems.

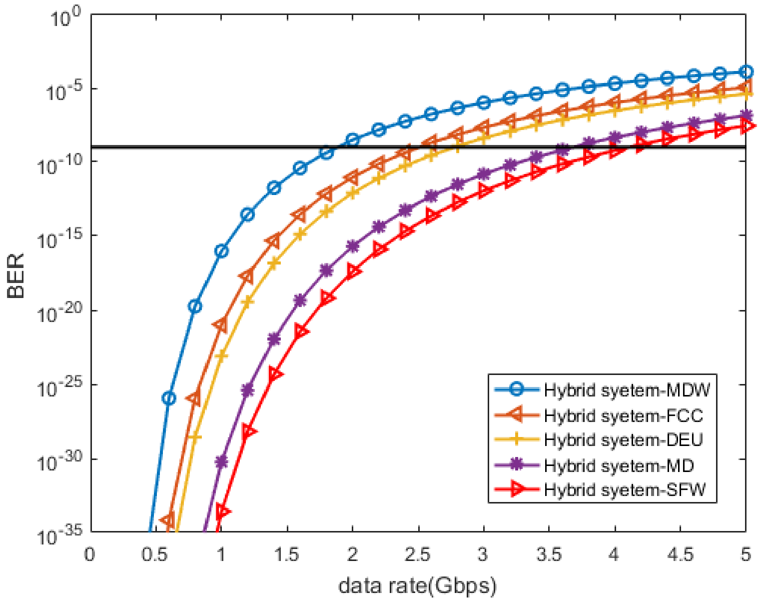

Fig.4 BER of hybrid system versus data rate via FSO channel

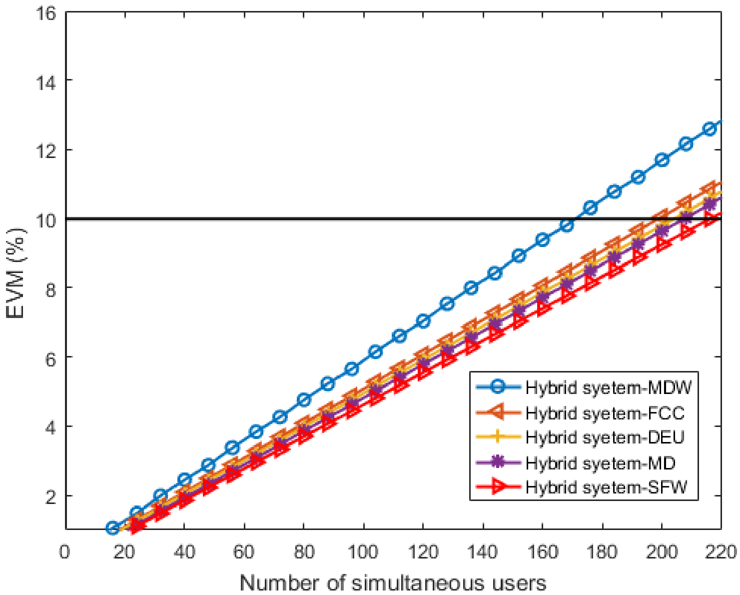

Fig.5 EVM(%) of hybrid system versus active users via FSO channel

The fifth figure (Fig.5) shows the alteration of EVM(%) regarding the user counts where EVM(%) was calculated using (18). The measurements were taken at a bit rate of 622 Mbps and a power of 12 dBm. When compared to the other codes, it is evident that our hybrid model has an extremely low EVM value. Our approach enables a large number of users equivalent to 220 at acceptable EVM (EVM=10%), whereas a hybrid system employing one-dimensional MDW, FCC, DEU, and MD codes favors 170,195,198, and 205 users, respectively. Consequently, we justify the superiority of our model in terms of the code's ZCC feature, which removes perfectly multiple access interference (MAI) and boosts cardinality.

$$EVM(\%) = \left(\sqrt{\frac{1}{SNR}}\right) \times 100 \tag{18}$$

Conclusion

This search includes a novel hybrid system called OCDMA-OFDM that employs 1D-SFW code via the FSO channel. The SNR and BER analytical mathematical formulae have been successfully provided by applying spectral direct detection. The simulation findings demonstrate that using the SFW code strengthens the performance of the OCDMA-OFDM system in terms of cardinality, received power, and data rate when thermal noise, shot noise, and FSO attenuation are taken into account, compared to a similar system using modified double weight (MDW), flexible cross-correlation (FCC), diagonal eigenvalue unity (DEU), and multi diagonal (MD) codes. Furthermore, our approach's ZCC feature increases system performance by minimizing MAI and completely suppresses the PIIN noise impact, signaling that our approach could be a promising technology for future generations of high-speed optical networks.

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Adaptive grouping of learners in a CSCL environment

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Abstract

Over the past few years, several research studies have been conducted on group formation in Computer Supported Collaborative Learning environments to increase interaction and collaboration among learners. The grouping of learners in a collaborative environment is based on several criteria related to learners, groups, and the strategy adopted for grouping, bearing in mind that this is an NP-complete problem.

In this paper, we first developed a collaborative learning environment where we integrated three clustering strategies (by exploiting the traces of the learners and their emotions): the first one is based on the learner profile, the second one is based on the choice of the learners and the third one is based on genetic algorithms that take into consideration the sociability, interest, interaction, and gender of the learners in order to obtain the greatest number of opportunities for better groups.

Keywords: Group formation, Collaborative learning, CSCL, Learners' traces, Genetic algorithms.

1. Introduction

Collaborative learning most often takes the form of teamwork. As a team is perceived as a group of learners interacting to set or achieve a common goal, teamwork involves sharing tasks and coordinating the efforts of team members (Burke, 2011; Springer, Stanne, & Donovan, 1999). Learners in small groups work together to complete a set of learning objects, problem-solving, multiple-choice questions, etc.

There are several methods of grouping learners, each one is based on certain criteria (Khandaker, Khandaker, Soh, & Soh, 2009; Lescano, Costaguta, & Amandi, 2016; Ounnas, Davis, & Millard, 2009; Springer et al., 1999; Wang, Lin, & Sun, 2007a). In addition, each method has its advantages and disadvantages. On the other hand, the grouping method chosen may not be effective for some learners.

Therefore, the main objective of this research is to design an intelligent system to provide an approach for dynamic and adaptive grouping of learners in collaborative learning environments. In order to have an ideal grouping, genetic algorithms were used to find an optimal group solution.

Given the popularity of social networks today, we proposed to integrate the social aspect into our collaborative system. Indeed, our system has a module for adapting grouping methods. This tool considers the learners' knowledge (cognitive profile), emotions during the collaboration, and their wishes.

2. IMPORTANCE OF GROUP FORMATION IN COLLABORATIVE LEARNING:

Collaborative learning has existed at the Centre for Educational Research since the 1980s. Several studies have shown the benefits of collaborative learning (O'Donnell & O'Kelly, 1994; Springer et al., 1999; Wang, Lin, & Sun, 2007b) but collaborative learning is a difficult process that may not always produce the desired outcomes (Kirschner, Paas, & Kirschner, 2009; Nokes-Malach, Richey, & Gadgil, 2015). Several educational interventions and strategies have been proposed to overcome these weaknesses, including the use of technology. The development of network technology has changed the way learners interact with each other and with teachers, allowing them to interact with other learners in different areas. These technological advances have led to the emergence of new areas of research, such as computer-supported collaborative learning (CSCL) and collaborative working, intending to use technology to support collaboration (Stahl, Koshmann, & Suthers, 2006). However, it is often difficult to separate collaboration from cooperation in real-life situations. The complexity of group work is such that members often need to collaborate while cooperating in the collaborative process. Whether it is pure collaboration or cooperation, the type of process we are interested in here is one in which a group of people engage in activities toward a common goal (Jeong & Hmelo-Silver, 2016).

The formation of the group is an essential process in the group's development life cycle. It has been a growing concern of many researchers to apply automatically in collaborative learning contexts. Group formation is an atomic process that is affected by various factors. These factors vary depending on the characteristics of the group members, the context of the grouping process, and the techniques used to form the group (Maqtary, Mohsen, & Bechkoum, 2017).

3. New approach for Adaptive grouping of learners in a CSCL environment:

This research aims to propose a system that takes into account various kinds of methods for grouping learners in a collaborative learning environment. The proposed methods are based on some criteria, such as the knowledge level of learners, the choice of learners, etc.

Our reflection led us to define the architecture of the system "Fig. 1", which is composed of three main modules:

1) Learning module,
2) Collaborative module and
3) the Grouping Module.

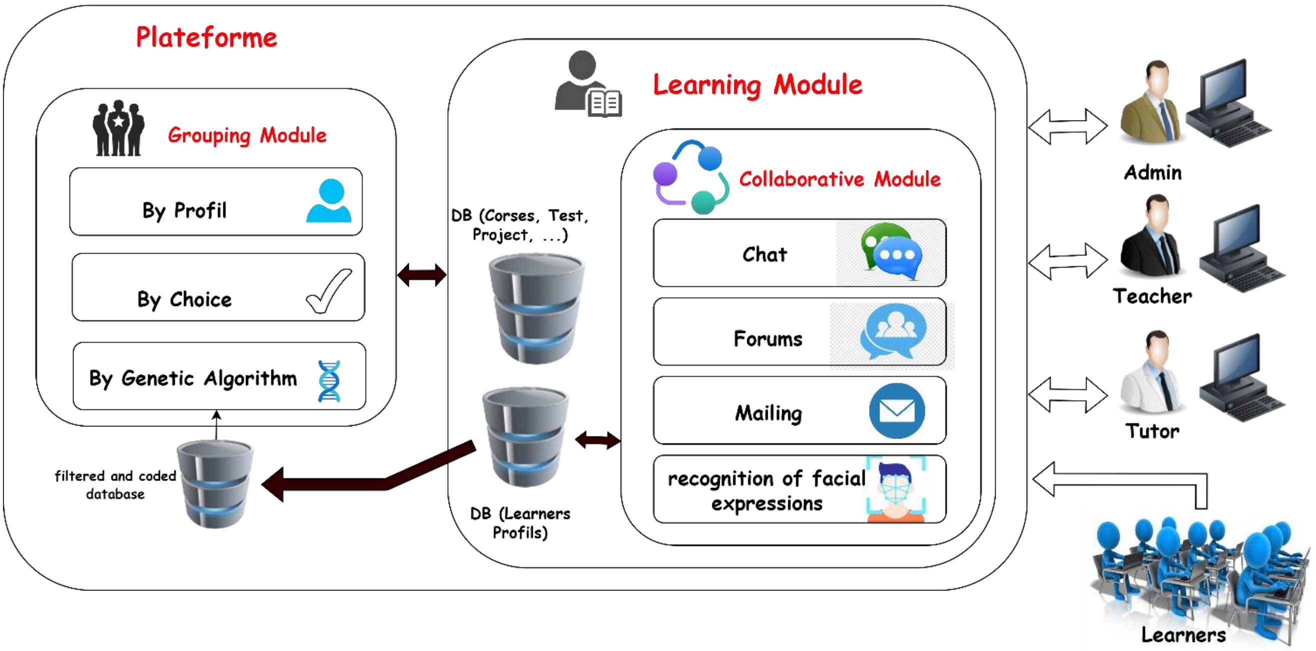

Fig. 1. System architecture.

In the following, we detail the functionalities as well as the components of each element of our architecture.

3.1. Collaborative learning platform:

As part of our research, we developed a learning platform that incorporates the grouping module, which is the core of our objective, as we found difficulties integrating our work into existing platforms. The CSCL platforms are specific computer technology solutions created by private or public companies or resulting from research work. The objective of the platforms is to offer a set of functionalities that can be integrated into a distance learning system (Springer et al., 1999).

There are several actors in our learning platform among them, for example: learners, teachers, and tutors. The learner will be able to follow and download the courses previously created by the teachers and be evaluated through tests in a collaborative framework (belonging to a group), as well as being followed by a tutor.

To support collaboration activities, the teachers, tutors, and learners communicate individually or in groups, create topics for discussion, and collaborate on joint work.

3.2. Human actors of the system:

In our learning platform, we distinguish four types of users: Learner, tutor, teacher, and administrator. Each one of them has his main functionalities (Fig. 2) :

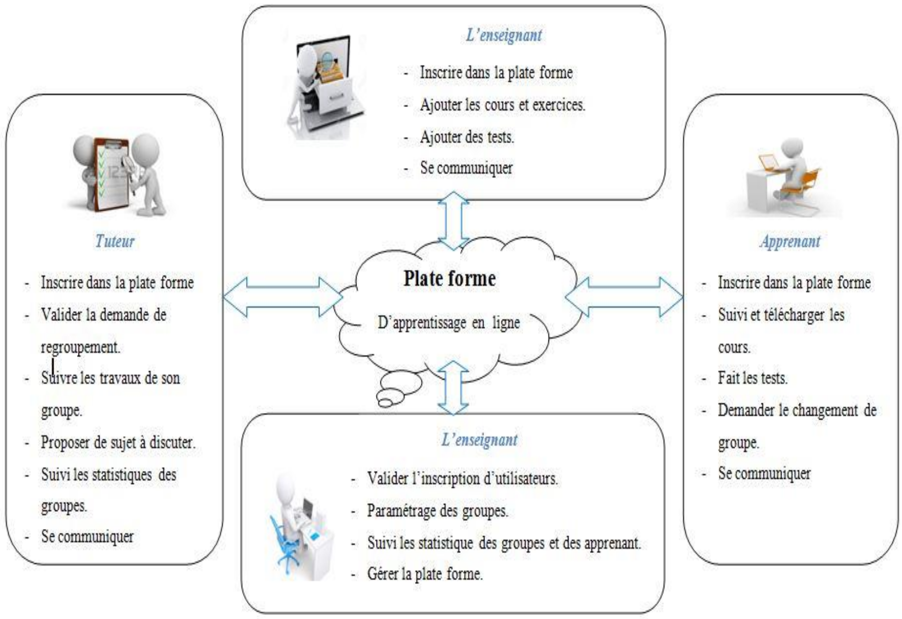

Fig. 2. The roles of the human actors.

3.3. Learning Module:

A learning module is a set of data extracted from the activities of many actors in the learning platform. Whatever the activity, it will be in the framework of a collective or individual action. It is composed of (a) A Learner profile database, which includes all learner profile data, whether static (data declared by the learner) or dynamic (data defined or calculated by the system); and (b) a Course database, which includes all data on courses offered by teachers, as well as all questions and answers concerning exercises and tests.

3.4. Collaboration module:

The collaboration module is the one that is requested by all the actors of the system. This module makes it possible to combine the points of view of the members of the group by suggesting topics for discussion by tutors and learners.

In our system, the collaboration process is based on the learners' activity in the collaboration tools (chat, forum, e-mail). The traces of learners during these activities are used as criteria for forming groups. Also, another criterion is used, which is the learners' emotions. Indeed, it is known that facial expressions play a role in the recognition of the actors' emotions to extract the mood during learning, which in turn presents many characteristics belonging to the learners. Statistics are then established which can be stored in the profile database. These data are filtered and coded and then stored in the filtered and coded database for later use as a means of grouping.

3.5. Grouping Module:

This module is a set of tools for group formation. We show here the relation between the learning module and the grouping module. This relation can be summarized by the following algorithm:

Algorithm: Grouping means

Begin

If (the number of entries of the learner in his space =1) then {Group by their profile;

} Else if (the number of learners entering the space > 2) and (the number of learners who took the test 1< 40) {

Take into consideration the choice of the learner's group by the tutor or he stays in his own;}

Else

{Applying the genetic algorithm which assigned a choice of belonging to the learner;}

End.

In our platform, we can therefore apply three types of grouping in the learning module, which are:

3.5.1. Grouping based on the learner profile:

If there is a new learner in our system, we have no data to classify him/her in a group at the beginning of the learning process. Therefore, the data reported by learners when they enroll in the learning platform is used to join a group, based on the learner's mentions to create mixed groups, as shown in the following scenario:

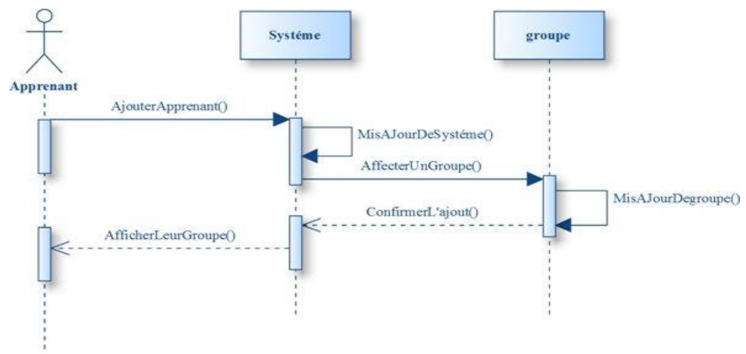

Fig. 3. Diagram of grouping sequence by learner profile

3.5.2. Grouping by choice:

If there are already learners in our system (i.e. already assigned to a group), they can see the list of groups and ask to join another group (change group), with the consent of the tutor, as shown in the following scenario:

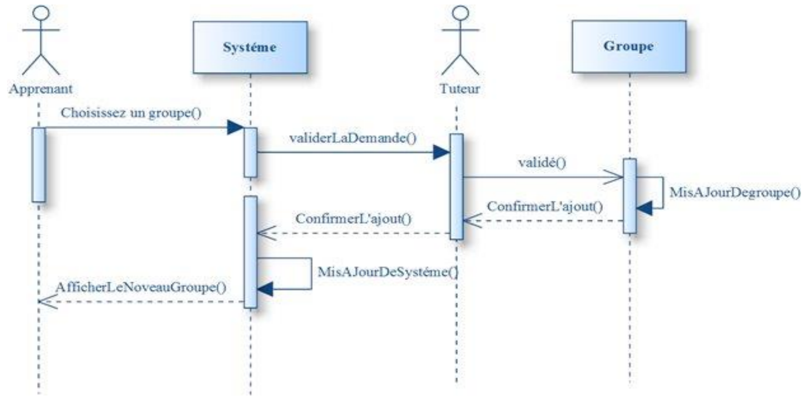

Fig. 4. Diagram of sequence of grouping by learner's choice.

In both cases, we can obtain traces of the learners from the communication between the group members in the collaboration module. When the grouping process is completed in both cases, the learner can consult the courses and take the first test, each one is done according to his or her year of study.

When the number of learners who have passed the first test reaches the value of 40 learners, we can apply grouping by a genetic algorithm.

3.5.3. Grouping by a genetic algorithm:

This clustering contains a set of attributes extracted from previous interactions, which are stored in the coded filtered database. We use these attributes to apply the genetic algorithms in order to obtain the best results, i.e. groups, in which the learner is invited to join the group that suits him or her best.

4. Conclusion and future works

In this paper, we have focused on the collaborative learning field and the strategies used for the grouping of learners. Despite the existence of many trends and problems related to our objectives, such as the group size, the emotional spirit of learners, and the ensuring of their collaboration activities.

Given the recent interest in research, it should be noted that the characteristics of group members require special attention, which led us to provide all the necessary means to obtain a survey that could reveal these characteristics.

The acquisition of traces requires a collaborative environment, which led us to achieve two types of aggregation: profiling and selection, through which we exploited the interaction between group members and the means of communication to obtain the information that helped us to apply the strategy based on the genetic algorithm for aggregation.

By comparing the first and second clustering methods, we can extract the effectiveness of our work in the lack of a real population to value the cluster or to see its effectiveness or not.

Our application requires further improvements; these can be listed as follows:

- Increase the number of courses and tests in the platform.
- Add the concept of course and test difficulty levels: for the personalization of the teaching (scenarios adapted to the learner).
- Add content recommendation notifications, according to the learner's deficiencies.

- Provide a group optimization strategy.

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Machine learning techniques for solar irradiance forecasting using different training datasets

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Abstract

In the field of renewable energy, solar irradiance prediction may be a highly valuable tool for forecasting and studying the evolution of solar energy parameters over time. Unfortunately, because of the fluctuating nature of meteorological conditions, a reliable forecast is difficult. In this paper, three machine learning models are used to forecast hourly Global Horizontal Irradiance (GHI) based on their ability to predict time series: Support Vector Machine (SVM), Artificial Neuron Network (ANN), and Long Short-Term Memory (LSTM). The models were trained using meteorological data from three datasets containing weather data from diverse regions, including Los Angeles, San Diego, and San Francisco. ANN outperformed other models in terms of Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Coefficient of Determination (R2) when compared to existing deep learning-based techniques.

Keywords: *Artificial Neuron Network; Support Vector Regression; Long Short-Term Memory; Machine learning*

1. Introduction

Currently, fossil fuels are the world's major source of energy, but owing to their non-renewable nature and impact on climate change (Wang, Lei, Zhang, Zhou, & Peng, 2019), renewable energy sources are gaining traction as the world moves toward more sustainable energy in the future(Wang et al., 2018). Solar energy, which is clean, emission-free, and inexhaustible, has the potential to provide a secure energy supply. Because of the increasing importance of photovoltaic (PV) solar systems in the power grid, accurate prediction of solar irradiance, which directly affects the performance of PV systems that convert solar energy into electrical energy (Kumari & Toshniwal, 2021), is critical to ensuring the security and stability of the power network. The intermittent and variable nature of solar resources presents a significant challenge in successfully integrating solar PV facilities into electric networks (Guermoui, Melgani, Gairaa, & Mekhalfi, 2020).

SVM, ANN, and LSTM machine learning algorithms are used in this work since they are well-known approaches for time series prediction. Although LSTM and ANNs have the ability to predict nonlinear relationships, they are difficult to train and can produce unstable models due to differences in their initial weight set. Moreover, SVR has been demonstrated to perform well for regression and time series prediction, and they can model nonlinear relations effectively and stably, but they do not perform well when the data set contains more noise (Thissen, Van Brakel, De Weijer, Melssen, & Buydens, 2003). In this work, after training them individually, three datasets from separate locations with diverse weather conditions, including Los Angeles, San Diego, and San Francisco, are used to compare the strengths and shortcomings of each model.

The article structure is as follows: The principles and procedures of the models utilized in this study are discussed in Section 2. The third section describes the employed methodology, including a description of data acquisition and pre-processing. Section 4 presents and discusses the obtained results of the study, and Section 5 concludes the paper with a summary and conclusion.

2. Theoretical Overview

In this work, SVM, ANN and LSTM models were applied, as they are the basic models found in most studies and also in most of the hybrid models studied. They also give the best results in GHI forecasting compared to other non-hybdir models.

2.1. Support Vector Machine

Support Vector Regression (SVR), a variant of Support Vector Machine (SVM) proposed by Vladimir Vapnik in 1979, is a powerful technique that permits modifying the model error tolerance by determining the total amount of permissible errors. It also permits the creation of hyperplanes in higher dimensions to fit the data, giving the user control over the error rate and acceptable error margin (Jana, Bhunia, Adhikary, & Mishra, 2023). Figure 1 depicts a two-dimensional example of SVR, where the data points represent the predicted values (Kleynhans, Montanaro, Gerace, & Kanan, 2017). The SVR is utilized to minimize the sum of allowed errors and the squared weight vector norm $\boldsymbol{w^T}.\boldsymbol{w}$. To measure the errors of samples outside of the margin zone, non-negative shrinkage variables $\boldsymbol{\xi_i}$ are introduced. Equation 1 represents the basic formulation of the SVR optimization problem.

$$\begin{cases} \min_{w,b,e} J(w,e) = \frac{1}{2} w^T.w + C\sum_{i=1}^{n}\left(l_e\big(f(x_i - y_i)\big)\right) + \frac{\gamma}{2}\sum_{i=2}^{n} e_i^2 \\ \quad s.t \quad z = w^T.\phi(x_i) + b + \varepsilon + \xi_i, i = 1,2, \dots \dots, n \end{cases} \tag{1}$$

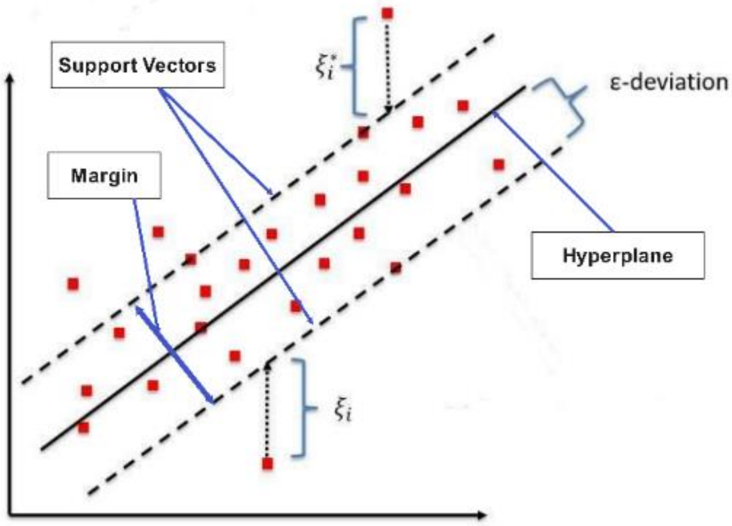

Fig. 1. Two-dimensional support vector machine (SVM) model.

2.2. Artificial neuron network

ANN consists of several layers of perceptron, it is distinguished by the presence of one or more hidden layers placed between its input layers and Release (see Fig.2). Except for entrance nodes, each node is made up of a neuron with a nonlinear activation function. ANN's potential to replicate biological networks improves as the number of connections increases, which results in learning well improved information models encoded in the data (Moncada, Richardson, & Vega-Avila, 2018). Errors between measured and anticipated values are decreased by updating weights 'w_{ij}'. Backpropagation is one of the greatest ways for optimizing these weights (Loka, Sumadja, & Resmi, 2017).

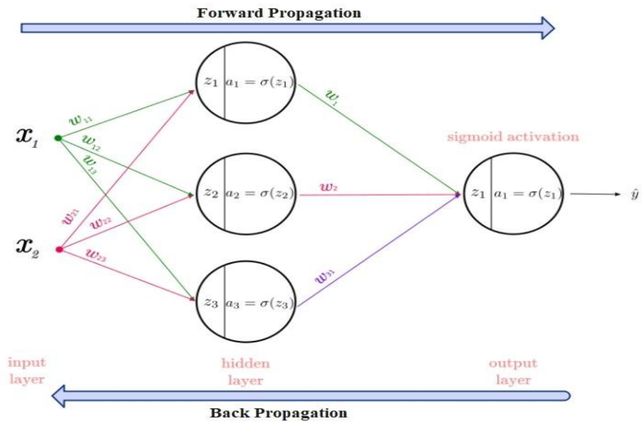

Fig. 2. artificial neural networks Network.

2.3. Long Short-Term Memory

LSTM network, proposed by Hochreiter and Schmidhuber, is a special type of Recurrent Neural Network (RNN) capable of learning long-term dependencies. Its excellent ability to solve both long-term and short-term dependencies makes it a great option for making predictions based on time series data. Its core component is the memory cell, which is jointly controlled by the input, forget, and output gates (Huang et al., 2021). As each gate is a neural network, the output of each gate is the result of the activation function as seen in Figure 3.

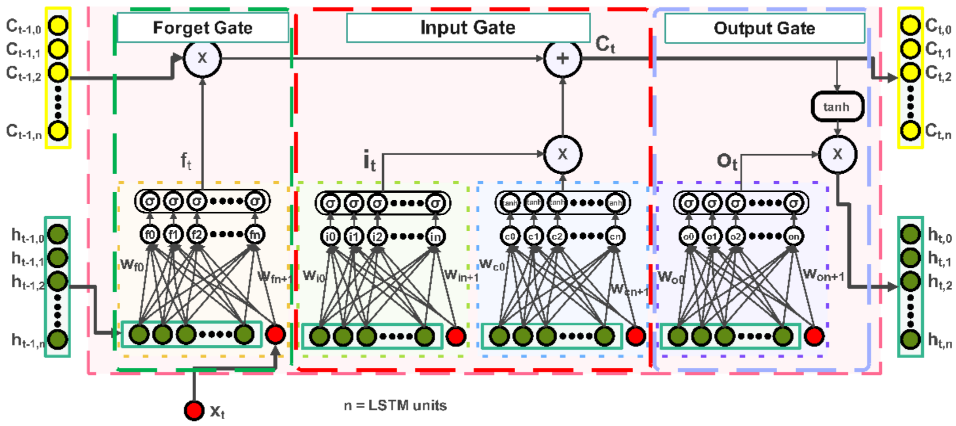

Fig. 3. The information distribution in the LSTM networks.

Based on the last hidden state, the forget gate f_t determines what information should be discarded from the cell state. The input gate i_t chooses which information should be preserved and incorporated into the new cell state. While the output gate o_t controls the output of the LSTM cell. The mathematical of LSTM is described as follows (Graves, 2013):

$$f_t = \sigma(w_f.[h_{t-1}, x_t] + b_f) \quad (2)$$

$$\tilde{C}_t = \tanh(w_c.[h_{t-1}, x_t] + b_c) \quad (3)$$

$$i_t = \sigma(w_i.[h_{t-1}, x_t] + b_i) \quad (4)$$

$$C_t = f_t * C_{t-1} + i_t * \tilde{C}_t \quad (5)$$

$$o_t = \sigma(w_0.[h_{t-1}, x_t] + b_0) \quad (6)$$

$$h_t = o_t.\tanh(C_t) \tag{7}$$

Where $ht{-}1$, $\boldsymbol{x_t}$, $\boldsymbol{\sigma}$ represents the previous state, input data, and sigmoid activation function, respectively. $\boldsymbol{w_f}$, $\boldsymbol{b_f}$ represents the weight matrices, and bias vector, respectively. $\mathbf{tanh}(.)$, $\widetilde{\boldsymbol{C}}_t$ demonstrates the hyperbolic tangent function, and the new candidate cell state are combined to update the new cell state $\boldsymbol{C_t}$, respectively. $\boldsymbol{C_{t-1}}$ represent the previous cell state. Figure 4 illustrates how LSTM cells communicate with each other to form two layers.

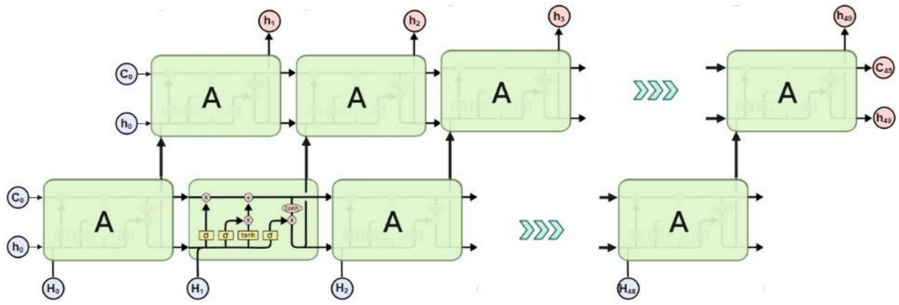

Fig. 4. Two layers of recursively connected LSTM cells series.

3. Methodology

3.1. Data exploration

Three datasets from Los Angeles, San Diego, and San Francisco are employed to assess the three considered models. These locations are distinguished by three distinct climates: hot-summer climate, cold semi-arid climate, and warm-summer climate. The dataset in question was obtained from the National Renewable Energy Laboratory (NREL) ('MIDC: NREL Solar Radiation Research Laboratory (BMS)', n.d.). The dataset under consideration contains sun irradiation data from 2010 to 2020, with 78840 samples with a 1-hour resolution. The first seven years of data are used to train the model, and the 2019 data is used to validate the model performance, while the last year is for testing the effectiveness of the predicting algorithm.

3.2. Data pre-processing

Scaling of input parameters using min-max normalization

To facilitate the extraction of relationships in the data set by the proposed models. The min-max normalization method is applied to the dataset to ensure that all elements fall between zero and one as follows:

$$X_n = \frac{X_{actual} - X_{min}}{X_{max} - X_{min}} \tag{8}$$

Where X_n, X_{actual}, X_{min}, and X_{max} are the new, actual, minimum, and maximum values of the input time series.

3.3. Evaluation criteria

To evaluate the performance of the proposed model, three statistical metrics including Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Coefficient of Determination (R2) are adopted. where the MAE penalizes errors amount, RMSE penalizes big errors, and R2 determines the relationship strength between the predicted value and actual value. Generally, the smaller values of MAE and RMSE values mean a better prediction of the model. For the R2 value, the higher this value, the better a model fits a dataset, where it ranges from 0 to 1 as shown below:

$$MAE = \frac{1}{n}\sum_{j=1}^{n}\left|y_j - \hat{y}_j\right| \quad (9)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(y_j - \hat{y}_j\right)^2} \quad (10)$$

$$R^2 = 1 - \frac{\sum_{j=1}^{n}\left(y_j - \hat{y}_j\right)^2}{\sum_{j=1}^{n}\left(y_j - \bar{y}_j\right)^2} \quad (11)$$

Where $\boldsymbol{y_j}$ and $\boldsymbol{\hat{y}_j}$ represent the measured and estimated solar irradiance respectively.

4. Results and discussion

Three separate area datasets (Los Angeles, San Diego, and San Francisco) were utilized and compared to test the prediction performance of the evaluated models. Table 1 shows the input parameters, the datasets, and the hyperparameters for the various models. The grid search approach was used to find the best hyper-parameters for all models analyzed, which took many hours of computer time per model. Figure 5 depicts the prediction accuracy of the models under consideration as well as their performance in relation to the three datasets. Figure6 and Table 2 show the yearly performance of all investigated GHI prediction models for three target sites, as well as commonly used assessment metrics (RMSE, MAE, and R2). The bolded values represent the best evaluation measure scores for each location among all models.

Table. 1. input parameters and optimal hyper-parameters of different models.

Model	Input parameters	Dataset	Hyper-parameters
ANN	Input: 24x1 (Los Angeles) 36x1 (San Diego) 48x1 (San Francisco)	Train: ‘2012’-‘2018’ Validation: ‘2018’ Test: ‘2020’	Dropout (0.3), Three Dense layers (1024,1024,1), linear Activation
SVM	Input: 80x1	Train: ‘2018’-‘2019’ Test: ‘2020’	kernel='rbf', gamma=0.05, C=10, epsilon=0.05
LSTM	Input: 24,1	Train: ‘2010’-‘2018’ Validation: ‘2019’ Test: ‘2020’	Two LSTM layers (units=128, units=64) Dropout (0.3), Three Dense layers (1024,2048,1), linear Activation

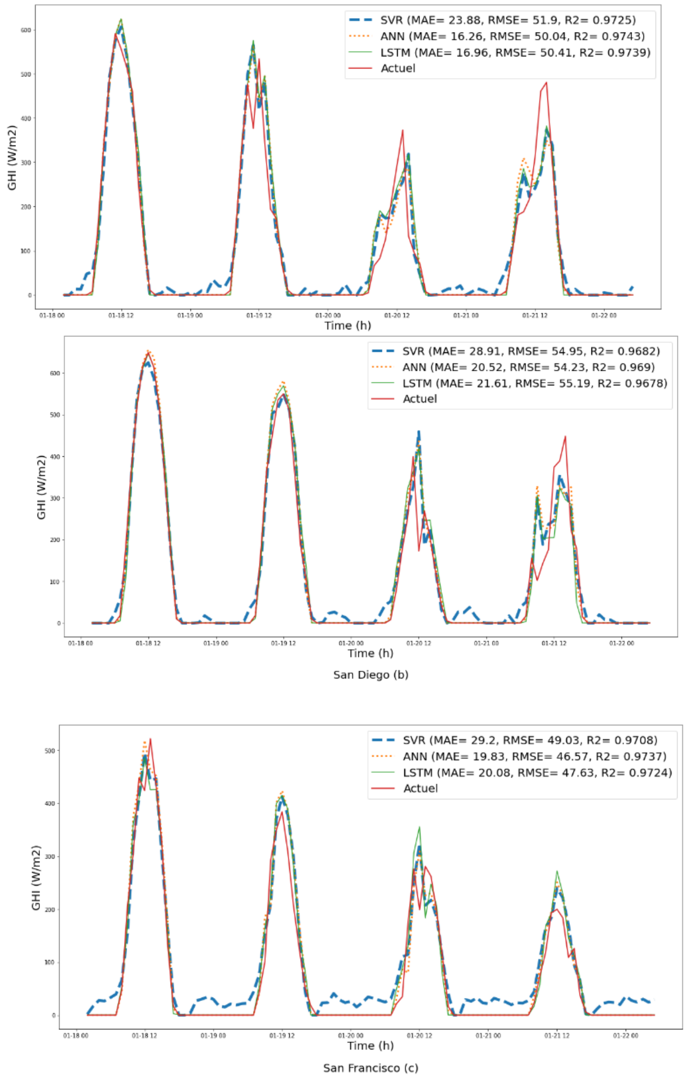

Fig. 5. The training and validation loss curves. (a) Los Angeles, (b) San Diego, (c) San Francisco.

Among all models as shown in Table. 2, the ANN has provided the most accurate forecast across all datasets, whereas the SVR has produced the largest errors, which may be due to the high level of noise present in GHI datasets. LSTM results were more comparable to ANN results. Since the R2 score determines the correlation between the predicted value and the actual value, the ANN model showed the highest correlation between its results and the actual value throughout the entire test, indicating that the ANN has a high resolution for dealing with unexpected solar irradiance fluctuations.

Table. 2. The annual prediction performance of studied models for considered locations.

		SVM	ANN	LSTM
Los Angeles	RMSE	51.9	**50.04**	50.41
	MAE	23.88	**16.26**	16.96
	R2	0.9725	**0.9743**	0.9739
San Diego	RMSE	54.95	**54.23**	55.19
	MAE	28.91	**20.52**	21.61
	R2	0.9682	**0.969**	0.9678
	RMSE	49.03	**46.57**	47.63

San Francisco	MAE	29.2	**19.83**	20.08
	R2	0.9708	**0.9737**	0.9724

Fig. 6. Performance evaluations of different models for each region. (a) Los Angeles, (b) San Diego, (c) San Francisco.

5. Conclusion

This paper presents deep learning models for short-term solar irradiance forecasting, with the aim of determining the highest accuracy that classical deep learning models can provide when predicting solar irradiance. The Artificial Neural Network (ANN) was found to be the simplest, fastest, and most accurate model, outperforming Support Vector Regression (SVR) and Long Short-Term Memory (LSTM) regardless of the characteristics of the data set or the meteorological conditions. In a future investigation, a variety of forecasting methodologies will be combined with the ANN model to improve the accuracy of GHI forecasts.

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Face Recognition Based On Transfer Learning : A Comparative Study

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Abstract

Learning based on convolutional neural networks (CNNs) has shown good performance in the field of pattern recognition, especially for face recognition, due to their capability of extracting discriminative features. In this paper, we perform a comparative study between some of the CNN architectures, such as VGG16, InceptionV3, MobileNetV2, Xception, and DenseNet169, based on both training from scratch and transfer learning strategies. The purpose of our experiment is to analyze the effect of deeper networks and the impact of the hyper-parameters used in the training. The obtained results based on transfer learning approach demonstrate the efficiency of the VGG16 network, with a recognition rate of 100% carried out on the ORL face database.

Keywords: *Convolutional Neural Network (CNN), Deep Learning (DL), Face Recognition, ORL Database, Transfer Learning.*

Introduction

Biometrics are one of the most important topics in computer vision and pattern recognition. Among the various systems used in real life is face recognition. It has been widely applied in many areas such as, public security, access control, and surveillance applications.

Variations in pose, expression, or even illumination still affect the performance. However, learning effective features plays a crucial role in face recognition systems.

Traditional methods that are used for feature extraction, such as Principal Component Analysis (PCA)(Zhao et al., 1998), Histogram of Oriented Gradients (Dalal & Triggs, 2005), Local Binary Pattern (LBP)(Ahonen et al., 2006) and others, fail to perform well in unconstrained scenes.

Recently, due to convolutional neural networks (CNNs)(LeCun et al., 2010), there have been significant advances in face recognition. CNNs are designed to recognize and classify visual patterns automatically by extracting high-level features from low-level pixels with minimal preprocessing.

Some researchers have introduced and employed various architectures, such as AlexNet, VGGNet and GoogleNet, as models for face recognition, while others have reused these networks, and this is what is known as transfer learning. As shown in ''Fig.1'', it can be defined as the process of using a model trained on a large dataset, such as ImageNet(Deng et al., 2009), and transferring its knowledge to a smaller dataset.

Furthermore, in transfer learning, pre-trained weights from a model trained on the source task are used as a starting point for training a model on the target task, where some layers are frozen to retain the knowledge learned during the source task, and typically, the last layer or a few top layers is fine-tuned to adapt the model to the distribution of classes in the target task for making predictions.

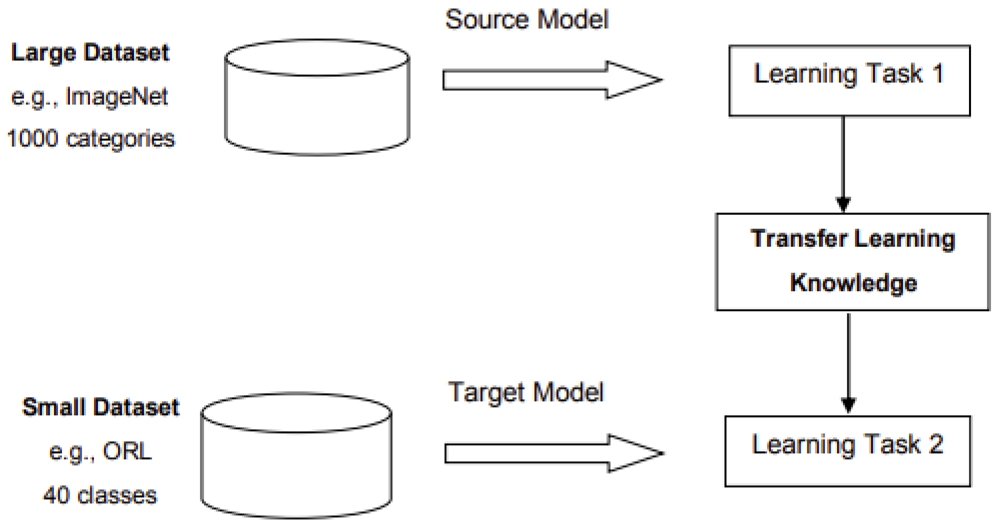

Fig. 1. Concept of the transfer learning strategy.

In the following section, we will discuss some related works that relied on both training from scratch and transfer learning approaches that were carried out using the ORL dataset.

(Almabdy & Elrefaei, 2019) conducted three experiments employing transfer learning with different classifiers. First, they applied the ResNet and AlexNet models for feature extraction separately, followed by a support vector machine as a classifier. Second, they applied only AlexNet with the softmax function as a classifier. An accuracy range of 94% to 100% was obtained.

(Prakash et al., 2019) performed a comparative study between the Principal Component Analysis (PCA) method and the transfer learning method using the pre-trained VGG16. Experimental results show that the accuracy rate using the transfer learning approach has achieved better performance compared to the traditional method.

(Liu et al., 2022) proposed an improved LeNet-5 structure that integrates a deconvolutional layer in the input layer of the network to optimize the process of feature extraction. This method achieved a recognition rate of 95% on the ORL dataset.

(Y. Zhang et al., 2016) suggested an Adaptive Convolutional Neural Network (ACNN), from which the structure can be determined by automatic expansion according to performance requirements. The system average error and the recognition rate of the training samples are adjust to control the expansion of CNN's structure. This model reached an accuracy rate of 91.67% and 93.33% for global expansion, and global expansion with local expansion, respectively.

(Fredj et al., 2021) presented a hybrid model of face recognition based on Principal Component Analysis (PCA) and CNN. The (PCA) technique is used to reduce the dimensions of data, and the CNN is employed for classification. In order to decrease the use of calculation blocks, reduce overfitting, and enhance generalization error, authors have minimized the number of layers and applied the dropout regularization technique. This optimization methodology reaches a recognition rate of 94.2% on the ORL dataset.

In our previous work (Nachet & Stambouli, 2022), we have proposed an approach based on convolutional neural networks (CNNs), in which a Multi-Task Convolutional Neural Network (MTCNN) (K. Zhang et al., 2016) algorithm was used for face detection while a custom model of CNN consisting of four convolutional layers and only two max-pooling layers was applied for feature extraction. The implementation results show that the suggested model achieved an accuracy rate of 97.50% on the ORL dataset, outperforming the state-of-the art models.

Materials and Methods

A. CNN architectures

Model	Number of layers	Parametres (M)
VGG-16	16	138.4
InceptionV3	42	23.9
MobileNet	53	3.5
Xception	71	22.9
DenseNet169	169	14.3

Table 1. Comparison between some CNN architectures.

VGG-16 is a large network with 138 million parameters (e.g., weights and biases). The architecture consists of thirteen convolutional layers, five Max-Pooling layers, and three dense layers, which equates to 21 layers, but it only has 16 layers with learnable parameters. **InceptionV3** architecture was introduced with 42 layers. It is an optimized version of the Inception models in which several techniques have been realized, including factorized convolutions to reduce the number of parameters, parallel computations, additional regularization with batch normalization, auxiliary classifiers, and label smoothing. **MobileNetV2**, this architecture is based on an inverted residual structure where the shortcut connections are between the thin bottleneck layers. The intermediate expansion layer uses lightweight depthwise convolutions to filter features. In general, the model contains an initial fully convolutional layer with 32 filters, followed by 19 residual bottleneck layers. The Xception model is a 71-layer deep CNN, inspired by Google's Inception model With a modified depthwise separable convolution and shortcuts between convolution blocks as in ResNet architectures. Compared with the Inception architecture, the **Xception** doesn't introduce any non-linearity after the first operation. **DenseNet169** is a dense convolutional network with a depth of 169 layers that implements dense connections between layers, e.g., dense blocks, where for each layer, the feature-maps of all preceding layers are used as inputs and its own feature-maps are used as inputs into all subsequent layers. ''Table. 1'' summarizes the number of layers and parameters of different CNN architectures

B. Methodology

In our study, we performed the following stages.

First, the preprocessing stage, in which we applied a multi-task convolutional neural network (MTCNN) algorithm as a face detector to extract only the region of interest. The detected faces were then cropped and resized to fit the size of each pre-trained model. In addition, data augmentation techniques, such as adjusting brightness and applying flipping operations, were employed to increase diversity and reduce overfitting. Data normalization was also applied, where the pixel values in images were rescaled to reduce complexity and accelerate learning in the training phase.

As a second stage, we performed two different experiments, the first of which consisted of training both the VGG-16 network from scratch and with transfer learning for the purpose of better selecting the fine-tuned network parameters. Then, we performed transfer learning using various architectures of CNN that were trained on the ImageNet dataset. ''Fig. 2'' illustrates the overall structure of the proposed strategy.

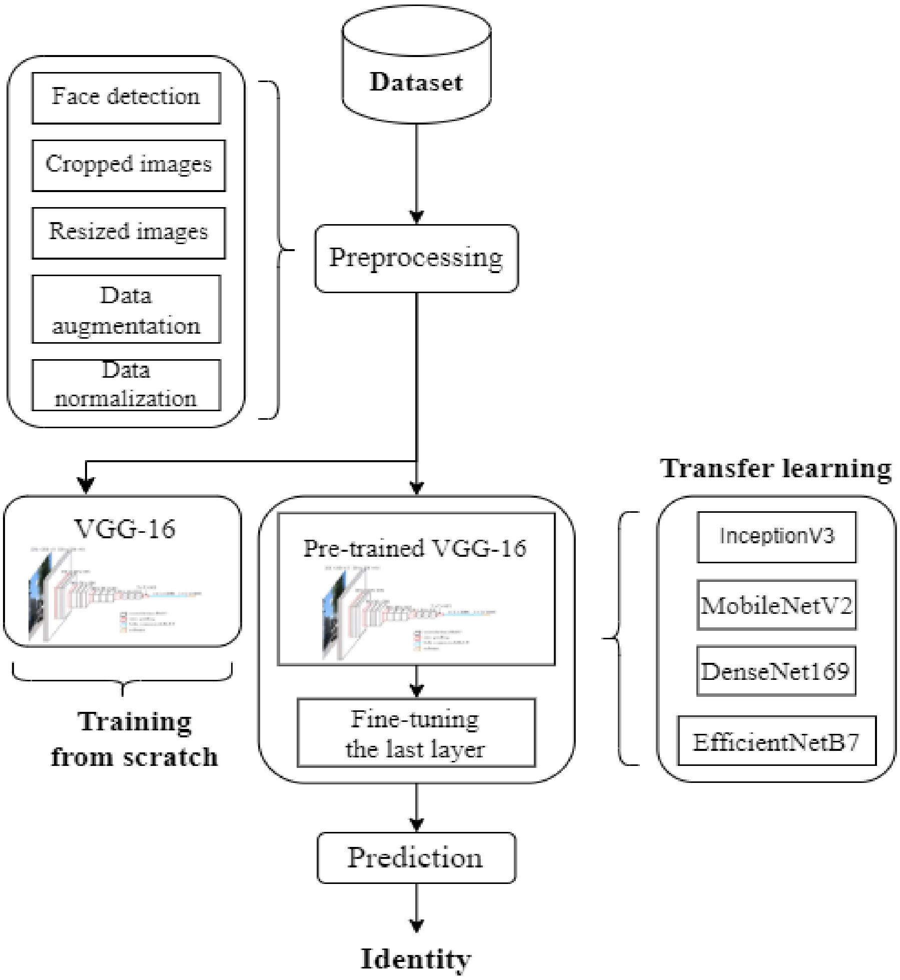

Fig. 2. the overall structure of the proposed strategy.

C. Face Data set

Fig. 3. Representative samples of the ORL database.

The Olivetti Research Laboratory (ORL) face database is used in this experiment, it contains 40 subjects, 10 images per person, and 400 images in total, including variations such as pose, expression, and illumination, as illustrated in ''Fig. 3''. The images are grayscale with a resolution of 92 x 112 pixels. The database is divided into a training set and a test set according to the ratio of 8:2.

D. Experimental environment

The experimental environment of this paper is CPU Intel (R) Core (TM) i5-10400 @ 2.90GHz, the GPU model is NVIDIA GeForce RTX 3060 16GB, and the software environment is CUDA 11.0, CUDNN 8, Python 3.7. The overall framework is Keras.

III. Results and Discussion

In the first experiment and after the preprocessing step, we trained and fine-tuned the VGG-16 pre-trained model for 25 epochs to select the appropriate hyper-parameters. We start by comparing two values of batch size: 32 and 64. It can be seen from ''Table. 2'' that with a batch size of 64, we can achieve better accuracy.

Batch size	Accuracy
32	97%
64	**100%**

Table 2. Performance results with different value of batch size.

For the learning rate, we also choose three different values. The results in ''Table. 3'' indicate that the best choice to obtain good accuracy is 0.001.

Learning rate	Accuracy
0.01	92%
0.001	**100%**
0.0001	97.50%

Table 3. The impact of Learning rate.

Then, we compared between three different optimizers: Adam, RMSprop, and SGD, with a batch size of 64 and a learning rate of 0.001. The results in ''Table. 4'' confirm the effectiveness of Adam's optimizer.

Optimizer	Accuracy
Adam	**100%**
RMSprop	98.75%
SGD	87.50%

Table 4. Performance results generated with three types of optimizer.

Next, we performed a comparison between training from scratch and with the transfer learning approach in terms of accuracy and running time. ''Table. 5'' shows that using the transfer learning approach took less time and reached higher accuracy than training from scratch.

Strategy	Accuracy	Time
From scratch	94%	30s
Transfer Learning	**100%**	**20s**

Table 5. Comparative results between training and transfer learning approach with VGG16.

Secondly, and according to the selected parameters from the results of the first experiment, we employed a transfer learning approach using different models that were trained on the

ImageNet dataset. Multiple metrics were used for evaluation, as listed in ''Table. 6''. The VGG16 has achieved better performance compared to other CNN architectures.

Architectures	Accuracy	Precision	Recall	F-Score
VGG-16	**1**	**1**	**1**	**1**
InceptionV3	0.93	0.94	0.95	0.93
MobileNetV2	0.95	0.93	0.93	0.92
Xception	0.92	0.93	0.94	0.92
DenseNet169	0.96	0.97	0.96	0.96

Table 6. Performance measurement of different CNN architectures.

A comparative analysis of the proposed method and related work using the ORL dataset is summarized in ''Table. 7''.

References	Method	Accuracy (%)
(K. Zhang et al., 2016)	ACNN	93.33
(Fredj et al., 2021)	CNN	94.2
(Liu et al., 2022)	LeNet	95
(Nachet & Stambouli, 2022)	CNN	97.50
(Almabdy & Elrefaei, 2019)	**Pre-trained ResNet**	**100**
	Pre-trained AlexNet	99.17
Our proposed. 2023	**Pre-trained VGG16**	**100**
	Pre-trained InceptionV3	93.75
	Pre-trained MobileNetV2	95
	Pre-trained DenseNet169	96
	Pre-trained Xception	92

Table 7. Summary results of the proposed and related work.

It can be observed that the utilization of pre-trained models as starting point for the training, such as ResNet and VGG16 yields to significant recognition rate compared to state of the art methods, which validates the effectiveness of employing transfer learning for small datasets.

IV. Conclusion

In this research paper, we have investigated the face recognition performance based on both training from scratch and transfer learning strategies using various CNN architectures, including VGG16, InceptionV3, MobileNetV2, Xception, and DenseNet169. The proposed system consists of two main modules; preprocessing and training. We have tested the influence of deeper networks and the impact of the hyperparameters.

Based on the experimental results, we have concluded that the transfer learning approach, specifically utilizing the VGG16 network trained on a huge ImageNet dataset, exhibits higher efficiency compared to alternative architectures

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A Gamification-based approach to improve the learners' engagement in online learning environments

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Abstract

For a long time, learning has used games as active pedagogies; this game-based technique is a very effective tool for improving the retention rate and the acquisition of knowledge of learners. Several research interests on gamification for learning when the learners can engage in their activities to acquire knowledge. In these cases, gamification consists of introducing the game into learning. This research study precisely interests the latter in engagement, where the involvement of learners motivates better. We, therefore, try to know how gamification has an impact on the learner's engagement in online learning environments. And what are the measures to take into account to calculate the engagement of learners to improve it, using the different methods such as traces analysis, and techniques of games.

Keywords: Cognitive *Engagement, Gamification, e-Learning, Learners' Traces, Behavioral Engagement.*

1. Introduction

Gamification is a term that was recently coined to describe the practice of incorporating and utilizing game design features in non-gaming contexts (Bouchrika et al., 2021; Deterding et al., 2011). Thus, the majority of gamification research uses game-based mechanics and game thinking to encourage active learning, engage individuals, and tackle motivating challenges in educational settings (Bouchrika et al., 2021). Also, gamification's purpose is to change a contextual learner's behavior or attitude (e.g., engagement), intending to improve pre-existing instruction as a result of that behavioral or attitudinal change (Landers et al., 2014).

In the past, student engagement was primarily characterized as students' participation in school/university-sponsored events, as well as their views about those activities, which led to engagement and positive outcomes (e.g., achievement, academic knowledge) (Moser, 2020). One of the first researchers who mentioned the concept of student engagement defined it as participation in school activities, in terms similar to those used by researchers today (Natriello, 1984).

Several authors such as (Moser, 2020) classify learner engagement into three types knowing that: behavioral, cognitive, and emotional (affective) engagement. Whereas behavioral engagement is the idea of participation (Mahatmya et al., 2012), cognitive engagement uses "the idea of investment, It entails deliberation and the determination to put in the necessary effort to grasp complex concepts and master difficult abilities" (Mahatmya et al., 2012). Emotional engagement, on the other hand, includes students' positive and negative reactions to classmates, teachers, etc., hence fostering or hindering their willingness to complete their work (Mahatmya et al., 2012). So, the aim of using game context is to get a better idea of the impact of game elements on online learners' learning engagement, various objective measures are collected to quantify behavioral and cognitive engagement.

In this context, the problems we are going to deal with are the following: How gamification impacts learner engagement in online environments? And what are the measures to take into account to calculate the commitment to improve it using game techniques?

Therefore, in our research, we seek to find a method based on gamification in e-learning that generates important learner engagement, and which then allows for an effective learning of learners. Then, we use the gamification approach to improve student engagement to see the impact of gamification on learner engagement.

This article is organized as follows: in the following section, the literature review is reported. Section 3 describes the gamification approach adopted to measure and improve engagement and the paper ends with a conclusion.

2. Related works

In the literature, many works had used gamification to engage students actively, among them (Cassano et al., 2019) suggested a smartphone application “VeeU2.0 Learning Dashboard” where the students gain XP points by using the application and interacting with the system, which they then utilize to advance in level.

Another research (Zainuddin et al., 2020) combined new gamified e-quiz applications and paper-based quizzes to evaluate students' learning performance. A formative evaluation was especially useful once each course was finished. The gamified instructional strategy used was appealing to the three groups because they had never seen it before or in other classrooms.

(Bouchrika et al., 2021) mentioned that at the university level, there was a very low acceptance rate for e-learning. Then, the authors combined a gamified platform with the online e-learning portal of the university. According to the results, gamification can be seen as a useful way to encourage users to utilize educational systems and raise their level of interaction and engagement.

Furthermore, some works (Ouahbi et al., 2020) used an application called Quiz Kahoot where Students were asked to create and play Kahoot quizzes covering the concepts taught in the grammar module. The results show a great interest of the students in these ICT (information and communication technology) activities. Which means that competition is an advantage for evaluation and the engagement of learners in their learning.

According to several authors (Hallifax et al., 2021), a straightforward architecture for a game element adaptation engine was presented. It is based on static adaptation techniques that have been previously studied and produce affinity vectors for learners based on their profiles, as well as dynamic adaptation techniques that analyze learner behavior using a variety of learning analytics to gauge learner engagement and improve these static adaptations. By alerting teachers to students who need the game element they are using to be modified and by offering a different game element to re-engage students. The system actively incorporates teachers in the adaptation process. This theory is supported by the LudiMoodle project (Hallifax et al., 2021), which serves as an example of how this method may be used in various circumstances; i.e this project adapts the games element "another games element for example" according to the learner's situation to engage them in their learning.

Other researchers use Learning analytics through systems developed to promote engagement, Educational games have been used as a tool to promote learner engagement. Educational games applied to a flipped classroom could improve engagement rates, produce favorable learning outcomes and stimulate students' reflective activities. Gamified applications, such as Socrative, Quizizz and iSpring Learn LMS, could significantly improve student performance and engagement (Zainuddin et al., 2020). Game skills could not exert a significant influence on the learning effect, but significantly increase students' engagement in the game. The feature of challenging strongly predicted the learning effect and prolonged learning retention (Yu et al., 2021).

There is research that investigated the effect of personalized metacognitive feedback support based on learning analytics in online learning for recommendation and guidance improved student engagement (Karaoglan et al., 2022). The scale has 3 factors and 19 items. The scale factors are behavioral engagement (5 items), cognitive engagement (6 items), and emotional engagement (8 items). The reliability of the scale was recalculated for this study and high scale scores indicate that students are highly engaged in the online learning environment. Some sample items from the scale are: “I like taking the online course.”, “The online class is a fun place.”, “I feel bored by the online course.”, “If I don’t understand what I’m learning online, I go back and watch the recorded session and learn again.”

Another research aims to deploy gamification as a tool to increase the engagement and motivation of students and thus observe the growth of their learning. The study explores the possibilities of dimensions in the form of game design elements. These elements an instructor can deploy as part of the teaching and learning process. The quantitative and qualitative analysis carried out on two batches of students for two successive terms shows a significant improvement in terms of student engagement, motivation and learning. (Rajput et al., 2022)

3. Proposed gamification-based approach for improving learners’ engagement

In e-learning platforms, learner’s learning activities can be effectively evaluated through online courses to increase learner engagement, using learning analytics. In this approach, Fig.1 illustrates the process of calculating and improving learner engagement from the learner traces. We start with the learner module, as this module calculates cognitive actions such as the learner's MCQ (Multiple choice questions) score, as well as behavioral actions such as logging on to the platform, consulting and downloading learning resources, publications posted and shared by the learner... etc., and then stores them in the learner module. The system then analyzes these traces from the trace management system and sends them to the engagement calculation module to calculate engagement according to formula 1 for cognitive engagement (we calculate the number of MCQs done by the learner L then we multiply them by the sum of corresponding XP experience points, i.e. the experience point earned by the learner fixed by each MCQ ”Multiple Choice Questions” done), and formula 2 for behavioral (we multiply each experience point XP awarded for each action i by the total number for each action i done by learner L, then we divide by the total number of all experience points xp) engagement, and they are proposed these formula because we want to know how the learner engages in learning activities and to know his motivation in the platform, and this through participation in extracurricular activities such as accessing the platform, consulation and downloading of educational resources, adding topics to the discussion forum, sharing publications, and completing his exercises in right time; here we used MCQs ”Multiple Choice Questions”, and normalizes it according to formula 3 (here we have used the normalization formula to normalize the learner's engagement, and we have used the min and max of the other learners' to make the engagement range between 0 and 1 simply) (Tadjer et al., 2022), according to the actions performed by the students through the game mechanism, experience points (XP) as said (Cassano et al., 2019) and classifies these actions thereafter into cognitive and behavioral actions as cited upper. The learner's engagement is tested at any time. According to its value, the learner is recommended an educational game element each time from the game database until the learner's engagement is improved. Fig.2 (We analyze the behavioral engagement of the learner from his traces, then we calculate the behavioral engagement of the learner by formula 2, if the engagement of the learner is down then we recommend an element of games, otherwise we analyze the behavioral engagement again, if the game element solves this engagement we say that the bihavioral engagement is improved, else we recommend another game element. This process will repeat until the bihavioral engagement is improved), and Fig.3 (We analyze the cognitive engagement of the learner from his traces, then we calculate the cognitive engagement of the learner by formula 2, if the engagement of the learner is down then we recommend an element of games, otherwise we analyze the cognitive engagement again, if the game element solves this engagement we say that the cognitive engagement is improved, else we recommend another game element. This process will repeat until the cognitive engagement is improved).

$$\boldsymbol{CoEng(L) = Nb\ (MCQ, L) * Sum(XP, i, L)} \qquad (1)$$

Where:

CoEng(L): The cognitive engagement of the learner L.

Nb (MCQ, L): The number of MCQ done for learner L.

Sum (XP, i , L): The sum of XP points fixed to MCQ i done by a learner L.

Table. 1: Example for calculating cognitive engagement by Learner

MCQ	MCQ1	MCQ2	MCQ3	MCQ4			
XP	2	3	5	4	**Nb (MCQ, L)**	**Sum (XP, i, L)**	**CoENG (L)**
Learner 1	Yes	No	No	Yes	2	6	12
Learner 2	Yes	Yes	Yes	No	3	10	30

$$BeEng(L) = \frac{\sum_1^n XP(i) * TN(i,L)}{N} \quad (2)$$

Where:

BeEng (L): The behavioral engagement for learner L.
XP (i): The XP points attributed to an action i.
TN (i, L): The total number of an action i done by a learner L.
n: The nth partial sum.

N: The total number of XP points.

Table. 2: Example for calculating behavior engagement by Learner

Action i	Log in to the platform	Consultation of pedagogical resources	Downloadin g of pedagogical resources	Publications posted	Publication s shared		
XP (i)	1	3	2	5	3	**N**	**BeENG (L)**
TN (i,Learner 1)	3	2	5	4	2	14	3.21
TN (i,Learner 2)	4	1	2	1	1	14	1.36

Then the formula3 to normalize the two formulas (1) and (2) is:

$$Transformedvalues\ (L) = \frac{Values\ (L) - Minimum}{Maximum - Minimum} \quad (3)$$

Where:

- **Transformedvalues (L)**: The value normalized of the engagement of the learner L.
- **Values**: The value of engagement of the learner L.
- **Minimum:** The minimum value of all learners.
- **Maximum:** The maximum value of all learners.

Then, for classifying the learners into five sub-intervals between the interval [0, 1] as said (Lafifi et al, 2016) by their engagement value, we follow this algorithm:

Begin

If 0<=Transformedvalues (L) < 0.2 **then** engagement is very low

Else if 0.2<=Transformedvalues (L) < 0.4 **then** engagement is low

Else if 0.4<=Transformedvalues (L) < 0.6 **then** engagement is mediaum

Else if 0.6<=Transformedvalues (L) < 0.8 **then** engagement is good

Else if 0.8<=Transformedvalues (L) < 1 **then** engagement is very good

End

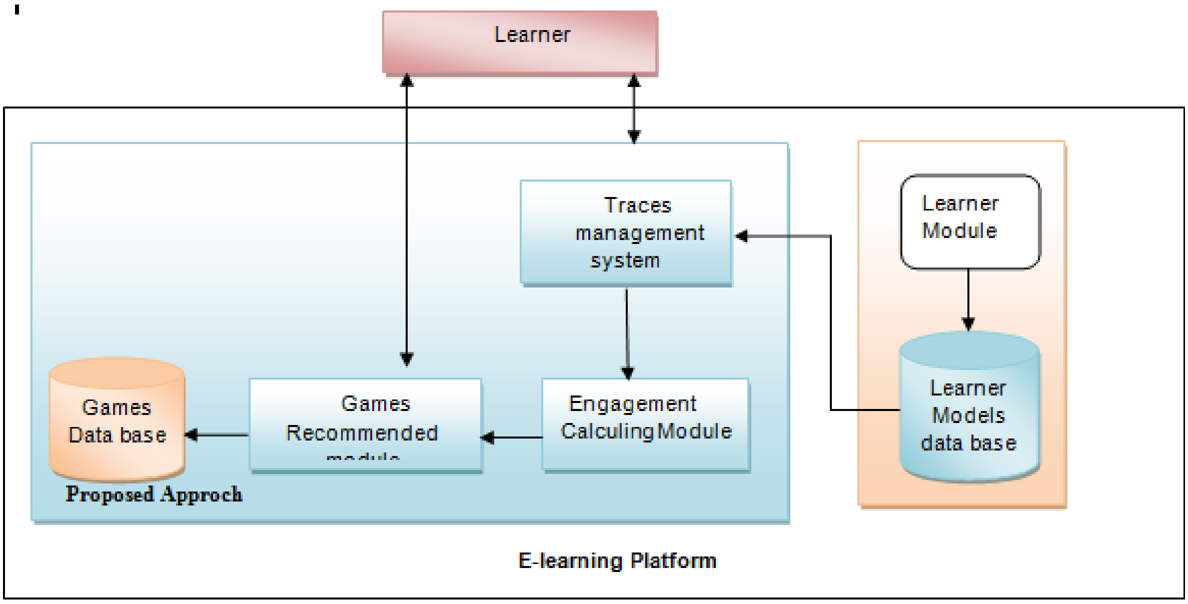

Fig. 1. System Architecture

Fig 1 presents the architecture of the system: first we collect the learner traces from the learner module from the e-learning platform and the store in the learner model, and after the system analyzes these traces from the trace management system, then it sends them to the engagement calculation module to calculate the behavioral and cognitive engagement, based on the actions done by the students, we use the game mechanism based on experience points (XP), and classify these actions according to the type of cognitive and behavioral engagement as mentioned above. The learner's engagement is tested at all times, and each time the engagement value is reduced, the learner is recommended an educational game item from the games recommendation module found in the game database, repeating the process until learner engagement improves.

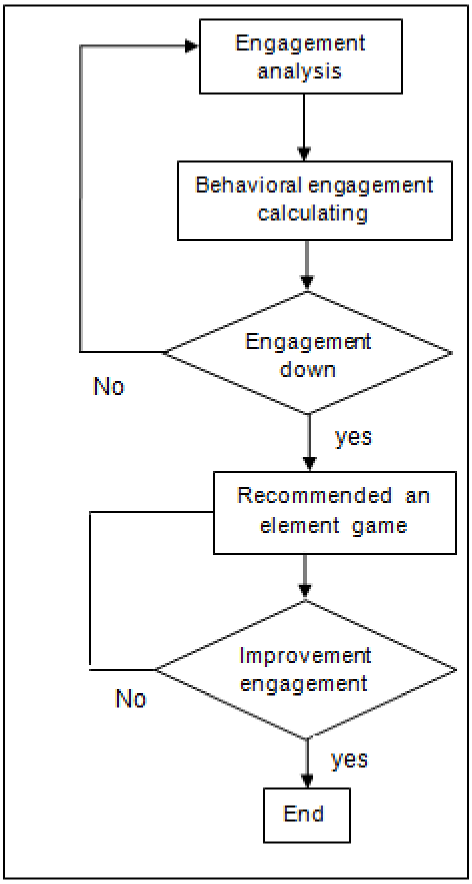

Fig. 2. Behavioral engagement diagram

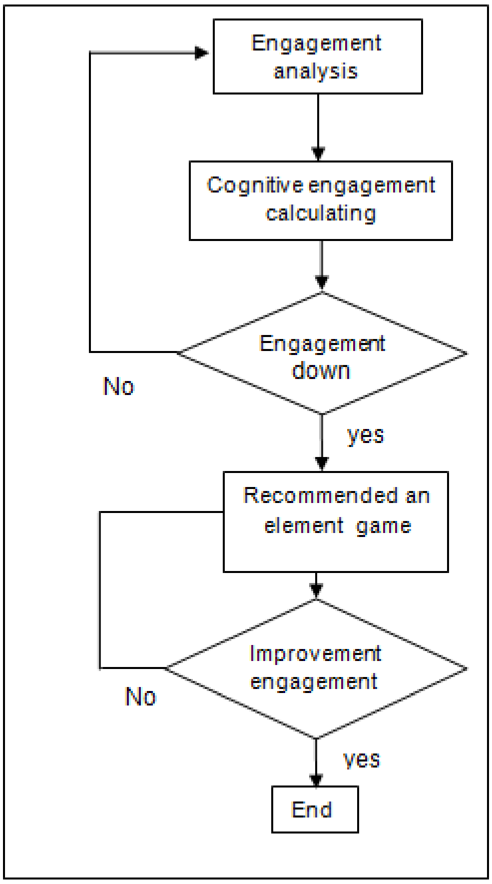

Fig. 3. Cognitive engagement diagram

Finally, we finish with the presentation of the two following elements:

1. **Recommendation of a game:**

Algorithm of recommendation of a game element

Begin

If the first game element is solved **Then** engagement is improved

Else propose another game element

End

(according to figures 2 and 3 we recommend a game element for each engagement (the behavioral and cognitive) when this engagement is down. if the game element solves this engagement we say that the bihavioral and cognitive engagement is improved, else we recommend another game element for each engagement. This process will be repeated until engagement improves.**)**

2. **Improvement of the learners‘ engagement:**

To improve the cognitive engagement of learners, it is necessary to know the game type. In our research context, we use educational games; for example, the game which moves the empty square in a matrix until obtaining the solution of a problem. So, first of all, you have to select this problem which can be:

- An algorithm (it is a method for resolving a data problem; because the learner is demotivated to resolve this problem with a classic method; he can play this game to resolve this problem), For example, if we have an algorithm to solve the following equation y=a+b; the learner starts moving the square of the matrix by “a” then moves the square until he finds the operator “+” then continues the movement until he finds the b, in which the algorithm is resolved and the result is displayed.

- A graph (it is a diagram presented on a plan; when the learner chooses a type of diagram, he can play this game to obtain the solution.), i.e the learner chooses the diagram from the movement of the square of the game matrix until finding the graph corresponding to your solution of his problem.
- A path (it is a way that begins with a starting point and an ending point; when the learner researches this way, he can play this game to arrive at the final point), i.e the learner starts moving the square of the game from the starting point of the path and continues the movement until the stopping point of the path is found, and the solution is displayed to you corresponding to your solution of the problem.
- A certificate (it's a sheet of paper that you get from one of the state establishments when the learner can obtain this certificate (for example greeting card) online by using this game), i.e the learner has the possibility of choosing his wishes from a list by the movement of the square of the game matrix from these wishes one by one in order to obtain the certificate of these wishes.
- etc.

If the learner uses this game to resolve this problem we consider the cognitive engagement as improving. i.e so this game makes it easier for the learner to solve problems without taking the effort to think about these problems and is more motivating and engaging.

To improve behavioral engagement, it is necessary to use the educational game too, but we allow learners to see the ranking and the results of other colleagues who enter a competitive situation, for example, the game in which a learner can see the solution of his pairs if the two solutions are correct then he passed to the next stage, else if the two solutions do not match then repeat the game until obtaining the same solutions and passed to the next stage, and continue like this until the last stage. when the behavioral engagement is improving.

If the learner gets improved the two types of engagement (behavioral and cognitive), so this engagement is improved.

4. Discussion

In this research, we have used what is called learner engagement to gamification which allows it to be improved from the learner's traces; first of all, we collect the traces of the learner such as logging on to the platform, consulting, and downloading learning resources, publications posted and shared by the learner... etc. and after we analyze these traces to calculate the engagement of the learner who has cognitive and behavioral indicators, these indicators are the accomplishment of cognitive tasks such as doing MCQs (Multiple Choice Questions), returning homework as soon as possible, as well as behavioral actions which are the presence in the platform which is measured by the number of connections, and the participation which is measured by the consultation and downloading of resources, and the publications inserted and shared by the learner. In this case, we test if the engagement is decreased, so we recommend a game element. If the latter solves the problem then we consider that the engagement is improved, otherwise, we propose another game element until the engagement is improved.

5. Conclusion and future work

In this article, we have presented the different types of engagement and we have focused on cognitive and behavioral engagement, then we have proposed an approach based on the gamification technique to improve student engagement, with the system earning XP points and the adaptive game “moves the empty square in a matrix”, which are used to increase the learner engagement.

In future research, we propose to use other games to further measure and improve learner engagement, and apply to more groups of learners. Furthermore, we plan to implement an online learning environment adopting the proposed approach, and then test it in real situations.

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Ear recognition system based on multi-scale feature extraction technique

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Abstract

Ear recognition is a biometric technology with great potential for identifying individuals. In this paper, we propose a new approach that utilizes multi-scale Local Binary Patterns (MLBP) for feature extraction and the city block distance for classification. The multi-scale LBP method captures local texture information of ear images at various scales, which is vital for robust feature extraction. To decrease the effect of illumination variations, feature normalization is carried out, which are classified into different categories using the city block distance as a distance metric. The proposed method was evaluated using publicly available database, namely IIT Delhi Ear Database, which contain ear images. The experimental results show that our approach achieves a recognition rate upof 97.67% in IIT Delhi-1 and IIT Delhi-2. These results outperform many recent methods in the field.Moreover, the proposed approach is computationally efficient, easy to implement, and can be used in different applications, such as access control and surveillance systems.

Keywords:ear recognition, feature extraction, MLBP, classification, KNN.

Introduction

Ear recognition is a biometric technology that utilizes the unique features of the human ear to identify individuals. The shape and structure of the ear are distinctive for each person, and unlike other biometric identification methods, the appearance of the ears does not change with facial expressions, emotions, states, age, beard, glasses, or makeup. Ear recognition has gained popularity in recent years as a reliable and accurate biometric identification technique. The most biometric systems for ear recognition are based on geometrical and global techniques.(Chan & Kumar, 2012) proposed a method for Reliable Ear Identification using 2-D Quadrature Filters. Their approach achieved a recognition rate of 96.5% on the IITD 1 database in 2012. In 2013, they investigated a new approach for even more accurate ear identification using visible illumination 2-D ear images, resulting in a recognition rate increase to 97.1%(Kumar & Chan, 2013). Benzaoui et al (Benzaoui, Hadid, & Boukrouche, 2014) utilized local texture descriptors to extract features and tested their methods on three databases: IIT Delhi-1, IIT Delhi-2, and USTB. The results obtained were 97.26%, 97.34%, and 98.46%, respectively. On the other hand, Bourouba et al (Houcine, Hakim, Amir, & Hani, 2015) proposed a system based on Multi-bags-of-features histogram. Their approach was tested on the Delhi-I database, and the reported recognition rate was 96.3%.

In this work, we propose a new scheme for individual ear recognition based on Multi-scale LBP (MLBP) that extracts Local Binary Pattern (LBP) features at multiple scales. This method comprises two main phases: (i) the feature extraction phase, where the MLBP descriptor-based features are computed from human ear images, and (ii) the matching process that uses the City Block Distance-based K-nearest neighbor (KNN) classifier.

The rest of the paper is organized as follows: Section 2 describes the proposed method while the experiments and results are given in Section 3. Finally Section 4 concludes the paper.

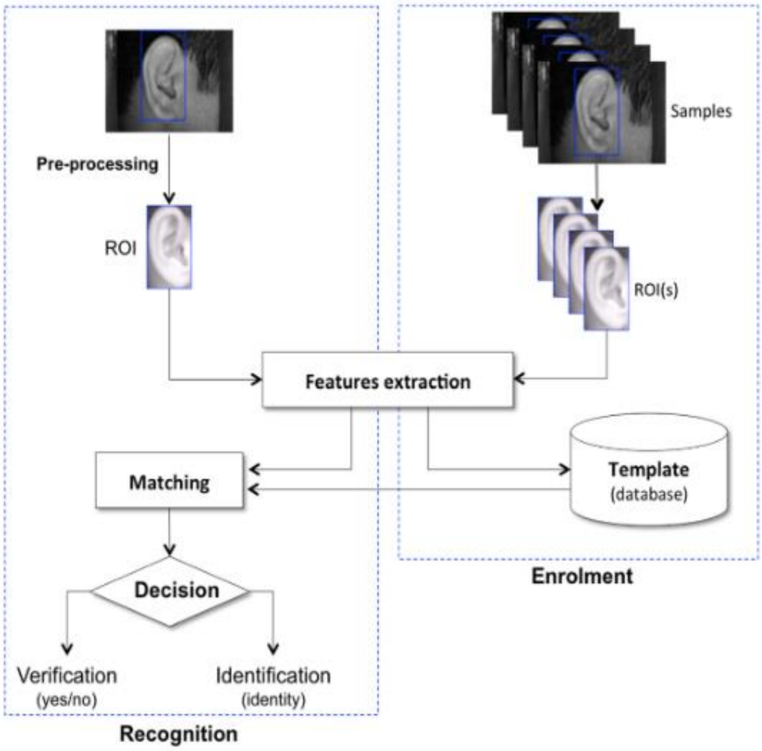


Figure 1. Diagram of ear biometric recognition system (Youbi, Boubchir, & Boukrouche, 2019)

Proposed method

In this section, we present the different steps for individual ear recognition such as: Preprocessing, feature extraction and classification. Figure 1 illustrate the diagram of a human Ear recognition approach.

A. Preprocessing

The suggested feature extraction and classification rules compose the essential steps in our proposed method. However, before driving these two steps, pre-processing is necessary to improve the visual quality of the captured image. The ear image is filtered with a non-linear filter the median filter was adopted to minimize noise while preserving the ear appearance.

B. Multi-scale local binary pattern (MLBP)

Multi-scale Local Binary Pattern (MLBP) is a texture descriptor used in computer vision and image processing. It is an extension of the Local Binary Pattern (LBP) that allows the use of multiple scales for feature extraction.

LBP is a popular texture descriptor where introduced by (Ojala, Pietikäinen, & Harwood, 1996) that computes a binary code for each pixel in an image by comparing its intensity value with that of its neighbors, it defined through:

$$LBP(x_c, y_c) = \sum_{n=0}^{7} 2^n s(i_n - i_c) \qquad (1)$$

where in this case n runs over the 8 neighbours of the central pixel c, i_c and i_n are the gray-level values at c and n, and:

$$s(u) = \begin{cases} 1 & if\ u \geq 0 \\ 0 & otherwise \end{cases}$$

The LBP encoding process is illustrated in figure 2.

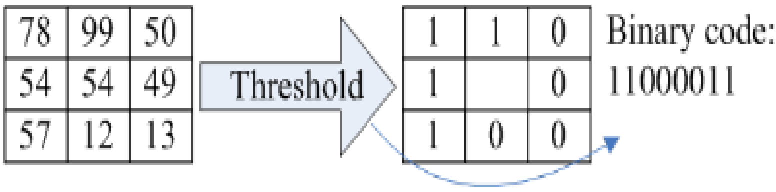


Figure 2. Illustration of the basic LBP operator.

The LBP operator in its basic form, which utilizes a single scale, may not effectively capture texture characteristics and may not be sufficiently robust in handling image translation and rotation. To address these limitations, an extension of the basic LBP, known as MLBP, is employed. MLBP involves dividing an image into several scales (figure 3) and independently applying LBP at each scale by varying the radius of a circle. The histograms from each scale are concatenated to form the feature vector.

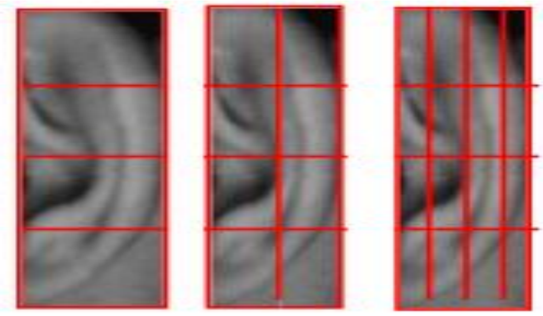


Figure 3. Image decomposition in several scales(Benzaoui, Kheider, & Boukrouche, 2015)

C. k-nearest neighbors (K-NN) classifier

in the process of classification, the tested ear image is compared to those stored in the dataset, and a corresponding label (representing identity) is assigned using the K-NN classifier with a distance metric such as Hamming, Euclidean, or city block. For our study, we utilized the city block distance, also known as Manhattan distance, which is defined in the following manner:

$$\mathbf{CTB}\,[(\mathbf{x_1}, \mathbf{y_1}), (\mathbf{x_2}, \mathbf{y_2})] = |\mathbf{x_1} - \mathbf{x_2}| + |\mathbf{y_1} - \mathbf{y_2}| \qquad (\mathbf{2})$$

In our work, the probability distributions (x_1 , y_1) and (x_2 , y_2) are replaced by feature vectors.

Results and Discussion

In this section, our proposed method is assessed benchmark dataset namely : IIT Delhi Ear Database.

The IIT Delhi ear image database consists of the ear image database collected from the students and staff at IIT Delhi, New Delhi, India. This database has been acquired in IIT Delhi campus during Oct 2006 - Jun 2007 (still in progress) using a simple imaging setup. All the images are acquired from a distance (touchless) using simple imaging setup and the imaging is performed in the indoor environment. The currently available database is acquired from the 121 different subjects and each subject has at least three ear images. All the subjects in the database are in the age group 14-58 years.

The database of 471 imageshas been sequentially numbered for every user with an integer identification/number. The resolution of these images is 272 × 204 pixels and all these images are available in jpeg format (see figure 4). In addition to the original images, this database also provide the automatically normalized and cropped ear images of size 50 × 180 pixels (see figure 5). Recently, a larger version of ear database (automatically cropped and normalized) from 212 users with 754 ear imagesis also integrated and made available on request(Kumar & Wu, 2012).

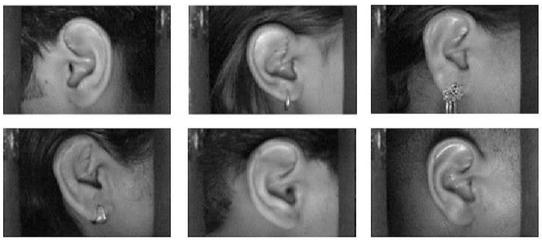


Figure 4. Some ear images from IIT Delhi database(Kumar & Wu, 2012)

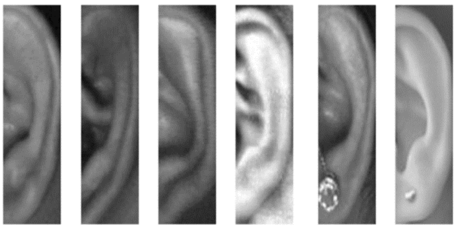
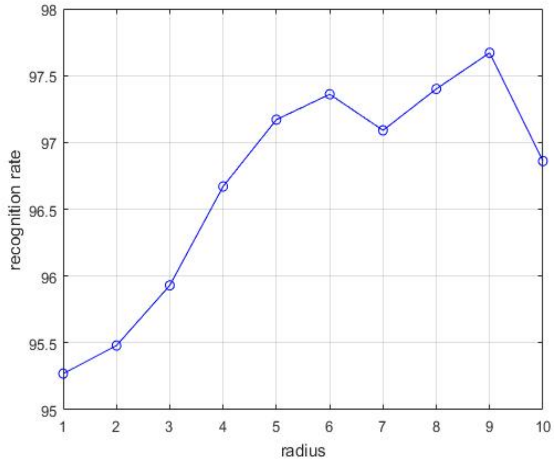


Figure 5. Some ear images from the normalized IIT Delhi database(Kumar & Wu, 2012)

To evaluate the proposed approach, we used hold-out validation techniques to improvedifferent aspects of the performance of a biometric system (See Table 1). Specifically, we used 80% of the whole dataset as the training set and the remaining data for testing. As part of our preprocessing step, we applied a median filter and explored several blocks to determine the optimal patch of the image that gives the best recognition rate. We identified seven patches in IIT Delhi-1 and ten patches in IIT Delhi-2 in our work and extracted features using the MLBP descriptor. Finally, we trained the K-Nearest Neighbor (K-NN) algorithm with K = 1 and the city block distance using the extracted features. The following figure shows the recognition rate for different radii.

Databases	**False Acceptance Rate FAR (%)**	**False Rejection Rate FRR (%)**	**Genuine Acceptance Rate GAR (%)**
IIT Delhi -1	0.03	2.4	75.20
IIT Delhi -2	0.03	4.98	66.06

Table I. The different aspects of performance in our biometric system



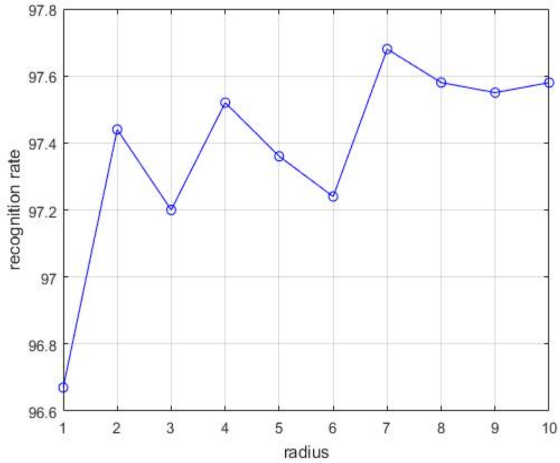


Figure 6. Represent the recognition rate for different radius: (a) IIT Delhi -1 (b) IIT Delhi -2

Based on Figure 6, we can see the effectiveness of the multi-scale structure in extracting features. We calculated the recognition rate for different radii, ranging from 1 to 10. The recognition rate reached 97.67% at R = 9 in IIT Delhi –1 and 97.68 % at R = 7 in IIT Delhi –2.

	recognition rate (%)	
Method	**IIT Delhi –1**	**IIT Delhi –2**
2D Quadrature Filter + Hamming distance (Chan & Kumar, 2012)	96.5	96.1
SRC of Local Gray-Level Orientations + Sparse representation (Kumar & Chan, 2013)	97.1	97.7
Local principal independent components + Inner product classifier (Mamta & Hanmandlu, 2013)	97.60	97.2
BSIF descriptor + KNN (Benzaoui et al., 2014)	97.26	97.3
Nonlinear curvelet features + KNN (Basit & Shoaib, 2014)	97.77	96.2
Gray Level Co-Occurrence + LBP + Gabor Filter (Jacob & Raju, 2014)	///	94.1
LBP and Haar Wavelet Transform + KNN (Benzaoui, Kheider, et al., 2015)	94.51	///
BSIF + KNN (Benzaoui, Hezil, & Boukrouche, 2015)	96.7	97.3

Multi-Bags-Of-Features Histogram (Houcine et al., 2015)	96.3	///
Improved BSIF descriptor (Benzaoui, Adjabi, & Boukrouche, 2017)	97.39	97.6
proposed method	**97.67**	**97.68**

Table II. Comparing the recognition rate (in %) of the proposed method with the state-of-the-art methods

In Table 2, we compared our proposed ear recognition method with several recent state-of-the-art methods that are similar and evaluated on the same dataset. The obtained results demonstrate the robustness and stability of our approach.

Conclusion

This paper introduced a method for human ear recognition based on the MLBP descriptor for feature extraction and the k-nearest neighbor algorithm for classification. Our experimental results on a benchmark dataset demonstrate that our proposed method outperforms similar state-of-the-art methods. Our future work will focus on investigating and studying other multi-scale features that could further enhance the performance of our proposed approach.

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Dynamic Threshold-Based Suitability Approach for Energy-Efficient VM Migration in Cloud Environments

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Abstract

In a cloud environment, virtualization is an effective technology for reducing energy consumption, However, managing virtual machines can be challenging due to factors such as workload, the number of virtual machines, and resources provided per virtual machine, which can affect the energy consumption of host machines. This paper proposes an energy-efficient approach to virtual machine management that takes into account the energy consumption of both virtual machines and host machines. The approach includes a new metric for evaluating the suitability of virtual machines for migration and a dynamic threshold-based algorithm for making migration decisions. The proposed approach was evaluated using experiments conducted on the OpenNebula cloud platform, and the results demonstrated its potential for significant energy savings, benefiting both cloud service providers and users.

Keywords: *Energy-efficient, Virtual machine, OpenNebula cloud environment, Migration.*

1. Introduction

With the increasing dependency on cloud computing, cloud data centers have emerged as more important than ever, as they define the main point of intersection for providing computer services to users. Among the essential devices used in these centers are virtual machines, which form the main foundation for running cloud applications and services. [5]

Managing energy-efficient virtual machines is crucial to improving the performance of these machines and realizing better use of available resources in the cloud data center. Improving virtual machine management involves many necessary steps, such as hardware upgrades, cloud computing techniques application, resource management improvement, use of automation tools, and cost reduction. [6]

The importance of managing energy-efficient virtual machines rests in improving the quality of services provided to customers and moderate costs, which can lead to increased productivity and improved user experience. To reach these objectives, combined plans and strategies must be implemented to enhance virtual machine management, which may include periodic hardware updates, application of the latest technologies, resource management improvement, and use of automation mechanisms. [2], [3]

One of the released open-source systems that support the management of private cloud environments for companies and enterprises is OpenNebula. OpenNebula has the capability to manage various cloud computing resources including virtual machines, virtual networks, and cloud storage. OpenNebula uses virtual simulation technologies to efficiently manage cloud computing resources and energy efficient. [3]

The proposed approach for energy-efficient virtual machine management is one of the major strategies to improve energy consumption efficiency in the cloud environment. [7] This approach relies on two main elements: a new metric to determine the suitability of a virtual machine for migration and a dynamic threshold-based algorithm to determine migration decisions. This approach allows cloud service providers and users to improve the deployment of virtual resources, reduce energy consumption, and achieve significant cost efficiency.

A set of experiments was conducted to evaluate the proposed approach in the OpenNebula cloud, and the results showed a significant gain in the efficiency of virtual resource utilization and energy consumption reduction. These results can provide significant benefits to both cloud service providers and users. Using OpenNebula, organizations can efficiently implement this approach, reach better resource utilization, and achieve cost efficiency.

The remainder of this article will first summarize the tendency of cloud computing technologies and the OpenNbula platform and discuss related studies in Section 2. In Section 3, the 3. System model is presented, revealing how the mentioned contributions are developed. Section 4 shows the evaluation methods and a discussion of the results.

2. Background and related work

The cloud computing environment is a model that allows on-demand access to an allocated pool of computing resources such as host servers, storage, and services over the internet. Cloud operators provide their services to cloud clients on a pay-per-use basis, which can be too cost-effective compared to on-premise solutions.

Virtualization is a major tech that involves cloud computing, which permits multiple virtual machines (VMs) to run on a single host machine. Each VM is isolated from the others and has its own operating system and applications, which provides flexibility and agility for cloud clients. Otherwise, running multiple virtual machines VMs on a host machine can point to high energy consumption and costs. Therefore, energy efficiency has emerged as a critical consideration for cloud operators to reduce their operational costs.

To address this concern, researchers have suggested different methods to optimize the energy efficiency of virtual machines in the cloud environment, such as:

- Dynamic VM consolidation: This technique involves consolidating VMs onto fewer physical machines during periods of low utilization to save energy.
- VM scheduling: This technique involves scheduling VMs on physical machines based on their workload characteristics and resource requirements to optimize energy efficiency.
- Power management: This technique involves adjusting the power consumption of physical machines based on the workload and utilization of VMs to reduce energy consumption.
- Resource allocation: This technique involves allocating resources to VMs based on their workload requirements to improve energy efficiency.

Overall, energy efficiency in virtual machines is an important area of research in cloud computing, as it has the potential to reduce operational costs, increase sustainability, and improve the overall performance of cloud services. increase sustainability, and improve the overall performance of cloud services.

2.1 Opennebula.

The OpenNebula solution is an open-source platform that allows users to manage cloud environments as well as deploy services and other computing resources on demand. OpenNebula provides a simple and flexible web interface for managing your entire cloud infrastructure, including virtualization, networking, and storage.

The architecture of OpenNebula, as depicted in Figure 1, comprises of various components that specialize in different aspects of virtual infrastructure management. OpenNebula follows a modular and strictly layered architecture, which allows it to be integrated with diverse virtualization technologies, such as KVM, Xen, VMware, and VirtualBox, and deployed in different environments. The IaaS is organized into a cluster centered around the Front-end node and multiple back-end nodes, which communicate through SSH and at least one physical network link. OpenNebula is categorized into three layers: tools, cores, and drivers, as depicted in Figure 1. The tool layer consists of management tools that include the command-line interface (CLI), which interact with one another via a set of APIs based on the XML-RPC interface.

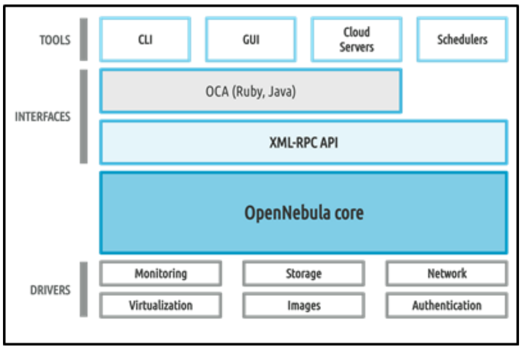

Figure 1. OpenNebula Architecture. [7]

2.2 Managing energy-efficient virtual machines in cloud environment.

One of the most difficult aspects of the Infrastructure-as-a-Service layout is resource management. Indeed, as the cloud environment expands, infrastructure management becomes increasingly complicated. Cloud monitoring solutions, in general, are required functionalities for the automatic scaling of services on both the provider and client sides. On one side, it is an important approach for monitoring, analyzing, and managing real and virtual computing resources. Continue to analyze and monitor the performance, dependability, and energy consumption of the infrastructure or applications, on the other hand.

To address this issue, several cloud providers have applied different energy-efficient approaches such as server consolidation, dynamic voltage and frequency scaling (DVFS), and virtual machine (VM) management. One approach to managing energy-efficient VMs is to dynamically allocate and consolidate VMs on physical servers based on their resource requirements and utilization patterns. [2]

Managing energy-efficient VMs in cloud environment involves monitoring and optimizing the energy consumption of VMs while guaranteeing that the performance and availability requirements of the applications running on these VMs are addressed. This requires the use of various techniques such as workload prediction, resource allocation, and power management. [1]

Overall, managing energy-efficient VMs is a major study in cloud computing, as it has the potential to reduce the energy consumption of data centers and make cloud computing more environmentally friendly and cost-effective.

2.3 Related work.

The progress of cloud computing based on virtualization technologies provides a considerable opportunity to host virtual services at a modest cost without owning an infrastructure. Users may access, configure, and charge virtualization technologies as they utilize them. However, cloud data centers are largely made up of heterogeneous solution servers, hosting multiple virtual machines (VMs), with varying potential specifications and fluctuating resource usages, which can result in unbalanced resource utilization within the servers, as well as performance degradation and Service Level Agreement SLA violations.

From multiple perspectives, this work identifies challenges and analyzes algorithms for resource management in a cloud environment, specifically focusing on managing energy-efficient virtual machines in cloud environment.

In the literature review [1], [2], [3], [4] many research efforts have been made Filed to monitor cloud environments. This research focuses on monitoring the physical and virtual resources of cloud infrastructures. The majority of solutions focus on implementing various strategies to optimize resource utilization while reducing energy consumption, such as Virtual Machine Consolidation, Dynamic Resource Allocation, Load Balancing, etc. By implementing these strategies, cloud operators can achieve optimal resource utilization while minimizing energy consumption.

Lilhor et al. [1] A load balancing method for cloud computing that takes into account energy efficiency. The authors propose a load-balancing algorithm that takes into account the power consumption of each virtual machine in addition to the workload distribution. The algorithm balances the workload across virtual machines while reducing overall power consumption. Li and He [4] propose a power-aware load-balancing algorithm for cloud computing centers. The proposed algorithm considers both the current workload and power consumption of each server in order to make load-balancing decisions that reduce power consumption while maintaining performance.

Sanjeevi and Viswanathan [2] propose a job consolidation algorithm to reduce power consumption in cloud environments by consolidating jobs in fewer servers and shutting down the remaining idle servers. The proposed algorithm takes into account each server's power consumption, workload characteristics, and job deadlines in order to make scheduling decisions that minimize power consumption while maintaining performance. Shaw et al. [3]. A reinforcement learning-based approach to automate energy-efficient virtual machine integration in

cloud data centers. The proposed approach uses reinforcement learning to learn the optimal virtual machine integration policy that minimizes power consumption while meeting performance requirements.

From multiple perspectives, this business identifies challenges and analyzes algorithms for resource management in a cloud environment, with special emphasis on energy-efficient virtual machine management in a cloud environment. Table 1 is a comparative summary of the different approaches to managing energy-efficient virtual machines in cloud environments mentioned in the literature review. It provides an overview of the key components of each approach, such as the energy efficiency measure used, the migration algorithm used, the experimentation environment, and the resulting benefits.

Approach	Energy Efficiency Metric	Migrati on Algorithm	Experimentation	Results
Proposed Approach	Suitability of VM to Migrate	Dynamic threshold-based	OpenNebula Cloud	Promising energy savings
Lilhore et al.	Power consumption of VM	Load balancing algorithm	CloudSim	Reduced energy consumption
Li and He	Power consumption of server	Load balancing algorithm	CloudSim	Reduced power consumption
Sanjeevi and Viswanathan	Power consumption of server and workload	Job consolidation algorithm	CloudSim	Reduced power consumption and improved performance
Shaw et al.	Virtual machine integration policy	Reinforcement learning-based approach	CloudSim	Improved energy efficiency and performance

TABLE I. SYNTHESIS OF RELATED WORK

3. System model

The OpenNebula platform consists of N heterogeneous physical nodes. Each node contains a group of host machines, where each host machine is characterized by its RAM memory size, number of CPUs, storage, and network to enable various processes to provide and migrate virtual machines, among other things.

In such an environment, we do not have prior information about the time when the virtual machine is present or the application loads requested by cloud users through a set of specified characteristics such as RAM memory, CPU, storage space, etc. On the other hand, a Service Level Agreement (SLA) has been allocated between the cloud operator and the cloud customer, whereby the cloud operator bears the burden in case the SLA is breached by failing to meet the requirements of virtual machines for cloud resources.

Figure 2 illustrates the system model, which consists of the cloud manager and OpenNebula VMM. The cloud manager interacts with the OpenNebula Cloud API (OCA) to communicate with the virtual machine monitor (VMM) of OpenNebula. OCA encapsulates access to OpenNebula's XML-RPC API, which is directly responsible for virtual machine migration. The cloud manager benefits from a comprehensive view of virtual machine control while executing by retrieving information related to available resources.

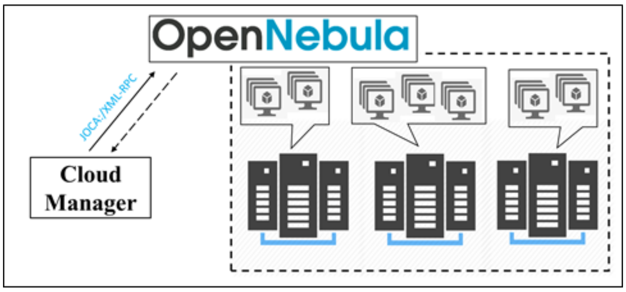

Figure 2. Scheme of interactions between the cloud manager and opennebula.

3.1 The proposed algorithm.

The proposed algorithm relies on two main points:

Determining the host's status (overloaded/underloaded): This leads us to determine resource consumption thresholds for the available RAM and CPU on the host. For example, when resource usage on the host exceeds its current capacity to handle it efficiently, this leads to a deterioration in the performance of the services and applications hosted on the host. This necessitates migrating the virtual machines from this host to other hosts.

Determining the suitable virtual machine for migration: Many factors and criteria can be used to determine the suitable virtual machine for migration. Among these factors, the Resource Utilization Factor can be used as a measure to determine the suitable virtual machine for migration based on the utilized resource factor.

Figure 3 illustrates the detailed steps followed by the algorithm, which are periodically executed.

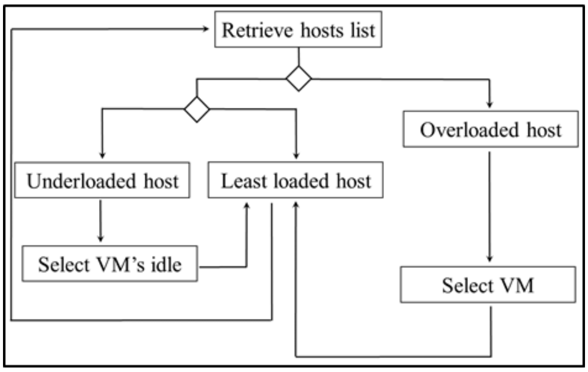

Figure 3. Algorithm flowchart.

3.1.1 Determine overloaded or underloaded hosts.

Determining overloaded hosts or underloaded hosts is the first step in the proposed algorithm to improve performance and ensure the sustainability of the cloud environment. Host workload can be interpreted as the amount of processing and memory that is being used by virtual machines that are running on the host. If the load on the host exceeds the maximum available processing power, system performance may be affected and lead to service breakdown. On the other hand, using a host with low load capacity can waste energy and resources used to run the host.

Algorithm 1 shows in detail how to determine which hosts are overloaded or which hosts are underloaded, as well as which hosts are suitable for virtual machine migration. The resource utilization ratio can be defined as a percentage of the actual usage of the resources available on the host. For example, the CPU utilization ratio can be defined using the percentage of processing used on the host compared to available through the following relationship (1):

$$CPU\ utilization\ ratio = \ (CPU\ used\ \div available\ CPU)x\ 100\% \qquad (1)$$

While the memory usage ratio can be defined using the percentage of memory capacity used on the host compared to the total memory capacity through the relationship (2):

$$Memory\ utilization\ ratio = \ (Memory\ used\ \div available\ Memory)x\ 100\% \qquad (2)$$

For adequately loaded hosts, i.e. hosts that have not exceeded the maximum available processing or memory capacity, or with low load capacity. To do this, the use of the ratio of processing utilization and ration of memory utilization was restricted between two thresholds, UpperThreshold and lowerThreshold, whose values were set to 90% and 5% respectively. Then we allocate the virtual machines for these hosts to meet the requirements of these machines in terms of resources.

Algorithm 1: Least Loaded Host

```
Input: host list
UpperTh: UpperThreshold adjustment factor
LowerTh: LowerThreshold adjustment factor
# Step 1: collect data
Foreach host in host list Do
    Memory_usage ← get_memory_usage(host)
    CPU_usage ← get_cpu_usage(host)
    host_data[host] ← { memory_usage, cpu_usage}
End foreach
# step 2: analyse data
Foreach host in host_data[host] Do
    CPU_utilization_ratio ← CPU_utilization_ratio
    Memory_utilization_ratio ← calculate Memory_utilization_ratio
    If (CPU_utilization_ratio > UpperTh or Memory_utilization_ratio > UpperTh) Then
        Host_status ← overload
        Select VM to migrate
    Else if (CPU_utilization_ratio < UpperTh and Memory_utilization_ratio < UpperTh) Then
        Host_status ← underload
        Select VM's idle to migrate
    Else
```

```
        Host_status ← Least loaded
        Select host ← {best host to accept vm migration}
    End if
end foreach
return {best host to accept vm migration}
```

3.1.2 Determine overloaded or underloaded hosts.

Migrating virtual machines (VMs) from the host machine requires careful consideration of several factors to ensure a successful migration. In our solution, we consider the low performance of the virtual machine as a criterion for selecting a suitable virtual machine for migration. Decreased performance of a virtual machine can be defined using an equation that calculates the difference between the current performance of the virtual machine and the expected optimal performance of the virtual machine as follows:

$$Performance\_Drop = (Current\_Performance - Optimal\_Performance) / Optimal\_Performance \quad (3)$$

where:

• Performance_Drop is a variable that expresses the percentage of performance drop.

• Current_Performance is the current performance value of the virtual machine.

• Optimal_Performance is the expected value of a virtual machine's performance under optimal conditions

The definition of current performance value and optimal performance depends on the type of operation that is performed on the virtual machine. It can be achieved by monitoring the resources used (such as memory and processing) for each virtual machine and selecting those that use resources in a balanced manner and do not put pressure on the shared resources of the host machine.

The resource utilization factor can be used as a mathematical measure to determine the appropriate virtual machine for migration based on the resource utilization factor. This coefficient is calculated as follows:

$$Resource\ Utilization\ Factor = (RAM\ used + CPU\ used) / (Total\ RAM + Total\ CPU) \quad (4)$$

where:

• RAM used is the used random space in gigabytes of RAM for the respective virtual machine.

• CPU used is the percentage of processor usage of the respective virtual machine.

• Total RAM is the total random memory of the server.

• Total CPU is the total processing power of the server.

The virtual machines on the host machine can be arranged according to the value of the resource utilization parameter and choose the one that gets the lowest value of this parameter to migrate, in order to obtain the best balance between resource use and performance improvement.

Algorithm 2 describes the steps involved in determining which virtual machines are to be migrated. The Threshold is determined based on the appropriate value that achieves the best balance between system performance and resource usage. Which ranges from 0.5 to 0.8 for the resource utilization factor of the algorithm. And the threshold value can be set periodically according to system need and practical load changes.

Algorithm 2: Lowest performance VM

```
Input: VM list, host list
Th: threshold for resources usage
Foreach host in host list Do
    Foreach VM in VM list Do
        Performance drop (vm) ← calculate performance drop (vm)
        If (Performance drop (vm) < Th and Least Loaded Host = true) Do
            set VM(Lowest performance VM). Least Loaded Host
        Else
            set VM's idle. Least Loaded Host
        End if
    End foreach
End foreach
return { Lowest performance VM}
```

4. Experiment and result

4.1 Expiremntal environment.

In this section, we will describe the experimental platform and methodology used to develop the model of the system and default algorithm provided in OpenNebula, and compare them with each other. The experimental environment consists of a physical machine equipped with an 11th Gen Intel(R) Core(TM) i7-1185G7 @ 3.00GHz 1.80 GHz, 8 Core processor, 32768MB of memory, and a 1TBSSD hard drive. Real-world resource consumption load paths for both cpu and memory are used using stress ressources tools, which enables us to monitor each host individually. Regarding OpenNebula, An appropriate virtual machine template must be created to launch the virtual machine instance. Table II shows the instance type for template configuration, which defines the most appropriate parameters for creating a virtual machine. Each instance type has a specific performance template (instance name, amount in terms of memory and CPU, storage, image on which this instance will be executed, etc).

	VM
CPU	0.1
Memory	512 MB
Disk	ttylinux-kvm-4
Hypervisor	KVM
NIC	Network = Private cloud

TABLE II. SPECIFIC PERFORMANCE TEMPLATE

4.2 Results and Discussion

The proposed system model was tested after applying the displacement technique based on fixing the values of the previous parameters. Figures 4 and 5 show results obtained from the sunstone graphical interface of the OpenNebula platform, in two different cases, results for the default algorithm provided in OpenNebula (Figure 4) and the second for the proposed system model (Figure 5).

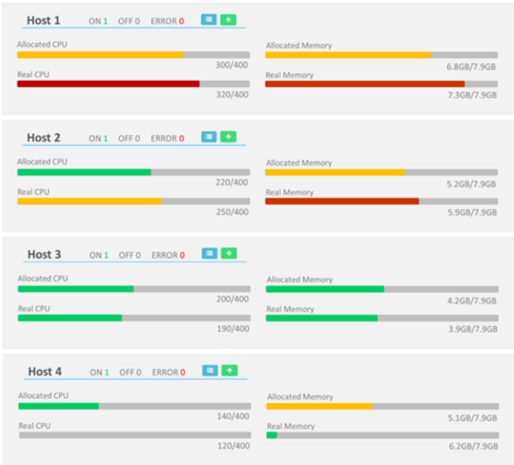

Figure 4. Default algorithm provided in OpenNebula.

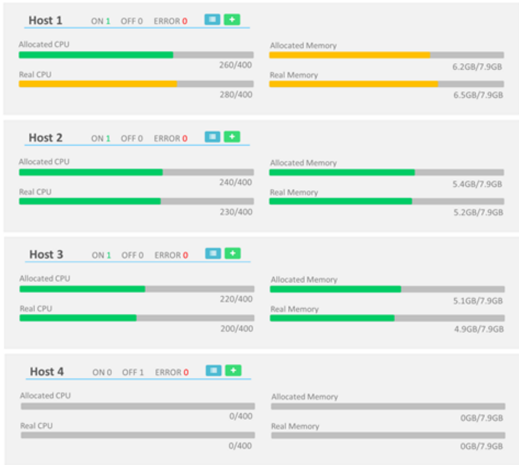

Figure 5. Our system model .

The results show that the performance varies according to the load applied to the host machine, which changes due to the number of virtual machines that are running on it. Our proposed solution shows a clear advantage in terms of resource consumption and optimal use of host machines, where fewer hosts are running compared to the default algorithm provided in OpenNebula.

Figure 6 illustrates that the proposed model has a lower number of migrations compared to the default algorithm provided in OpenNebula. This indicates that virtual machines are not being migrated excessively during the initial stages of migration from overloaded hosts. The reason for this is that the proposed system selects hosts with the lowest load and the fewest number of virtual machines with low consumption. In addition, the migration process is guided by a methodology that identifies virtual machines that require the most resources.

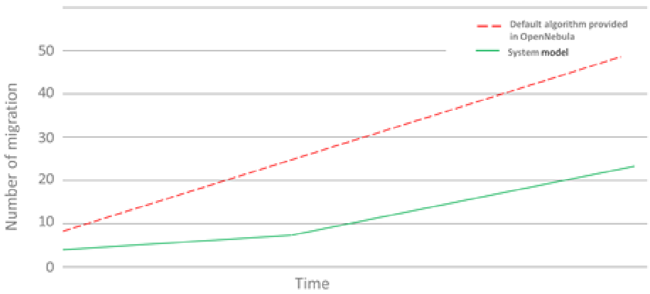

Figure 6. The number of migration in each of default algorithm provided in OpenNebula and our algorithm

5.Conclusion

In this research, we have presented an effective solution to the problem of balancing between energy-efficient and performance in the OpenNebula cloud environment. We compared the algorithm that we adopted through the system model that we proposed with the default algorithm available in the OpenNebula, taking several factors, such as choosing the least loaded host machines, which It is directly related to the number of migrations we aim to achieve, as well as the choice of virtual machines that need more resources than others.

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A comprehensive Studies Between Maximum Power Peak using Stochastic Techniques for PV Systems under PSC

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Abstract

The use of Maximum Peak Power Tracking (MPPT) algorithms in photovoltaic (PV) systems is crucial, as it can significantly impact PV system performance during operation under partial shade conditions (PSC) or variable climate conditions (temperature and irradiance). To enhance the output power of a solar PV system, it is essential to ensure that it operates at its highest possible maximum power point (MPP) to provide sufficient power to meet the required load. This paper presents a comparative study between two stochastic MPPT-based controllers: the Cuckoo Search (CS) algorithm and Particle Swarm Optimization (PSO). The aim is to mitigate the effects of PSC on system efficiency and determine the MPPT controller that can accurately track the maximum power generated by the PV panel. Simulation results demonstrate that the CS algorithm tracked the highest power output at 233.6262 kW, while the PSO reached up to 234.6449 kW, indicating better performance, efficiency, and accuracy.

Keywords: *partial shading conditions (PSC), maximum power point tracking (MPPT), Stochastic techniques.*

I. Introduction

In recent years, the demand for energy has significantly increased, prompting a greater emphasis on finding alternative energy sources, especially considering the eventual depletion of fossil fuels. One such alternative source is the photovoltaic (PV) power system, which is gaining popularity due to its eco-friendliness, durability, and low maintenance requirements [1-2]. To maximize the benefits of PV systems, they must operate at their maximum power point under various atmospheric conditions, given their relatively low conversion efficiency. PV systems operate outdoors and are exposed to various environmental factors such as irradiation and temperatures [3], among others. The output power generated by a PV module is not constant due to its non-linear characteristics, which are influenced by climatic conditions. Therefore, it is essential to ensure that the PV array operates at the maximum power point (MPP), achievable through the use of MPPT-based controller algorithms [4]. Partial shading conditions are a common occurrence that can significantly reduce the efficiency of photovoltaic (PV) systems [5]. This can lead to issues such as the formation of hot spots, power loss, and imbalanced loads within PV array modules [6]. In partial shading conditions, the PV array does not receive uniform sunlight [7], resulting in a change in voltage polarity across the shaded cells, transitioning from positive to negative and causing hot spot problems [8]. While these issues can be mitigated using bypass diodes, this solution may introduce another problem: multiple peaks in the medium-term PV characteristic curve of the PV system.

Numerous approaches exist to mitigate the effects of PSCs and find the MPPT. These methods can be categorized into two types: conventional and stochastic techniques [9]. Among the most preferred conventional methods used for determining the MPP are the Incremental Conductance Technique (ICT) [10], Hill Climbing Technique (HC-T), Fractional Open Circuit Voltage (FOCV) algorithms, and more [11-12]. However, the most commonly used method is the Perturb and Observe (P&O) [13-14]. This popularity is due to its simple structure, ease of implementation, and efficient tracking.

However, these algorithms are only reliable under conditions of uniform irradiation and temperature with stable atmospheric conditions. They do have various drawbacks, such as potentially bringing the operating point to the maximum local power (LMPP) and becoming disabled in this scenario [15].

Stochastic techniques are known for their accuracy and high speed in tracking the MPP under various environmental conditions. These approaches offer several benefits, including the absence of continuous state oscillations and the capability to trace the MPP during PSC. However, the negative aspects of these methods mainly stem from their high implementation costs, extensive memory requirements, complex structures, and the need for substantial data training, among other factors [9].

A significant advantage of most MPPT methods based on artificial intelligence and evolutionary algorithms is their ability to track the maximum power point (MPP) under different environmental conditions by analyzing the PV array's output characteristic curves, such as the P-V curve or I-V curve [12].

In this research work, a MATLAB Simulink model is employed to investigate two stochastic algorithms for tracking the global MPP, namely PSO and CS. These methods are utilized to analyze and evaluate tracking performance, efficiency, and accuracy under various weather conditions.

The remainder of this paper is structured as follows: Section 2 discusses the PV system and its controllers. Section 3 explains the MPPT algorithms. Moving forward, Section 4 presents the numerical simulations and results. Finally, Section 5 provides conclusions and outlines future work.

II. Modeling Of PV array under PSCs

The single-diode PV cell model is widely employed for modeling PV systems due to its simplicity, robustness, and minimized redundant connections [12] [16]. This model is depicted in Fig.1.

The I-V characteristics of the PV cell model can be explained using Kirchhoff's current law, which is represented by the following equation [12]:

$$I_{PV} = I_{ph} - I_d - I_{sh} \tag{1}$$

$$I_{PV} = I_{ph} - I_o \left(\exp \frac{q(V_{PV} - I_{PV}R_s)}{nKT} - 1\right) - \left(\frac{V_{PV} - I_{PV}R_s}{R_p}\right) \tag{2}$$

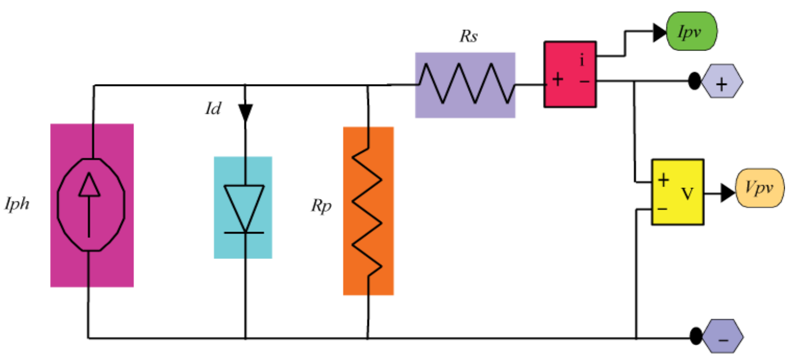

Fig. 1. Equivalent circuit of Single diode model PV cell

where V_{pv} and I_{pv} denotes the output voltage and output current of PV solar cells; I_{ph} is the insulation current or photocurrent generated directly by the incident of sunlight on the PV cell; I_d is a diode current, I_0 is the diode saturation current; R_s and R_p are the series resistance and shunt resistance of the PV cell respectively; K is the Boltzmann constant; T is the PV cell temperature.

II.1 Characteristics of PV Model

Table I. shows the electrical specification parameters of the PV module used in this work.

TABLE I. PV MODULE PARAMETERS OF OF THE PV MODULE

Parameters	Abbreviation	Value
Maximum power	Pmax	213.15W
Voltage at MPPT	Vmax	29V
Current at MPPT	Imax	7.35A
Short circuit current	Isc	7.84A
Open circuit voltage	Voc	36.3V
Temperature coeffecient Isc	Tsc	0.102% deg.C
Temperature coeffecient Voc	Toc	-0.36099 % deg.C
Series-connected cells	No.cells	60

According to the equations (1), and (2), the typical characteristics of the solar photovoltaic cell are illustrated by the current versus voltage (I-V) and the power versus voltage (P-V) curves, Which can illustrate in figures 2 and 3

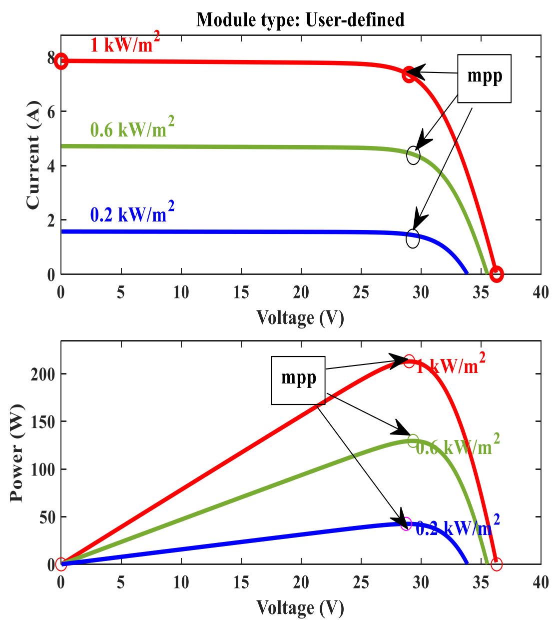

Fig. 2. (a) Demonstrates the I-V and P-V characteristics of PV module at various irradiance (1000 W/m2, 600, and 200 W/m2) and a constant temperature of 25°C.

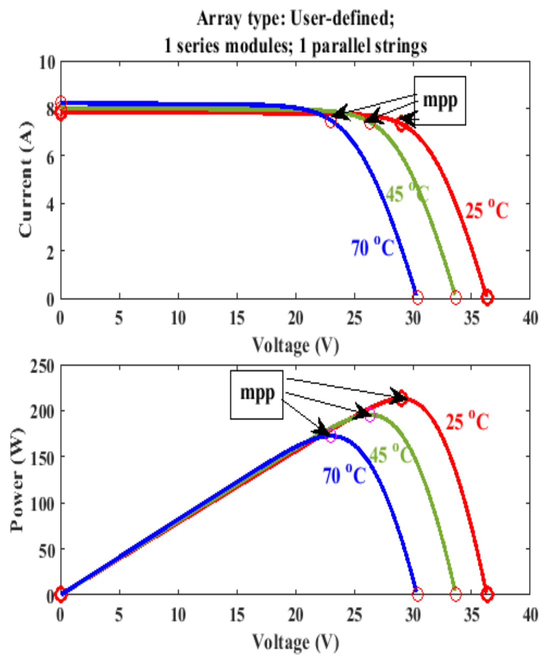

Fig. 2. (b) Demonstrates the I-V and P-V characteristics of PV module at various temperatures (25°C, 45°C, and 70°C) and constant irradiance of 1000 W/m2.

It can be observed that, at a fixed irradiance and temperature, there is a unique point corresponding to the maximum power that the PV array can generate. Therefore, a tool for tracking this specific point is required to maximize the energy produced by the PV system.

II.2 Modelling of Partial shading conditions in Photovoltaic Power Systems

A PV system is modeled using two series (2S) PV Soltech modules connected in series with a DC-DC boost converter acting as a step-up stage between the source and the load to control the operating voltage. The partial shading irradiance values for each module are 1000 W/m² and 500 W/m², while the other module operates under normal conditions, both maintaining a constant irradiance with a temperature of 25°C. The 2S PV system configuration is depicted in Figure 3. By adjusting the switching signals (duty cycle) of the power electronic converter, the output voltage can be varied from its minimum value to the maximum value defined by the converter rating. When D = 0, the output voltage from the converter is at its minimum, and as the duty cycle approaches unity (maximum value), the output voltage reaches its maximum. Consequently, the duty cycle operating range for the boost converter is from 0 to 1. As a result of shading, the power generated by the shaded modules decreases significantly. Consequently, the power versus potential (P-V) characteristic plot reveals both a local and a single global maximum power peak. Environmental changes such as variations in irradiance and temperature lead to an exclusive operating point on the P-V characteristic plot known as the maximum power point (MPP). This single operating point adapts its position in response to changes in weather conditions.

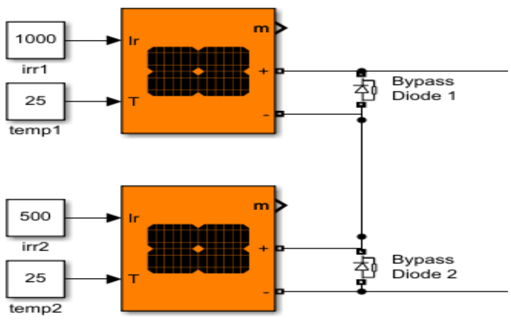

Fig. 3. Simulation of PV Array Model.

The power versus voltage (P-V) and power versus current (I-V) characteristic plots of photovoltaic strings during the partial shading condition are shown in Fig. 5 and Fig. 6.

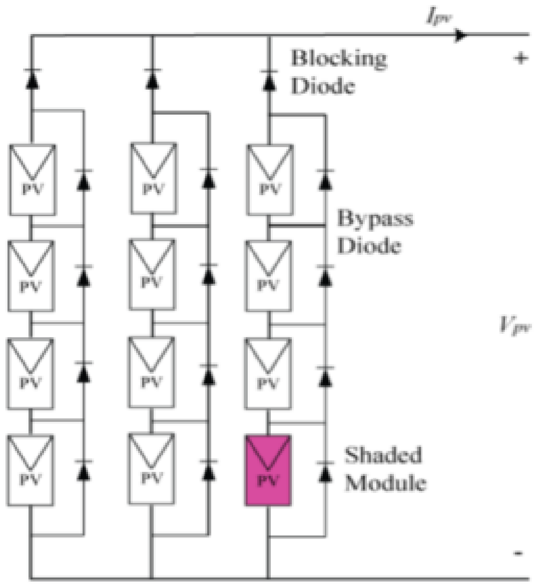

Fig. 4. Characteristics of partially shaded PV array

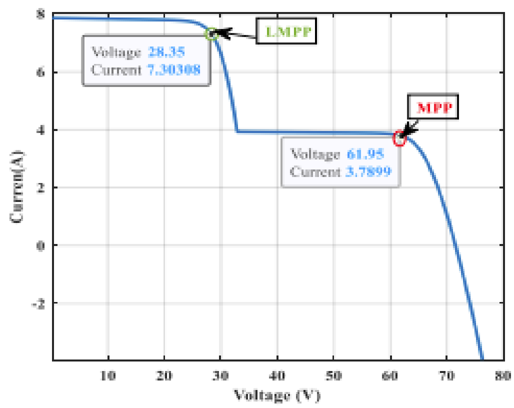

Fig.5 I-V under partial shading condition

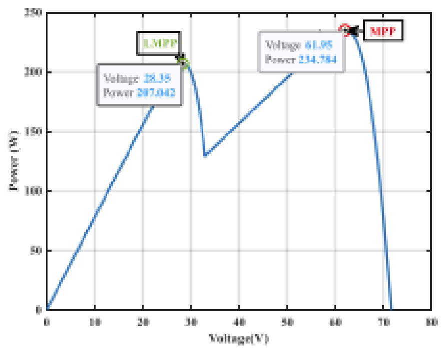

Fig. 6. P-V under partial shading condition

Figs. 5 and 6 display the resulting curves under partial shading conditions (PSC). Consequently, these curves are characterized by two peaks in both the P-V and I-V curves. The highest peak represents the maximum power point (MPP), while the lower peak corresponds to the local maximum power point (LMPP). The photovoltaic (PV) array operates at its maximum power point (MPP) with a value of 234.784 W, at a voltage of 61.95 V, and a current of 3.7899 A.

III. Metaheuristic Optimization for Tracking MPP

This section will cover a brief description of the metaheuristic methods used in this work to track the MPP under PSC. The Fig. 7 presents a block diagram of the proposed model.

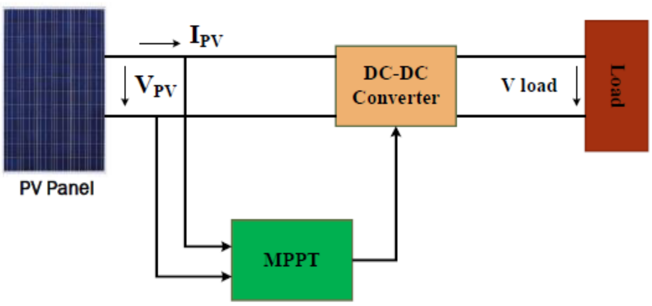

Fig. 7. Block diagram of the proposed model.

III.1 Application of PSO in MPPT technique

The PSO method is widely employed for extracting the optimal energy from PV sources. This is mainly due to its simpler structure, which requires no mathematical model, high adaptability, and few tuning parameters [17]. PSO is considered the best approach for precisely tracking the maximum power point (MPP), and it is typically used in various weather conditions, including partially shaded PV systems, thanks to its versatile search mechanism [15]-[18].In Fig. 8, the topology of the PSO-based MPPT [19] is described. The duty cycle and the output power generated are specified as the particle swarm position and fitness value assessment function, respectively. The position and velocity of each particle are randomly initialized within a uniform distribution. The particle's fitness value is then computed and updated in relation to the previous value. Each particle's best position and global best position are updated in comparison to their earlier values. After that, the locations and velocities of the particles are adjusted appropriately [18].

III.2 Application of Cuckoo Search (CS) in MPPT

The Cuckoo Search (CS) technique is a recent metaheuristic used for tracking the Maximum Power Point (MPP). Figure 9 illustrates the implementation of the search mechanism using CS [20]. Initially, the number of cycles of use is randomly selected. Each cycle is then implemented in photovoltaic power systems (PVPS). The system's current and voltage are measured to obtain an estimation of the PVPS output power, which serves as the fitness function. The duty cycle is associated with the best fitness function and is chosen as the best current nest (dbest) [21] [22]. Next, a Lévy flight is updated to create new nests. The new fitness values are examined through PVPS. Subsequently, the worst nest is randomly removed [1], simulating the behavior of a host bird that discovers and destroys cuckoo eggs. The new nest takes the place of the removed one via a Lévy flight, after which the PV power is measured, and based on this measurement, the best current nest is selected. When the stopping criterion is achieved, the CS-based tracker stops and provides the best optimum duty cycle and fitness function corresponding to the maximum power [1].

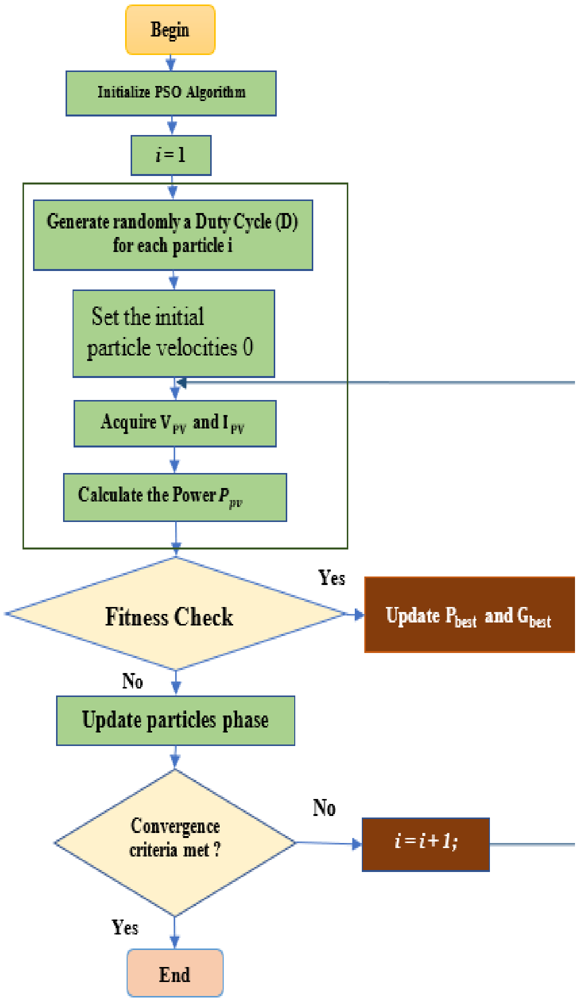

Fig. 8 Flowchart of PSO-based MPPT

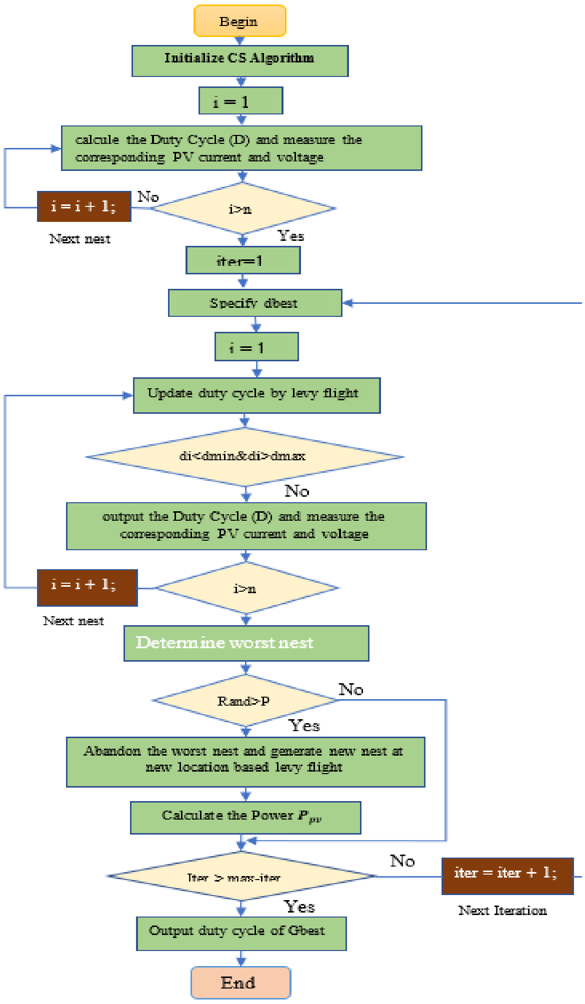

Fig.9 CS-based MPPT algorithm flowchart.

IV. EXPERIMENTS AND RESULTS

The above algorithms have been successfully applied in MATLAB/SIMULINK 2021. The model of the MPPT with Algorithm is shown in fig 9.

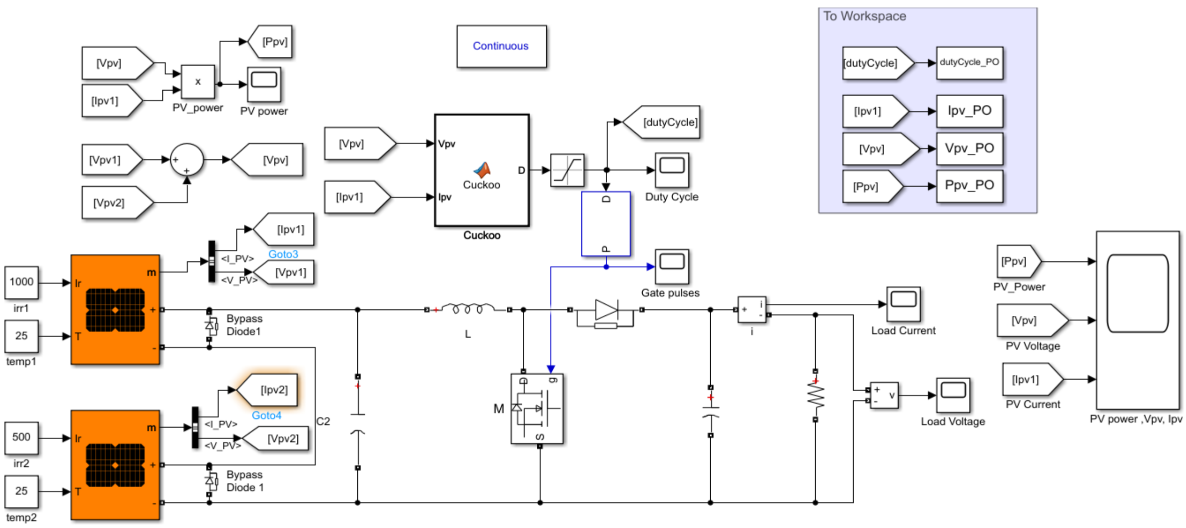

Fig. 10 Schematic diagram of overall system

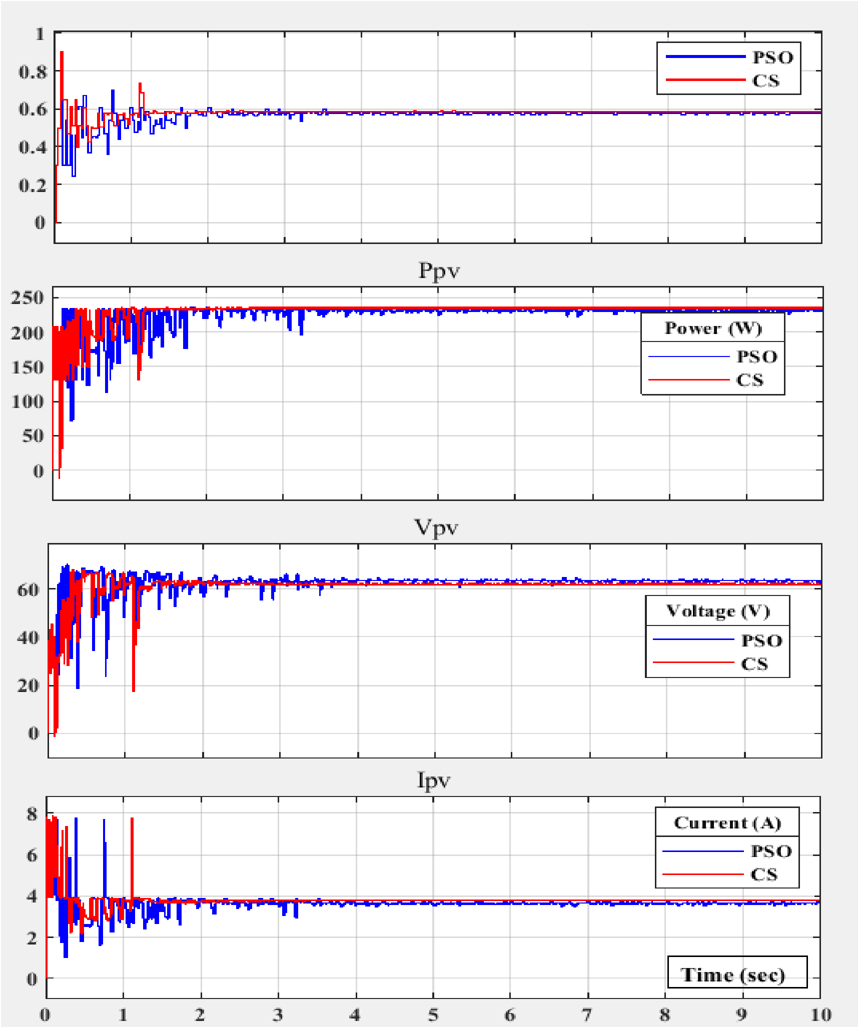

Fig. 11 simulation results waveforms: tracking voltage, current, duty cycle, and power. (a) HC method. (b) Proposed method.

V. Discussion of Results:

A simulation using MATLAB was conducted to validate the effectiveness of various optimization techniques in tracking the maximum power peak under Partial Shading Conditions (PSC). The MPPT process presents a challenge due to the intricate nature of the characteristic curves model for photovoltaic (PV) cells. Difficulties arise because of the formation of multiple peaks in the characteristic curves of the PV array. Conventional algorithms struggle to identify the global maximum power point (MPP) of a photovoltaic (PV) array due to its non-linear behavior. The quantity of peaks depends on the number of shaded modules.

TABLE II. PERFORMANCE COMPARISON OF DIFFERENT MPPT METHODS IN PARTIAL SHADING CONDITION

Rated Power (W)	Tracking Algorithm	Maximum Power (W)	Voltage Tacking (V)	Current Tacking (A)	Time Tacking (sec)	Tracking efficiency (%)
234.784 W	PSO	233.6262	63.3986	3.8352	3.30585	99.51%
	CS	234.6449	62.0379	3.7869	2.33202	99.94%

While PSO shares similar characteristics, it is evident that the proposed CS algorithm consistently achieves a higher maximum power output. On average, the CS algorithm attains 233.6262W of power, whereas PSO achieves the same power level. Additionally, the CS optimizer algorithm achieves values of 62.0379V, 3.7869A, and 234.6449W, which are higher than the maximum power attained by PSO at 3.30585, 2.33202, with 99.51% and 99.94% efficiency, respectively. This observation highlights the CS algorithm's superior ability to track the global Maximum Power Point (MPP) with greater accuracy and in less time compared to the PSO algorithm.

Simulation results demonstrate that the CS algorithm offers higher accuracy and faster tracking speed when compared to PSO, making it highly effective for MPP tracking. Notably, the PSO's oscillation around the MPP is attributed to continuous perturbation. To mitigate this, the step size is reduced to decrease oscillation, albeit at the cost of increased tracking time. This oscillation results in increased power loss and reduced efficiency. Furthermore, fluctuations in irradiation lead the operating point to shift to another P-V curve.

Conclusion

This paper presents a comparison of MPPT methods, with a focus on identifying the most effective one based on MPPT efficiency, considering their suitability for systems that encounter a wide range of operating conditions. The PV system, comprising a PV array with an MPPT tracker algorithm, has been simulated in the Matlab/SIMULINK environment. The proposed algorithms aim to reduce the time spent during the exploring phase by implementing a variable sampling time. Simulation results demonstrate a significant improvement in global peak tracking speed. The CS algorithm successfully tracks the maximum peak with high accuracy under various environmental conditions, including partial shading. It is evident that each MPPT method possesses its own set of advantages and disadvantages. Moreover, the CS algorithm is simple and computationally efficient. In general, the CS approach can be considered one of the best-suited solutions for MPPT applications, especially in scenarios involving partial shading conditions.

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Stereo SALM of mobile robot

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Abstract

The study introduces visual simultaneous localization and mapping (v-SLAM), a comprehensive SLAM system with map reuse, loop closing, and relocalization capabilities for stereo cameras of mobile robots in outside environments. Accurate trajectory estimate is possible thanks to our backend, which uses Bundle Adjustment and stereo observations. A light localization mode that uses visual odometry is part of our system, provides zero-drift localization, tracks for unmapped regions and matches to map points. The outcomes demonstrate that the approach delivers cutting-edge accuracy.

Keywords: *SLAM, localization, stereo-vision, bundle Adjustment, mapping.*

Introduction

Simultaneous Localization and Mapping (SLAM) has caught the interest of high-tech corporations recently and has been a popular study issue for the previous 25 years in the Computer Vision and Robotics sectors. With a major emphasis on real-time operation, SLAM algorithms create a map of an uncharted environment and localize the sensor inside the map. Among the several sensor modalities, cameras are affordable and offer extensive environmental data that enables reliable and accurate place detection.

The task of visual localization depends on three principal terms, visual odometry (VO)[1][2], structure from movement SFM [3][4], and SLAM, in which the VO depends on locating the ego of a moving object such as a robot by relying on the input of the camera "image". It's primarily focused on reconstructing the camera path. The SFM is based on the recovery of the relative poses of a camera and the three-dimensional (3D) structure from a set of (2D) images of a camera or video. SLAM consists of these two pieces of information at once, estimating the trajectory of the camera while simultaneously reconstructing the environment. This method was first put forth to enable autonomous robot control in the field of robotics [5].

The smallest and least expensive sensor array, a monocular camera, can be used to execute visual SLAM. However, because depth cannot be seen from a single camera, the predicted trajectory's scale is indeterminate and subject to drifting over time. Additionally, numerous views are necessary to create an initial map in order to bootstrap the system because it cannot be triangulated from the first frame. These issues are resolved and a more dependable vSLAM solution is offered by using a stereo camera. Their processing techniques is based on features direct and indirect methods, which are “appearance-based” and “feature-based” respectively.

The first approach "feature-based" or the indirect method, is based on two steps detecting than tracking a set of salient features of the image such as corners and lines, and following them in the following images. By calculating the Euclidean distances of each element, the points between the frames, the displacement and velocity vectors can be calculated, using detectors such as: FAST(Feature From Accelerated Segment Test)[5], SURF (Speeded Up Robust Features)[6], BRIEF(Binary Robust Independent Elementary Features)[8], ORB(Oriented Fast and Rotated BRIEF)[8], Harris detect of corner[9].

The second technique, "appearance-based" or the direct method, estimates camera movements directly using pixel intensity changes, usually photometric errors. The pixel selection can be all pixels (dense) or a sparse selection (sparse). The direct method eliminates feature extraction time at a cost that is much greater for optimization problems than the feature-based method.

Paz et al.'s early stereo SLAM system was impressive [11]. It was able to operate in greater spaces thanks to Conditionally Independent Divide and Conquer EKF-SLAM. compared to other methods at the time, surroundings. Most crucially, it was the first stereo SLAM to use both close and far points, utilizing an inverse depth parametrization [12] for the latter (i.e. locations whose depth cannot be accurately assessed due to small discrepancy in the stereo camera).

The majority of contemporary stereo SLAM systems are keyframe-based [13] and carry out local BA optimization to achieve scalability. A joint optimization of BA (point-pose constraints) in an inner window of keyframes and pose-graph (pose-pose constraints) in an outer window is carried out in the work of Strasdat et al. [14]. The approach achieves constant temporal complexity by restricting the size of these windows, but at the cost of not ensuring global consistency. The RSLAM developed by Mei et al. [15] executes relative BA in an active region that can be limited for constant-time using a relative representation of landmarks and poses. RSLAM can close loops, allowing active areas on both sides of the loop to increase, but global consistency is not required. Pire et al.'s [16] latest S-PTAM accomplishes local BA but lacks big loop closing. We conduct BA in a local collection of keyframes, similar to this strategy, such that the complexity is independent of map size and we can function in vast areas. Engel et al.'s [17] Stereo LSD-SLAM is a semi-dense direct technique that minimizes photometric error in image regions with strong gradient. Because it does not rely on features, the technique is predicted to be more resistant to motion blur and poorly textured environments. However, being a direct technique, its effectiveness can be significantly affected by unmodeled effects such as rolling shutter or non-lamberttian reflectance.

In this study, we developed a stereovision SLAM using the following steps:

- Initialization of the Map: The pipeline begins by using the disparity map to initialize the 3-D point map created from a pair of stereo pictures. The first key frame is saved as the left image.
- Tracking: After initializing a map, the attitude of the camera is inferred for each fresh stereo pair by comparing elements in the left picture to those in the previous key frame. The local map is tracked to improve the estimated camera pose.
- Local Mapping: New 3-D map points are computed from the disparity of the stereo pair if the current left picture is recognized as a key frame. The camera posture and 3-D points are now adjusted using bundle adjustment to reduce reprojection mistakes.
- Loop Closure: Using the bag-of-features method, loops are found for each key frame by comparing them to all of their predecessors. The pose graph is optimized to improve the camera postures of all the crucial frames after a loop closure is found.

The figure1 describes the architecture of the algorithm of stereo visual SLAM.

Initialization:

The map holding the 3-D world points is initialized at the beginning of the SLAM. This phase is very important and has a big effect on how accurate the final SLAM output is. In stereovision, the algorithm to determine the depth and disparity map is composed of four steps, the first is feature extraction, the second is feature matching across images, the third is disparity computation, and the last is disparity refinement and post-processing. Using matching Features between two pictures in a stereo pair, initial ORB feature point correspondences are discovered. The matched pairs must adhere to the following requirements:

The corrected stereo pair image has a horizontal shift between the two matching feature points that is smaller than the maximum disparity. The stereo anaglyph of the stereo pair image will reveal the approximate maximum disparity value. Check out Choosing Range of Disparity for further details.

The rectified stereo pair image has a vertical shift between the two associated feature points that is smaller than a threshold.

The matching features' scales are almost identical.

The following is how the 3-D world locations that correspond to the matching feature points are found:

For each pair of stereo pictures, use the Choosing Range of Disparity tool to calculate the disparity map using the semi-global matching (SGM) approach.

To determine the 3-D world point coordinates from the disparity map, use reconstructe Scene.

Locate the spots on the disparity map that line up with the feature points and where they are in the 3-D environment.

The bags-of-words method is used to detect loops. A visual vocabulary in the form of a bag of Offline, a features object is generated using ORB descriptors collected from a wide set of photos in the dataset.

The system employs the ORB features for tracking, mapping, and location identification. These characteristics are resistant to rotation and scale, and they are resistant to camera auto-gain and auto-exposure, as well as variations in lighting. Furthermore, they are quick to extract and match figure 3 and 4, allowing for real-time operation, and they perform well in bag-of-word location recognition[18]. As a feature-based technique, ORB-SLAM preprocesses the input to extract features at prominent keypoints positions, as shown in Figure 2.

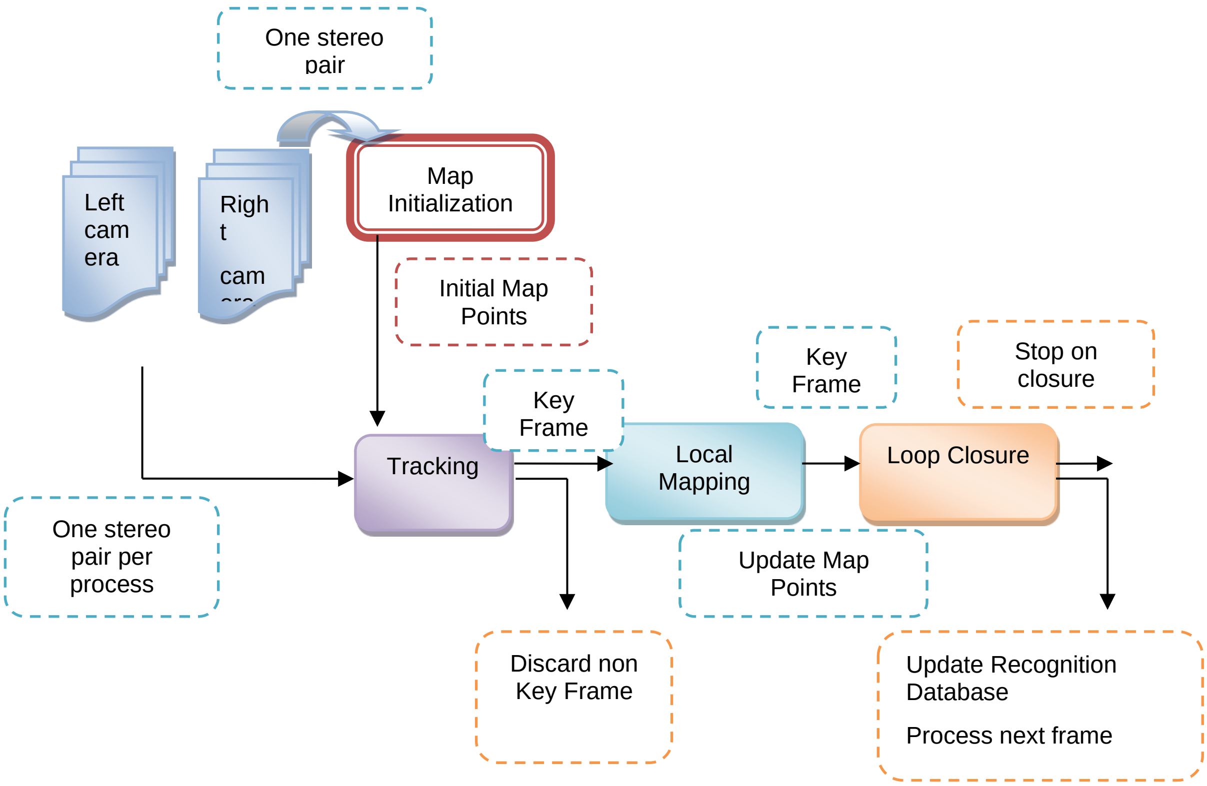

Fig. 1. Architecture of stereo visual SLAM.

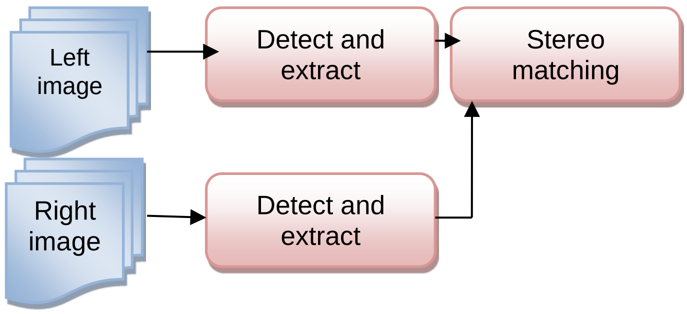

Fig. 2. Input Pre-processing.

Tracking:

Every pair is used in the tracking process, which decides when to insert a new key frame. Following is how each frame is processed:

Each new stereo pair of images has its ORB features retrieved, which are then matched with features in the previous key frame that have known corresponding 3-D map locations.

Utilize the Perspective-n-Point algorithm to determine the camera posture.

Project the map points seen in the previous key frame into the current frame given the camera pose, then use to look for feature correspondences. Perform a motion-only bundle adjustment to fine-tune the camera posture with 3-D to 2-D correspondences in the current frame. To find further feature correspondences and to further fine-tune the camera pose using BA, project the local map points into the current frame.

In order to optimize the camera pose in the tracking (motion-only BA), a local window of keyframes and points in the local mapping (local BA), and all keyframes and points after a loop closure (full BA), our system executes bundle adjustment. The Bandle Adjustment is a vision technology that aims to refine a visual reconstruction of the three-dimensional structure and parameters of the camera (pose and calibrations). The symbol ‘bundles’ refers to rays of light leaving each 3D feature and converging on each camera center, Then they are optimally ‘adjusted’ concerning both the feature and the positions of the camera. The main idea is optimization, usually based on the objective function (ML) Levenberg-Marquardt algorithm[10]. The optimization of the best parameters (camera and landmark positions) is achieved by reducing some cost functions that determine the fitting error and finding the optimal solution concerning both structure and camera variations.

Motion anly BA: optimizes the camera position $\boldsymbol{t} \epsilon \mathbb{R}^{\boldsymbol{3}}$ and orientation R $\boldsymbol{\epsilon}\ \boldsymbol{SO}(\boldsymbol{3})$, reducing the reprojection error between matched 3D points $\boldsymbol{X^i} \epsilon \mathbb{R}^{\boldsymbol{3}}$ in word coordinates and keypoints $\boldsymbol{x^i}$. The set of all matches:

$$\{\boldsymbol{R}, \boldsymbol{t}\} = \boldsymbol{argmin_{R,t}} \sum_{i \in x} \boldsymbol{\rho}(\left\| \boldsymbol{x^i} - \boldsymbol{\pi_{stereo}}\ (\boldsymbol{RX^i} + \boldsymbol{t}) \right\|_{\boldsymbol{\Sigma}}^{\boldsymbol{2}})$$

Where $\boldsymbol{\rho}$ denotes the robust Huber cost function and $\boldsymbol{\Sigma}$ is the covariance matrix associated to the scale of keypoint. $\boldsymbol{\pi_{stereo}}$ presents the projection function is defined as follows:

$$\pi_{stereo}\left(\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}\right) = \begin{bmatrix} \frac{X}{Z} + C_x \\ f_y \frac{Y}{Z} + C_y \\ f_x \frac{X - b}{Z} + C_x \end{bmatrix}$$

Where (f_x, f_y) is the focal length, (C_x, C_y) presents the principal point and b is the baseline.

Local Mapping:

Every key frame undergoes local mapping. When a new key frame is found, include it in the list of key frames and change the properties of the map points it saw. A legitimate map point must be noticed in at least three key frames in order to guarantee that mapPointSet contains as few outliers as feasible.

By triangulating ORB feature points in the current key frame and its related key frames, new map points are produced. Use match of features to look for a match between each unmatched feature point in the current key frame and other unmatched points in the linked key frames. The current key frame's posture, the poses of all related key frames, and all the map points visible in these key frames are all refined by the local bundle adjustment.

Local BA : improves a set of covisible keyframes K_L and all points seen in those keyframes P_L. The other keyframes K_F not in K_L, observing points in P_L contribute to the cost function but they are fixed in the optimization. Introducing X_k as the set of matches between points in P_L and keypoints in a keyframe *k*, The optimization issue is as follows:

$$\{\boldsymbol{X^i}, \boldsymbol{R_l}, \boldsymbol{t_l} | \boldsymbol{i} \in \boldsymbol{P_L}, \boldsymbol{l} \in \boldsymbol{K_L}\} = \boldsymbol{argmin}_{X^i, R_l, t_l|} \sum_{k \in K_L \cup K_F} \sum_{j \in X_k} \boldsymbol{\rho}\,(\boldsymbol{E}(\boldsymbol{k}, \boldsymbol{j}))$$

$$\boldsymbol{E}(\boldsymbol{k}, \boldsymbol{j}) = (\left\| \boldsymbol{x^i} - \boldsymbol{\pi_{stereo}}\,(\boldsymbol{R_k X^j} + \boldsymbol{t_k}) \right\|_{\Sigma}^{2}$$

Full BA: is a particular instance of local BA in which every keyframe and point on the map is optimized, with the exception of the origin keyframe, which is fixed to remove gauge freedom.

Loop closing: The loop closure step attempts to identify and complete the loop using the most recent key frame that has been processed by the local mapping process. By searching for photos in the database that are similar to the current key frame, loop candidates are found. The process of closing a loop involves two steps: first, a loop must be found and verified; then, the loop must be fixed by optimizing a pose-graph.

To get the best result in SLAM, we included a comprehensive BA optimization following the pose-graph. We do this optimization, which may be very costly, in a separate thread so that the system may keep building maps and identifying loops. The result of the bundle modification must then be combined with the map's current state, which presents a problem. While the optimization is ongoing, if a new loop is found, we stop the optimization and proceed to terminate the loop, which will restart the whole BA optimization. We must combine the non-updated keyframes and points that were entered while the optimization was taking place with the updated subset of keyframes and points that the entire BA has optimized when it is finished. This is accomplished by propagating the updated keyframes' correction to non-updated keyframes across the spanning tree (i.e., the change from the non-optimized to the optimized posture). Non-updated points are altered in accordance with the modification made to the keyframe that serves as their reference.

Results and Discussion:

On the mobile robot, simulations of the stereo visual slam are performed to evaluate the suggested strategy and gauge the results. In this simulation, I use the a comprehensive SLAM system with map reuse and loop closing. Instead of using two pictures from separate frames, 3-D map points are formed during the map initialization step using a pair of stereo images from the same stereo pair. When a map is initialized, the posture of the camera is inferred for each new stereo pair by comparing elements in the left picture to elements in the previous key frame thanks to ORB technique figure 3 and 4. The local map is tracked to improve the predicted camera pose. The disparity of the stereo pair is used to compute additional 3-D map points if the present left picture is recognized as a key frame. The camera posture and 3-D points are now adjusted using bundle adjustment to reduce reprojection mistakes. The bag-of-features method is used to compare each key frame to all preceding key frames in order to identify loops for each key frame. The posture graph is adjusted to improve the camera poses of all the crucial frames whenever a loop closure is discovered. Figure 5 presents the trajectory estimated by the algorithm.

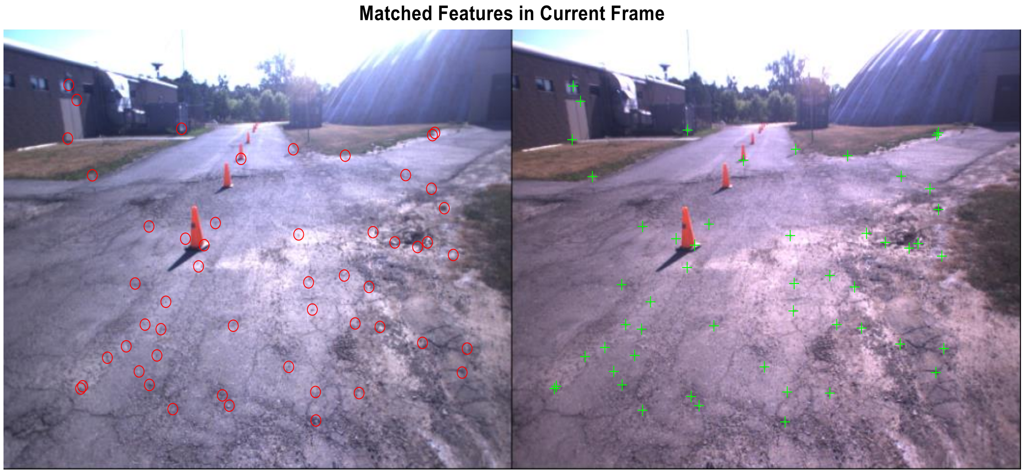

Fig. 3. Detect and extract features of left and right images.

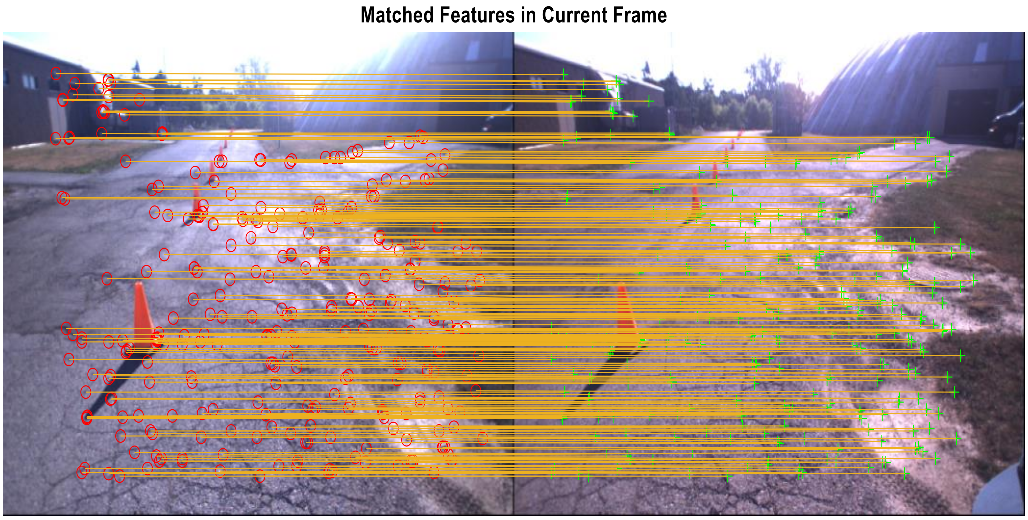

Fig. 4. *Matched features of left and right images.*

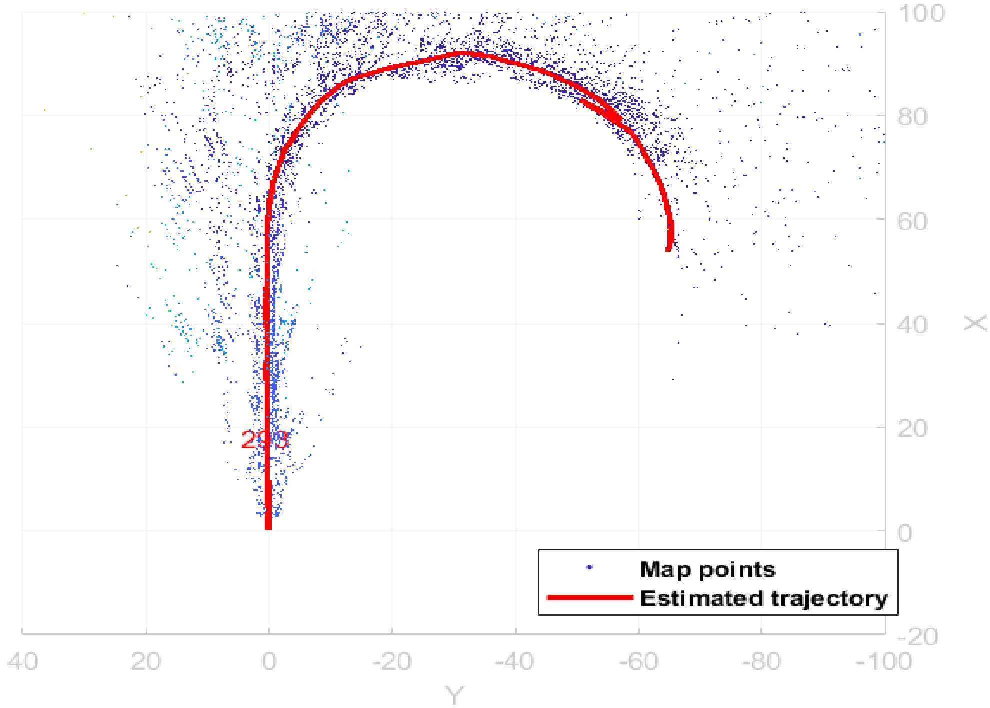

Fig. 5. Estimate the trajectory.

Conclusion

This paper provides a summary of visual SLAM using a stereo camera. we described demonstrate how to use ORB-SLAM to map an outside scene and determine the camera's trajectory. The algorithm based on four steps Initialization of the Map, Tracking, Local Mapping and loop closing.

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SHORT PAPERS

Environment training to identify the image

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Abstract

Welcome to our presentation on the importance of environment training to identify the image. As technology continues to advance, identifying images accurately has become more critical than ever before. However, traditional training methods may not be enough to prepare employees for the challenges they may face. That's where environment training comes in.

Environment training provides a realistic simulation of the work environment, allowing employeesto practice identifying images in a safe and controlled setting. By doing so, they can develop the necessary skills and confidence to perform their jobs effectively. This type of training is essential for industries such as healthcare, aviation, and manufacturing, where mistakes can have severe consequences. So, let's dive deeper into the world of environment training and discover its benefits.

Keywords: *Environment Training -identify the image– Surveillance - Artificial intelligence techniques.*

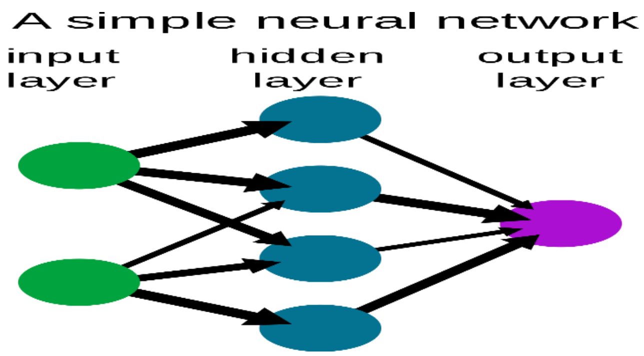
Introduction

The importance of environment training lies in its ability to provide individuals with a realistic understanding of the challenges they may face when performing a task. By exposing individuals to real-world scenarios, they can develop the skills and knowledge necessary to identify and overcome obstacles. This is particularly important when it comes to identifying the image, as even small details can have a significant impact on the outcome of a task. By providing individuals with environment training, organizations can improve their accuracy and efficiency, ultimately leading to better outcomes [I].

The aim of this study is to explore modern solutions based on open sources to detect objects in the power grid because if the obect is contaminated or damaged it cuases problems in the power grid, in this case to detect high voltage insulators.

SYSTEM DESCRIPTION

Training neural networks is the process of teaching neural networks to perform a task. Neural networks learn by processing several large sets of initially named or unlabeled data. Then it can process unknown inputs more precisely, by using these examples[II]. This work diagnoses a photo or video clip. This model puts a frame on the insulator and gives a percentage of the safety of the insulator based on a pre-trained environment to diagnose the insulator[II].



1.Install softzare : Anaconda3- Python 3.6 - TensorFlow v1.12 CUDA Toolkit v8.0

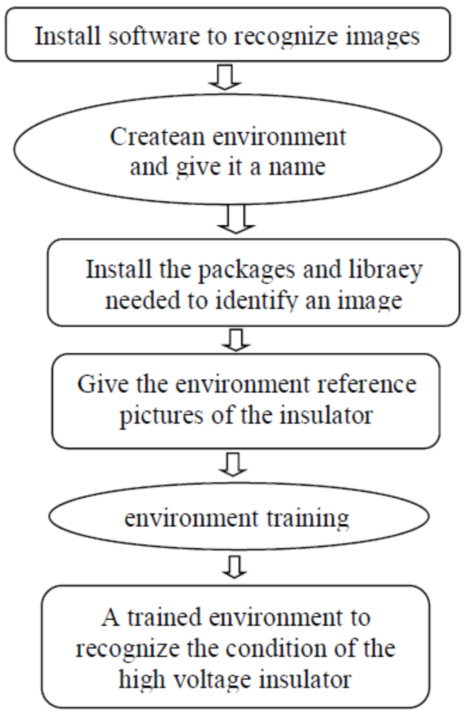
2.Createan environment : open the Anaconda invitation window then we create the working folder with the following command conda create -n projet pip python=3.6 .

3.Install paqckages : We install the necessary libraey and packages in the following order Tensorflow==1.12 /Anaconda protobuf Pillow/ Lxml/ Cython/ contextlib2 /Jupyter /Matplotl/ Pandas/ OpenCV-python

4.This time the TensorFlow object detection API is configured and ready to use, we need to provide the images it will use to train a new detection classifier.

5.Now he will begin a real work. The computer will learn from the data set and create a neural network. As we are modeling the training on a CPU version, it will take several days to get a good result.

6. Finally, obtaining a trained environment to recognize the condition of the high voltage insulator surface



PRESENTATION OF THE RESULTS OF THE SURFACE CONDITION OF THE INSULATORS

After configuring the model parameters, we run the python file of the surface state detection of theinsulators

The experiment is very effective than traditional methods used by energy sector workers. This method is simpler and more comfortable: a drone can be sent carry out this task without exposing workers to danger.

Conclusion

We succeeded in developing an insulator recognition model via static images, an image captured by a Web Cam and finally a scrolling image on a video.

This model makes it possible to detect the state of the insulator is whether it is clean or polluted. Our model was trained through artificial intelligence techniques incorporated into the TensorFlow library programmed by the Python language.

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Deep Supervised Hashing with Multiscale Feature Fusion (DSHMFF)

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Abstract

Deep networks-based hashing has gained significant popularity in recent years, particularly in the field of image retrieval. However, most existing methods only focus on extracting semantic information from the final layer, disregarding valuable structural information that contains important semantic details crucial for effective hash learning. To address this limitation and improve image retrieval accuracy, we propose a novel deep hashing method called Deep Supervised Hashing by Fusing Multiscale Deep Features (DSHMFF). Our approach involves extracting multiscale features from multiple convolutional layers and fusing them to create stronger representations, enhancing the effectiveness of image retrieval. Experimental results on the CIFAR10 and NUS-WIDE datasets demonstrate that our method surpasses the performance of state-of-the-art hashing techniques.

Keywords: *Deep learning, Image retrieval, Multi-scale feature, Deep supervised hashing.*

Introduction

The internet and communication advancements have led to an overwhelming influx of images on the web (Yan et al., 2020; C. Yan et al., 2020; S. Li et al., 2019), creating a challenge for accurate and efficient large-scale data retrieval. To address this, hash-based image retrieval techniques (J. Wang et al., 2017) have gained attention due to their ability to generate compact binary codes, offering computational efficiency and storage advantages.

These techniques can be classified as data-independent and data-dependent approaches. Data-independent methods, such as locality-sensitive hashing (LSH) (A. Gionis et al., 1999), use random projections as hash functions but suffer from limitations. They do not utilize auxiliary information, leading to poor retrieval accuracy, and require longer codes, consuming more storage (A. Andoni & P. Indyk, 2008; P. Indyk & R. Motwani, 1998). In contrast, data-dependent methods leverage training information to learn hashing functions, resulting in shorter codes with improved performance. They can be further categorized as unsupervised (Y. Gong et al., 2012, 2013; G. Lin et al., 2014; B. Kulis & T. Darrell, 2009; C. Strecha et al., 2011) or supervised hashing methods (G. Lin et al., 2013, 2014; Z. Chen & J. Zhou, 2018; Y. Cui et al., 2018; J. Song et al., 2018).

Deep hashing techniques (V. E. Liong et al., 2015; H. Zhu et al., 2016; H. Lai et al., 2015; F. Cakir et al., 2019) have arisen as a result of the achievements made by deep neural networks in computer vision tasks. These methods, as opposed to traditional hashing methods, possess the ability to effectively extract high-level semantic features and facilitate end-to-end frameworks for generating binary codes. Nevertheless, a drawback of numerous existing deep hashing techniques (A. Gordo et al., 2016; Q.-Y. Jiang & W.-J. Li, 2018; F. Shen et al., 2017) is their reliance on features from the penultimate layer in fully connected networks, which serve as global image descriptors but fail to capture local characteristics.

To overcome these challenges, this paper proposes a novel deep hashing method called Deep Supervised Hashing by Fusing Multi-scale Deep Features (DSHMFF), which effectively captures multi-scale object information. Specifically, it extracts features from different network stages, fuses them at the fusion layer, and encodes them into robust hash codes. The network used various hashing results based on different scale features, enhancing retrieval recall without sacrificing precision. The key contributions of this paper are as follows:

1. DSHMFF employs multiple feature scales to learn binary codes, which are then fused together to enhance retrieval performance.
2. The research paper presents a novel deep hashing method that integrates the learning of feature representations and binary codes within a unified framework.
3. Through experimental assessments conducted on two extensive datasets, DSHMFF demonstrates superior performance compared to existing methods in real-world applications.

The subsequent sections of this paper will elaborate on the "State-of-the-Art" section, describe the details of our proposed DSHMFF method, present experimental results, and conclude by highlighting the contributions and implications of our research.

State-of-the-Art

The field of image retrieval has seen remarkable advancements in recent years, driven by various techniques that aim to efficiently match and retrieve images from large datasets. In this section, we provide an overview of the state-of-the-art methods and approaches that have been prominent in the field, highlighting their strengths and limitations.

Data-Independent Methods: Traditional data-independent methods, such as Locality-Sensitive Hashing (LSH) [Gionis et al., 1999], have long been used for image retrieval. LSH employs random projections as hash functions to map data points into binary codes. However, these methods often suffer from limitations in retrieval accuracy and code length [Andoni and Indyk, 2008]. Shallow Hashing Techniques: In the realm of shallow hashing, methods like Spectral Hashing [Weiss et al., 2009] and Semantic Hashing [Salakhutdinov and Hinton, 2007] have been prominent. While they produce compact binary codes, they may struggle to capture intricate semantic details, which can lead to suboptimal retrieval performance.

Deep Hashing Techniques: Deep learning-based approaches have gained significant traction in recent years due to their ability to extract high-level semantic features. Notable deep hashing methods include: Cakir et al. (2019): This method utilizes convolutional neural networks (CNNs) for feature extraction and binary code generation. However, it may face challenges in capturing local characteristics. Zhu et al. (2016): Introducing an end-to-end deep hashing framework, this method effectively learns binary codes from image data. Nonetheless, it may still fall short in capturing fine-grained semantic details. Gordo et al. (2016) and Shen et al. (2017): These methods focus on addressing the issue of local feature capture in deep hashing. Nevertheless, their performance might not be optimal for all datasets and retrieval scenarios.

Proposed Method: In this paper, we introduce a novel deep hashing approach called Deep Supervised Hashing by Fusing Multiscale Deep Features (DSHMFF). Our method addresses the limitations of existing approaches by extracting multiscale features from multiple convolutional layers and fusing them to capture both local and global semantic information effectively. Experimental results on the CIFAR-10 and NUS-WIDE datasets demonstrate the superior performance of DSHMFF compared to state-of-the-art hashing techniques.

In summary, while data-independent and shallow hashing methods have been fundamental in image retrieval, deep hashing techniques have shown promise in capturing high-level semantic features. Our proposed method, DSHMFF, advances the state-of-the-art by improving the retrieval accuracy through the fusion of multiscale features. The subsequent sections of this paper will delve into the details of our approach and present experimental results that validate its effectiveness in real-world applications.

Proposed method

A. Problem definition

Let $X = \{x_i\}_{i=1}^{N} \in \mathbb{R}^{d\times N}$ represent training dataset consisting of N image. Here, $Y = \{y_i\}_{i=1}^{N} \in \mathbb{R}^{k\times N}$ denotes the true labels associated with the samples x_i, where K refers to the total number of classes present in the dataset. The pairwise label matrix $S = \{s_{ij}\}$ indicates the semantic similarity between training image samples, with $s_{ij} \in \{0, 1\}$. If $s_{ij} = 1$, it signifies that samples x_i and x_j are semantically similar, whereas $s_{ij} = 0$ indicates that they are not. Deep hashing methods aim to achieve the goal of learning a deep hash function denoted as $f: x \longmapsto B \in \{-1,1\}^L$, where B represents binary codes and each input x_i is encoded into a binary code $b_i = \{-1,1\}^L$. The length of the binary codes is denoted by L.

B. Model architecture

Our model architecture is designed to effectively extract, fuse, and encode multiscale features from input images, facilitating the generation of robust binary codes for image retrieval. It comprises several key components, each with a specific role in the overall framework.

Feature Extraction: At the core of our model, we employ the VGG-19 network as a feature extractor. This deep convolutional neural network (CNN) is pretrained on the ImageNet dataset, allowing it to capture high-level semantic features from the input images. The VGG-19 network is known for its ability to extract both low-level and high-level features, making it suitable for our purpose.

Feature Reduction: After feature extraction, we incorporate a dimensionality reduction step using a 1x1 convolutional kernel. This operation retains the discriminative power of the features while reducing their dimensionality. This is crucial for creating more efficient and compact representations.

Feature Fusion: The feature fusion layer plays a pivotal role in our architecture. It combines features from different levels of the network, capturing both local and global information. This fusion of multiscale features is a key aspect of our approach, as it ensures that the model can effectively represent various details in the images, enhancing its retrieval capabilities.

Hash Coding: To create binary hash codes, we introduce hash layers in our architecture. These layers perform non-linear mapping of the fused features, transforming them into

compact and efficient binary codes. This step is essential for the final representation of images as binary codes.

Concatenation and Refinement: The hash layers produce binary codes for each input image. These codes are concatenated to form a consolidated representation, which is further refined by a final hashing layer. This step ensures that the binary codes capture the most salient features for effective retrieval.

Classification: The learned representations, now in the form of binary codes, are utilized in the classification layer. This layer is responsible for classifying images into their respective classes.

While our primary focus is on retrieval, this classification step adds versatility to our model, making it suitable for various computer vision tasks.

To ensure that our generated binary codes are similarity-preserving, our DSHMFF approach utilizes three loss functions during training:

- Pairwise Similarity Loss: This loss encourages the model to produce binary codes that reflect the semantic similarity between pairs of training image samples. If two images are semantically similar, their binary codes should also be similar.
- Quantization Loss: This loss enforces quantization of the binary codes, ensuring that they adhere to the {-1, 1} binary format.
- Classification Loss: This loss aids in classifying images into their respective categories, adding a supervised component to our training process.

These loss functions are effectively combined during model training, leading to enhanced image retrieval performance by preserving semantic information and capturing both local and global details in the binary codes.

In summary, our model architecture is a carefully designed framework that leverages the power of deep learning to extract, fuse, and encode multiscale features for image retrieval. It combines the strengths of feature extraction, dimensionality reduction, feature fusion, and hash coding to generate binary codes that outperform state-of-the-art techniques, as demonstrated by our experimental results.

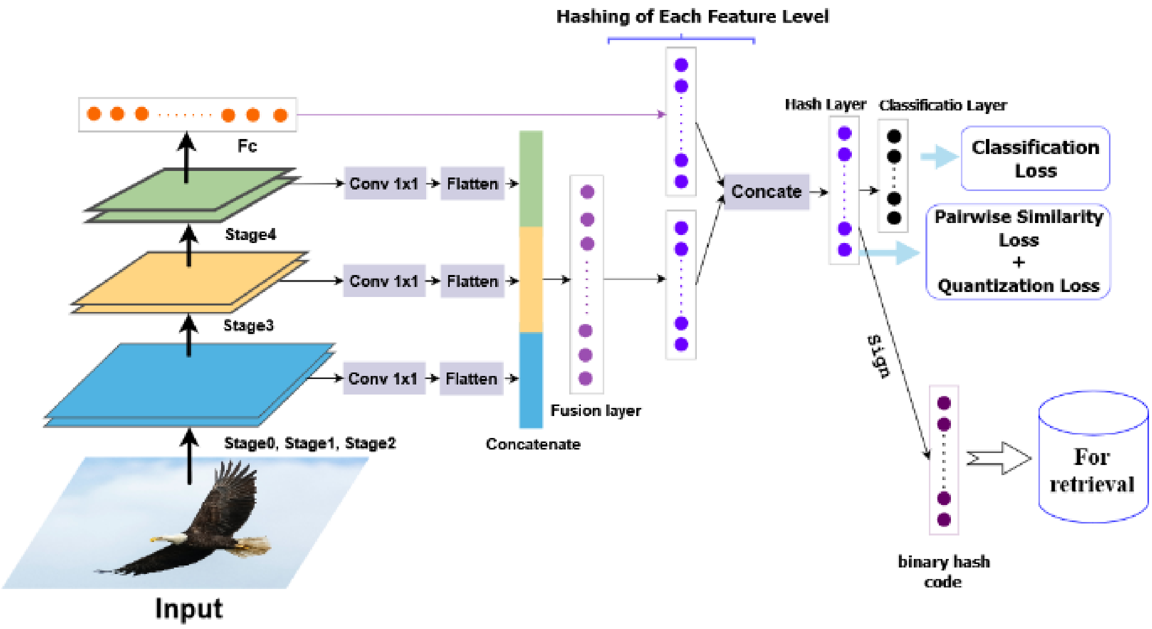


Fig. 1. Deep Supervised Hashing by Fusing Multiscale Deep Features(DSHMFF).

Experiments

We validate effectiveness of our approach using two pub- licly available datasets: NUS-WIDE and CIFAR-10. Firstly, we provide a concise overview of these datasets, followed by an exploration of our experimental configurations. Section IV-C presents the evaluation metrics and baseline methods. Finally, in the concluding section, we present the results of our method, including validations and comparisons with several state-of-the-art hashing techniques.

A. Datasets

CIFAR-10 database, as described in the work by Krizhevsky et al. (2009), comprises a collection of 60,000 images categorized into 10 classes. Each image has a dimension of 32×32 pixels. we randomly choose 100 images per class to serve as queries, resulting in a total of 1,000 test instances. The remaining images form the database set. Additionally, we randomly select 500 images per category (totaling 5,000) from the database to create the training set.
NUS-WIDE database, introduced by Chua et al. (2009), is a comprehensive collection of

approximately 270,000 images sourced from Flickr. It consists of 81 different labels or concepts. For our experiment, we randomly choose 2,100 images from 21 class to form the query database set, while the remaining images serve as the database. Furthermore, we randomly select 10,000 images from the database set to construct the training dataset.

B. Experimental settings

To implement DSHMFF, we utilize PyTorch as our frame- work. As a base network, we employ a VGG-19 convolutional network that has been pre-trained on the ImageNet dataset. Throughout our experiments, we train our network using the Adam algorithm with a learning rate of 1e−5. As for the hyperparameters of the cost function, we assign a value of 0.01 to alpha and 0.1 to beta.

C. Evaluation metrics

In order to assess the performance of various approaches, we employ four evaluation metrics: (MAP) Mean Average Precision , (PR) Precision-Recall curves , Precision curve within Hamming radius 2, and Precision curves with top N returned results (P@N).

We conduct a comparison between our proposed DSHMFF method and several classical or state-of-the-art methods, which encompass unsupervised shallow methods, and traditional supervised hashing techniques, and deep supervised hashing technique. In the case of the multi-label CIFAR-10 and NUS-WIDE datasets, samples are considered similar if they share the same semantic labels. Conversely, if the samples have different semantic labels, they are considered dissimilar.

D. Results and Discussion

The results of our experiments on the CIFAR-10 and NUS-WIDE, evaluating binary code lengths, are shown in Table 1. Our DSHMFF method significantly outperforms other methods, including the top shallow hashing technique SDH. DSHMFF achieves substantial improvements in average Mean Average Precision (MAP), with absolute increases of 49% and 24% on CIFAR-10 and NUS-WIDE datasets, respectively. Deep hashing methods, like DSHMFF, outperform traditional techniques by leveraging robust feature representations from deep neural networks. DSHMFF surpasses the second-best technique LRH, with average MAP increases of 11% and 8% on the CIFAR-10 and NUS-WIDE. These results highlight DSHMFF's superiority in capturing and preserving semantic information, leading to improved retrieval performance.

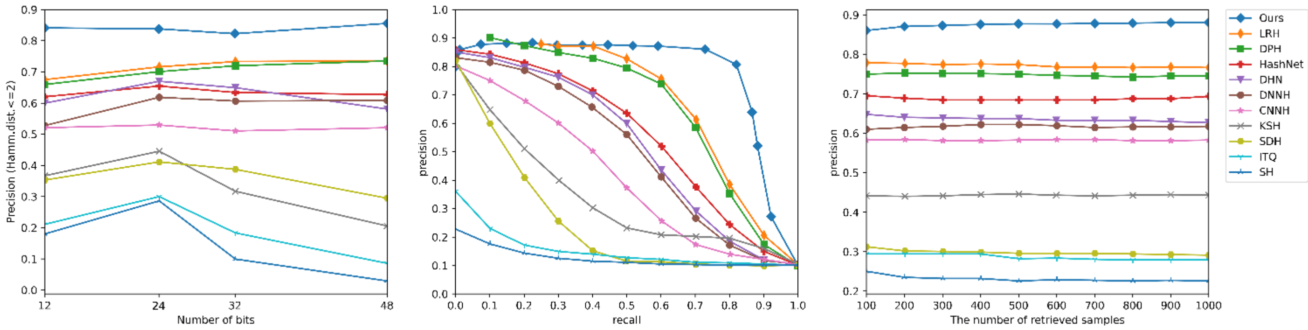
In order to provide a more detailed analysis of our results, we present precision curves (P@H = 2) in Figure 2a , which illustrate the retrieval performance of different methods. Notably, the precision curves clearly demonstrate that our proposed DSHMFF model consistently outperforms the other methods as the code length increases. This indicates that our method maintains the highest precision rate even when longer hash codes are used, showcasing its effectiveness in producing accurate and reliable retrieval results.

To further evaluate the performance of DSHMFF, we analyze its Precision-Recall (PR) performance and Precision at N (P@N) measures compared to other approaches. Figures 2b, and 2c present the PR performance and P@N results for the CIFAR-10 dataset. In Figure 2c, it is evident that the proposed DSHMFF method achieves the highest precision when using 48-bit hash codes. This demonstrates its effectiveness in generating precise retrieval results. Additionally, Figure 2b show consistently high precision levels at low recall, which is of great importance in precision oriented retrieval tasks and finds practical application in various systems.

In conclusion, our DSHMFF method surpasses the compared methods across multiple evaluation aspects, highlighting its superiority in image retrieval tasks.

Method	CIFAR-10 (MAP)				NUS-WIDE (MAP)			
	12 bits	24 bits	32 bits	48 bits	12 bits	24 bits	32 bits	48 bits
SH Weiss, Torralba (2008)	0.127	0.128	0.126	0.129	0.454	0.406	0.405	0.400
KSH Liu, Wang, Ji 2012)	0.303	0.337	0.346	0.356	0.556	0.572	0.581	0.588
SDH Shen, Shen, Liu (2015)	0.285	0.329	0.341	0.356	0.568	0.600	0.608	0.637
CNNH Xia, Pan, Lai (2014)	0.439	0.511	0.509	0.522	0.611	0.618	0.625	0.608
DNNH Lai et al. (2015)	0.552	0.566	0.558	0.581	0.674	0.697	0.713	0.715
DHN Zhu et al. (2016)	0.555	0.594	0.603	0.621	0.708	0.735	0.748	0.758
HashNet Cao, Long (2017)	0.609	0.644	0.632	0.646	0.643	0.694	0.737	0.750
DPH Bai, Ni, et al. (2019)	0.698	0.729	0.749	0.755	0.770	0.784	0.790	0.786
LRH Bai, Li, et al. (2019)	0.684	0.700	0.727	0.730	0.726	0.775	0.774	0.780
Ours	**0.779**	**0.827**	**0.835**	**0.845**	**0.823**	**0.851**	**0.851**	**0.863**

TABLE I: presents the Mean Average Precision (MAP) scores obtained from Hamming ranking on the CIFAR-10 and NUS-WIDE datasets, considering various numbers of bits. The MAP values are calculated by evaluating the top 5,000 retrieved images specifically for the NUS-WIDE dataset.



(a) Precision within hamming radius 2 (b) Precision Recall Curve on 48 bits (c) Precision curve w.r.t top-N @48 bits

Fig. 2 The results obtained by comparing various methods on the CIFAR-10 dataset using three evaluation metrics.

Conclusion

In conclusion, this research introduces a novel approach to image retrieval known as Deep Supervised Hashing by Fusing Multiscale Deep Features (DSHMFF). DSHMFF addresses the limitations of existing methods by effectively capturing multi-scale object information, extracting features from different network stages, and fusing them to create robust hash codes. The key contributions of this research include: The utilization of multiple feature scales to enhance the learning of binary codes, resulting in improved retrieval performance. The development of a unified framework that integrates the learning of feature representations and binary codes, making DSHMFF a versatile and powerful tool. Experimental assessments conducted on two extensive datasets, CIFAR-10 and NUS-WIDE, demonstrating superior performance compared to existing methods in real-world applications. Overall, DSHMFF advances the state-of-the-art in image retrieval by improving retrieval accuracy through the fusion of multiscale features. The results show its effectiveness in preserving semantic information and capturing both local and global details, making it a promising tool for various computer vision tasks.

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An intelligent system to support the teaching of algorithms

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Abstract

The field of computer-aided education has seen the emergence of increasingly sophisticated systems that integrate artificial intelligence and pedagogical design principles to deliver personalized, adaptive learning experiences. These systems represent a major advance in the field, as they offer learners individualized instruction, feedback and support in a variety of areas, and all of this is done automatically. This approach has the potential to revolutionize the world of education by replacing human assistance with AI-based assistance.

The aim of this work is to develop an intelligent assistance system and integrate it into a learning platform in order to mimic the role of a human tutor by offering comments, feedback and advice. This assistance system is rule-based and specialized for teaching algorithms. It offers many advantages, including its ability to track learner progress as they study algorithmic content, analyze their preferences and responses to ensure optimal assimilation of content, and provide personalized support.

Keywords: *Intelligent assistance system, Elearning, Personalized learning, Feedback.*

Introduction

During the COVID-19 pandemic, we became aware of the importance of distance learning systems to ensure continuity of study. As the number of learners on these platforms continues to grow, so does the number of tutors required. As a solution, these systems can be enhanced by intelligent systems that replace the human tutor and provide personalized learning tailored to learners' individual needs, and finally capable of providing ongoing support during the learning process.

Intelligent assistance in e-learning platforms has been explored in several articles. This approach involves developing an assistance system that uses artificial intelligence (AI) to track and recognize learners' behaviors during the learning process, in order to adapt to each learner and provide personalized instructions and feedback. These systems can automatically track and recognize learners' actions and behaviors, making it possible to analyze their performance and progress. The information gathered will be used to tailor instructions to learners as part of an interactive and adaptive teaching process. In this way, features such as interactivity, adaptability and feedback clearly enhance the learning experience. The assistance system can also be used to predict student performance, taking into account the number of hints and attempts required to answer questions correctly.

The intelligent assistance system for teaching algorithms

The intelligent assistance system (IAS) we propose will monitor the learner's progress in learning the algorithmic subject. It proposes to analyze the learner's behavior and responses in order to provide instant feedback and advice that will ensure maximum assimilation of the material as well as close assistance.

To achieve this objective, we have proposed a design that takes the following elements into account:

- Determining the learner's level by means of a test carried out at the time of registration.

- Concept-based courses based on prerequisites. In multiple formats (pdf, html, videos) and levels.
- Offer learners several optional resources (Exercises, Links to external courses, Videos) in addition to the obligatory resources, with several variations adapted to their level in the form of texts and videos.
- Tailor courses to learner levels and enable dynamic updating of learner levels based on results. (Three course levels are available depending on the learner's level).
- Detect the learner's difficulties by analyzing their answers to the concept assessment, then guide them towards the right answers.
- Make help decisions based on test results and scores, giving advice, guiding the learner in revising concepts, suggesting additional concepts, etc.

Conclusion and future work

Through the intelligent assistant we have proposed and developed, we aim to facilitate online learning of algorithms, which is an important material in many disciplines. The intelligent assistant system provides individualized teaching by adapting content to the levels, preferences, results and progress of each learner. It uses rule-based artificial intelligence techniques to offer personalized advice, clear explanations, practical exercises and feedback tailored to each stage of learning. In addition, the system has the potential to be extended to other subjects.

In terms of research perspectives, we propose to add other forms of concept representation. For example, different methods of visual representation of algorithmic concepts to facilitate learner comprehension.

Another proposal is to extend the test bank to automatically propose new tests on each failure. This could be useful to enable learners to review and reinforce their knowledge after failing a test, by proposing different questions or adjusting the questions according to their previous mistakes.

précédentes.

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Détection des difficultés d'apprentissage dans un réseau social éducatif

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Résumé

De nos jours, les réseaux sociaux représentent l'une des technologies les plus largement utilisées, avec une popularité incontestable dans tous les domaines. Ils se distinguent par leur convivialité et leur capacité à faciliter les échanges et les interactions entre les utilisateurs. En effet, ils permettent à différentes personnes de se rassembler, souvent sous l'appellation d'amis, afin de discuter, partager des idées et collaborer autour d'intérêts communs. Les réseaux sociaux exercent aujourd'hui une influence majeure dans tous les secteurs de l'activité humaine, qu'il s'agisse du travail, du divertissement ou de l'apprentissage. Leur utilisation intensive a fait d'eux des éléments cruciaux dans des domaines tels que la médecine, le commerce et l'éducation. Leur popularité réside principalement dans leur simplicité, leur praticité et leur accessibilité, attirant ainsi un large public.

Dans le domaine de l'apprentissage, les réseaux sociaux ont apporté une valeur ajoutée tant à l'apprentissage traditionnel qu'en ligne. En enrichissant les méthodes d'enseignement par une plus grande facilité d'utilisation et des possibilités accrues d'interaction, ils encouragent la collaboration entre les apprenants. D'autres part, la majorité des apprenants rencontrent plusieurs difficultés d'apprentissage : désorientation, la difficulté de communication et de coordination, les problèmes de comportement, etc. Ces difficultés d'apprentissage reviennent généralement aux objectifs imprécis et changeants des apprenants d'une part et d'autre part au manque de communication, de suivi de la part des enseignants. Aussi, ce problème revient aux ressources et aux outils trop nombreux et inadaptés disponibles sur la plateforme.

L'objectif principal de ce travail consiste à concevoir et mettre en place un réseau social éducatif qui permette aux apprenants de communiquer et d'interagir entre eux. Ce réseau offrira également aux apprenants la possibilité de suivre les cours publiés par les enseignants, ainsi que de passer des tests. Notre second objectif sera de détecter et d'améliorer le comportement des apprenants en difficulté, en leur fournissant un soutien collaboratif basé sur leurs activités d'apprentissage.

En résumé, ce travail vise à créer un réseau social éducatif favorisant les échanges entre apprenants et enseignants, tout en offrant des outils de détection et d'assistance pour les apprenants en difficulté.

Mots-clés: *Réseaux sociaux, difficulté d'apprentissage, traces d'apprentissage, systèmes à base de traces*

A Human-based Metaheuristic Algorithm for Large-scale Multi-objective Problems

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Abstract

This paper presents a teaching-learning-based optimization algorithm to address Large-Scale Multi-objective Optimization Problems (LSMOPs) distinguished by the multiplicity of objectives to be optimized and the large search space. Experiments on large-scale multi-objective optimization benchmarks, as well as comparisons with well-known algorithms, have shown that the proposed algorithm outperforms them in terms of Pareto front approximation and computation time.

Keywords: *Large-scale optimization, Multi-objective optimization, Population-based algorithms.*

Introduction

Multi-objective optimization problems (MOPs) are defined as optimizing a vector $F(x) = (f_1(x), f_2(x), .. f_M(x))$ in the objective space, where $x = (x_1, x_2, \dots x_D)$ is a vector in the decision space X (Tanabe & Ishibuchi, 2020). There is no single global optimal solution, but a set of Pareto-optimal compromise solutions can be obtained, known as the Pareto-optimal set (PS) and its projection in the objective space as the Pareto-optimal front (PF). Large-scale problems (LSMOPs) are MOPs with hundreds or thousands of decision variables (Zhang, Wang, Li, & Zhang, 2023). MOPs benefit from a wide range of population-based algorithms, which have been classified into several categories like evolutionary-based, swarm-based, human-based algorithms and others. However, their performance on LSMOPs degrades significantly, so some approaches are tailored for LSMOPs. Among them, we mention: the Multi-Objective Evolutionary Algorithm based on Decision Variable Analyses (MOEA/DVA) (Ma, et al., 2016), Large-Scale Multi-Objective Framework (LSMOF) (He, et al., 2019), and Large-scale Multi-objective Competitive Swarm Optimizer (LMOCSO) (Tian, Zheng, Zhang, & Jin, 2019).
The rest of this paper is organized as follows. Section 2 describes the proposed Large-scale Multi-objective Teaching-Learning-Based Optimization (FMTLBO) algorithm. Section 3 presents the experimental studies. Finally, section 4 draws a conclusion.

The proposed algorihtm

This section describes, briefly, the proposed Fast Multi-objective Teaching-Learning-Based Optimization (FMTLBO) algorithm. The main contribution is the independent teaching-learning scheme. In previously proposed TLBO algorithms, the output population of the teaching phase is used as input for the learning phase. But with large-scale problems, the diversity of solutions in the search space must be improved. Motivated by this idea, we propose a variant of TLBO for multi-objective large-scale problems. The proposed FMTLBO starts with a random initialization of N learners. Then, the learners participate separately in the two phases (teaching and learning) and two new

populations have resulted. These two populations are merged with the old one to select the N best learners. This process is repeated until reaching the termination condition.

In the teaching phase, each learner X_i improves its knowledge by learning from a teacher X^T, by considering the average of the population X^M given by equation (1).

$$X^M = {}^{1}/_{N} \sum_{i=1}^{N} X_i \tag{1}$$

Let the random number $r_i \epsilon [0, 1]$ and the randomly selected teaching factor $T_f \epsilon [1, 2]$. The position of the learner X_i is updated using equation (2). Then, the new X_i^{new1} is evaluated.

$$X_i^{new1} = X_i + r_i(X^T - T_f X^M) \tag{2}$$

In the learning phase, learners anticipate improving their knowledge by interacting with another learner. For each learner X_i, a peer learner X_j is randomly selected. If X_j outperforms X_i, the latter gains more knowledge and advances toward its peer, as equation (3) shows. Otherwise, the learner X_i must repulse X_j and move away from it, as shown in equation (4).

$$X_i^{new2} = X_i + r_i(X_j - X_i) \tag{3}$$

$$X_i^{new2} = X_i + r_i(X_i - X_j) \tag{4}$$

Results and Discussion

FMTLBO is compared with six state-of-the-art algorithms, namely LSMOF (He, et al., 2019) LMOCSO (Tian, Zheng, Zhang, & Jin, 2019) CMOPSO, SPEA/R, MOEA/DVA (Ma, et al., 2016) and NSGA-II on LSMOP test suite. For each algorithm, the IGD (Inverted Generational Distance) metric is recorded to examine both convergence to the true Pareto front and diversity of obtained solutions. As shown in Fig.1, the proposed algorithm achieves promising IGD levels in earlier stages, due to the high diversity of generated populations that can be attributed to the proposed scheme. Also, the proposed FMTLBO, shows competitive performances in terms of computational time (see Fig.1).

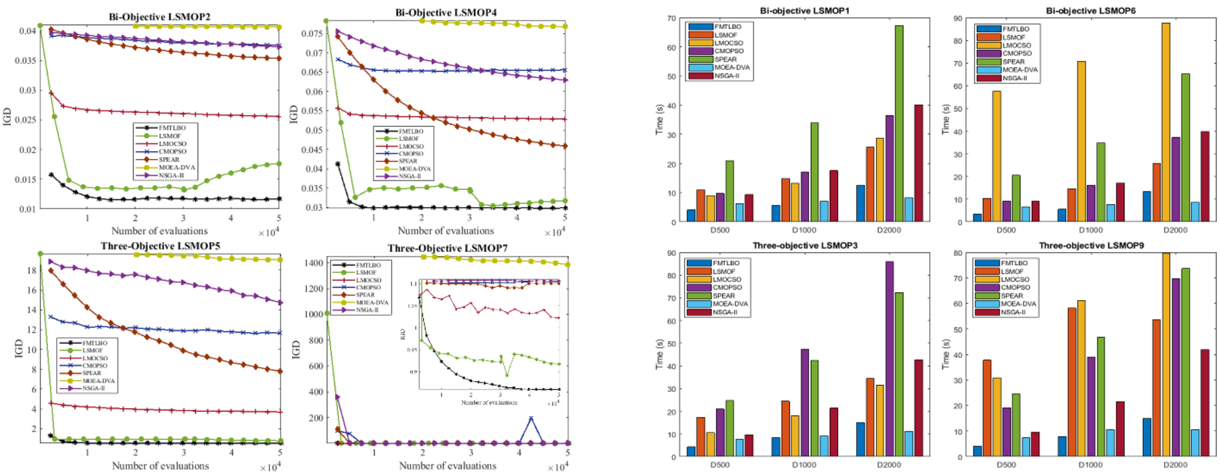

Fig. 1. IGD values and computation time of compared algorithms on LSMOP benchmarks

Conclusion

In this work, we propose an independent teaching-learning scheme. Unlike previously suggested TLBO versions, the two phases of teaching and learning are carried out separately in order to increase the diversity of the generated solutions. Actually, this is required to deal with the high dimensionality of large-scale MOPs. FMTLBO demonstrates its competitiveness, in terms of generating a good PF approximation and computation time, compared to recent and well-known algorithms. In future works, we would like to compare

the suggested algorithm to conventional TLBO versions and to use it for solving real-world large-scale problems.

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Un apprentissage personnalisé à base des annotations dans les MOOC

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Résumé

Les Cours en Ligne Ouverts et Massifs (CLOM ou en Anglais les MOOC) ont connu une popularité croissante ces dernières années en offrant un accès à une formation de qualité, flexible et accessible à tous, indépendamment du lieu et du temps. Ils sont souvent conçus pour atteindre un public large et diversifié, ce qui rend le suivi de l'apprentissage des apprenants un enjeu majeur pour les enseignants qui doivent adapter leurs enseignements en fonction des besoins et des difficultés de chaque apprenant. Les MOOC permettent également aux apprenants d'interagir avec le contenu du cours et avec leurs pairs en utilisant des fonctionnalités telles que l'annotation.

Les annotations sont des notes ou des commentaires qu'un apprenant peut ajouter à un contenu en ligne (une vidéo de cours ou un texte PDF, …etc). Elles peuvent prendre différentes formes, telles que des surlignages, des commentaires écrits ou des marqueurs de temps.

Les annotations peuvent aider à personnaliser l'expérience d'apprentissage pour chaque apprenant.

En premier lieu, l'acte d'annotation encourage la réflexion sur le contenu. Les apprenants sont incités à articuler leurs pensées, à poser des questions et à faire des liens avec leurs connaissances antérieures, ce qui peut renforcer leur compréhension. En deuxiéme lieu, les annotations permettent aux apprenants de mettre en évidence des parties spécifiques du contenu qui les intéressent davantage ou qui posent des questions. Ces annotations fournissent des indices précieux aux enseignants sur les besoins individuels de chaque apprenant, et leurs permettent d'adapter le contenu pour répondre aux besoins spécifiques. Cela peut inclure la fourniture de ressources supplémentaires, de modules de renforcement, ou de questions de révision spécifiques. En troisiéme lieu, les apprenants peuvent annoter et commenter le travail de leurs pairs, ce qui favorise la collaboration et l'apprentissage social. Les annotations peuvent être utilisées pour des activités telles que la révision par les pairs et le partage d'idées (Kastrati et al.,2020).

En résumé, les annotations peuvent faciliter la compréhension du contenu, stimuler les interactions sociales, promouvoir l'apprentissage actif et soutenir la réflexion métacognitive.

Cependant, le suivi des annotations pose un certain nombre de défis. Tout d'abord, les MOOC attirent souvent des milliers d'apprenants, ce qui peut rendre difficile et fastidieux pour les enseignants et les tuteurs de suivre et d'évaluer toutes les annotations. De plus, les annotations peuvent être très hétérogènes en termes de qualité et de contenu, ce qui rend difficile la détection des erreurs et des questions pertinentes.

L'objectif de ce travail s'articule principalement sur la mise en place d'un outil d'analyse des annotations des apprenants dans une perspective de personnalisation des MOOC.

Le système conçu permettra aux enseignants et aux tuteurs d'analyser facilement les annotations des apprenants, d'identifier leurs problèmes et leurs difficultés d'apprentissages puis de répondre de manière efficace sur leurs questions et leurs demandes d'aides. Il devra également aider les apprenants à mieux gérer leurs annotations et à tirer le meilleur profit de leurs interactions avec les enseignants, les tuteurs et leurs pairs.

L'approche proposée est composée de 5 étapes :

- **Etape 1:** les apprenants postent des annotations (question,réponse ou commentaire) sur des parties du cours afin d'enrichir le cours.
- **Etape 2:** chaque apprenant evalue le degré de pertinance de chaque annotation postée, si elle est pertinente ou non pertinente (vote sociale).
- **Etape 3:** le système classifie ces annotations selon leurs types(question, commentaire, réponse) et leurs degrés de pertinences, par order decroissant .
- **Etape 4 :** Les annotations les plus pertinentes de chaque type seront envoyer aux tuteurs et aux enseignants pour des éventuelles réponses.
- **Etape 5:** les réponses et les recommandations des enseignants seront ajoutées au contenu du cours (vidéo et pdf) aux mêmes intervalles de temps de l'apparition de chaque annotation postée par les apprenants.

La conception de notre plateforme MOOC « Ulearn » dotée d'un outil d'analyse des annotations repose sur une architecture robuste et modulaire. Cette architecture se compose de plusieurs modules interconnectés qui assurent le bon fonctionnement du système (Figure 1).

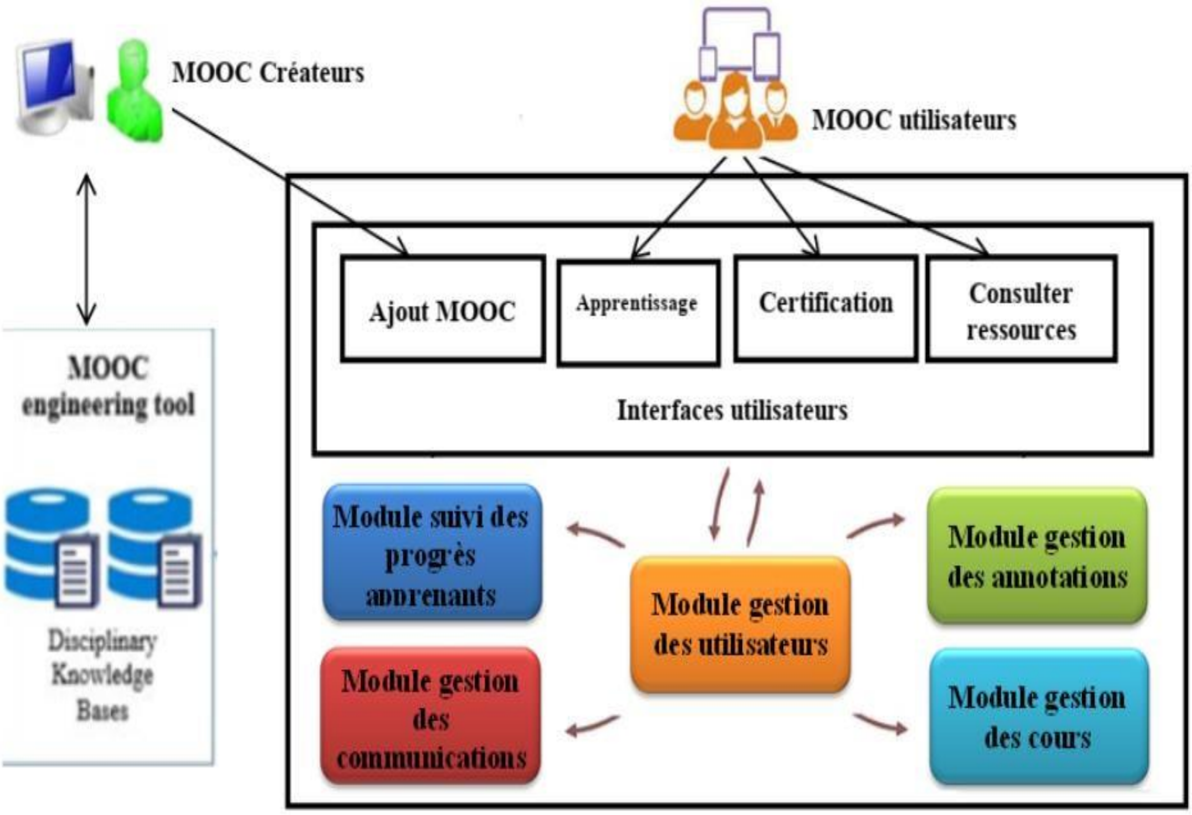

Figure 1 : Architecture générale proposée du MOOC « Ulearn ».

- **Le module de gestion des utilisateurs**, qui gère l'inscription, l'authentification et les profils des utilisateurs. Il permet aux apprenants et aux formateurs de créer des comptes, d'accéder à leurs informations personelles et les modifier.
- **Le module de gestion des cours** : il gère les informations relatives aux cours, telles que les ressources d'apprentissage, les sujets d'évaluations et les activités. Ce module offre aux formateurs la possibilité de créer et de structurer les MOOC, d'ajouter du contenu pédagogique, d'organiser des activités et de gérer les évaluations.

- **Le module de gestion des annotations** : il est responsable de la création, du filtrage du stockage, de la classification et du partage des annotations des apprenants.
- **Le module de gestion des communications :** il permet aux apprenants et aux formateurs de communiquer de manière synchrone ou asynchrone. Il comprend des fonctionnalités de chat en temps réel, les participants peuvent échanger des idées, poser des questions supplémentaires, discuter de sujets liés aux cours et collaborer sur des projets.
- **Le module de suivi des progrès des apprenants** : il collecte et enregistre les données liées aux activités d'évaluation des apprenants. Il offre des fonctionnalités de suivi et de visualisation des progrès individuels, permettant aux apprenants de suivre leurs performances et aux formateurs de mieux comprendre l'engagement des apprenants.

Mots-clés: *Personnalisation des MOOC, Apprentissage collaboratif à distance, Annotations ,Vote sociale.*

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L'extraction automatique des entités nommées Spatiotemporelles basée sur les Régles JAPE

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Résumé

L'extraction automatique de l'information est un processus important et nécessaire au moment où les informations sont devenues des sources électroniques, que ce soit dans des sites commerciaux, d'actualités ou de médias sociaux. Cependant, l'extraction des informations sans utilisation de moyens auxiliaires ou spécification du contenu de ce que l'utilisateur veut avec précision, ne lui donne pas des résultats satisfaisants et efficaces, car il est possible de se retrouver dans certains cas de similitude ou d'erreur complète. L'objectif d'utiliser les entités nommées dans l'extraction de l'information est de renforcer la performance des résultats données et améliorer leur qualité. Dans ce travail nous présenterons une approche basée sur un système d'extraction d'information, des réseaux sociaux (Facebook) sur les accidents afin d'extraire des entités nommées temporelles et spatiales avec des événements.

Mots-clés: Extraction de l'information, Entité Nommée, Traitement Automatique du Langage Naturel.

Introduction

Nous avons appliqué les règles JAPE sur un ensemble des messages Facebook importé en ligne dans l'environnement du GATE pour extraire les entités nommées Spatiales, Temporelle, et d'évènement. Nous avons cité les résultats avant et après l'application des règles JAPE. Dans ce travail, nous avons réalisé une approche qui a pour objectif de se limiter à l'extraction des entités de type « Temporelle », « Spatiale » et « Evènement » dans des textes traités d'après les medias sociaux**.**

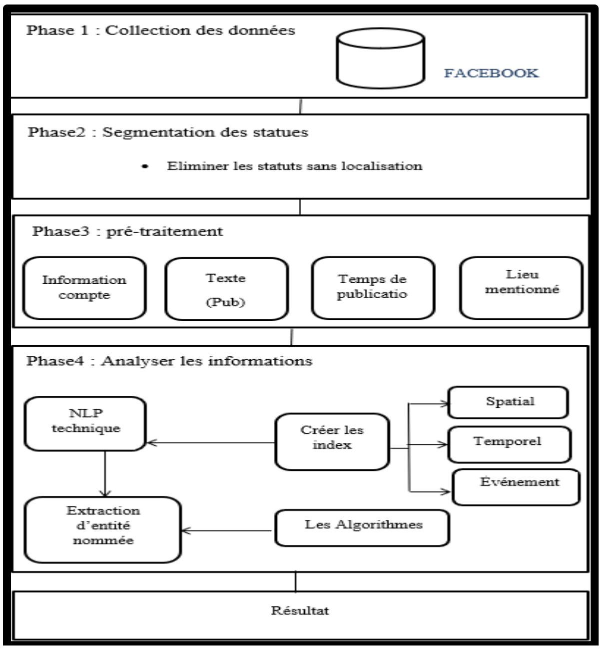
Architecture d'approche proposée

L'architecture suivante représente la conception détaillée denotre système. L'approche proposée construit un prototype qui extraitles entités spatiale et temporelle, des individus(personnes) et desévènements dans les réseaux sociaux. Le système proposé se compose de plusieurs phases ;

- **Phase de préparation :** les données sont collectées à partir des réseaux sociaux(Facebook).
- **Phase de la segmentation :** les statuts sont choisis selon les conditions posées.
- **Phase de prétraitement** : dans cette phase le bruit est réduit, et tous les caractères non alphabétiques et signes, et les liens, etc. sont effacés.
- **Phase d'analyse des informations :** on applique les techniques NLP (Natural Language Processing) et les Gazetteers et on extrait les informations nécessaires ; comme le montre la figure 1.
-

Le formalisme JAPE

Une partie des différents modules proposés dans GATE est basée sur JAPE (Java Annotation Patterns Engine), un transducteur à états finis permettant de reconnaître des expressions régulières sur les annotations. Ce système s'avère très utile en extraction d'informations car il permet de définir les contextes d'apparition des éléments à extraire pour ensuite les repérer et les annoter.(figure 3)




```
Rule: OrgAcronym
((
 {Organization}
 {Token.string == "("}
 ({Token.orth == "allCaps"}):org
 {Token.string == ")"}
)
-->
:org.Organization = {rule = "OrgAcronym"}
```

Fig. 1. Architecture du système proposé **Fig. 2.** Les règles JAPE

Table.1. Résultats du Système par default **Table.2. Résultats du Système Proposé**

	Précision	Rappel	F-M
Entité Spatial	0.26	0.22	0.23
Entité Temporel	0.15	0.13	0.14
Entité Evènement	0.53	0.51	0.52

	Précision	Rappel	F-M
Entité Spatial	0.86	0.72	0.78
Entité Temporel	0.76	0.66	0.70
Entité Evènement	0.46	0.42	0.44

Conclusion

Notre principal objectif est l'extraction des informations spécifiques sur un document à l'aide de certaines techniques de TALN basé sur l'entité nommé et d'évaluer notre système qui donne une meilleur perfermance d'extraction par rapport aux autres systèmes présents dans GATE par default. Pour une meilleure évaluation de notre approche et afin de compléter ce travail, il serait souhaitable de donner quelques perspectives qui s'inscrivent dans la continuité de notre travail qui est l'amélioration de l'extraction des entités nommées avec d'autres moyens sémantiques basées sur les ontologies.

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Comparative Study Between Conventional and Metaheuristic MPPT Algorithms for Solar Applications Under Standard Testing Conditions.

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Abstract

This paper explores how Maximum Power Point Tracking (MPPT) controllers enhance the output of photovoltaic (PV) arrays. PV energy's clean and limitless nature has sparked considerable interest. However, optimizing PV array performance requires addressing output variations using MPPT controllers. We examine a range of MPPT methods, from simple conventional techniques to advanced metaheuristic algorithms, highlighting their strengths and weaknesses.

Keywords: *Boost, CSA, DC-DC, MPPT, P&O, PSO, PV*

Introduction

PV energy has gained significant attention in industry and research due to its clean and unlimited nature. To enhance PV array efficiency, Maximum Power Point Tracking (MPPT) controllers are employed. This paper reviews different MPPT methods, ranging from conventional to advanced metaheuristic algorithms. We analyze their strengths, weaknesses, and effectiveness in optimizing PV array output.

Materials and Methods

In this study, a DC-DC boost converter was used. The converter consists of an input capacitor Cin, an inductor L, a power MOSFET, a diode D, a filter capacitor Cout and a load resistance RL. The MOSFET which is considered as a switch is turned ON and OFF at the switching frequency fs=1/T with the ON duty ratio D=ton/T where ton is the time interval where the MOSFET is ON. [1] The MOSFET's commutation is managed by the MPPT controller, which adjusts the duty cycle of the MOSFET to track the maximum power point of the PV array. By doing so, the MPPT controller ensures that the PV array operates at its maximum efficiency.
In order to maximize the output of a PV array, various MPPT methods have been proposed. These methods can be broadly classified into two categories: conventional methods and intelligent algorithms.

Algorithms Definition:

1. Perturb and Observe (P&O): chosen as a baseline to our comparison, P&O is a conventional MPPT method that operates by incrementally adjusting the PV module's voltage and monitoring the resulting change in output power. It continuously perturbs the operating point and observes whether the power increases or decreases, thus tracking the MPP. Its strengths include simplicity and ease of implementation, but it may suffer from oscillations and slower convergence.[2]
2. Particle Swarm Optimization (PSO): chosen due to its popularity in optimization problems, PSO is based on the population-based stochastic optimization algorithm inspired from swarms. Mimicking the performance gained by interaction between the different individuals or particles. The movement of the particles is defined as follows: [3]

$$X_i^{k+1} = X_i^k + V_i^{k+1} \qquad (1)$$

$$V_i^{k+1} = wV_i^k + c_1 r_1 \left(Pbest_i - X_i^k\right) + c_2 r_2 \left(Gbest_i - X_i^k\right) \qquad (2)$$

where *X* is the position of the particle; *i* the particle number, *k* the number of iteration; *V* the velocity; w the inertial weight; c_1 and c_2 the particle acceleration coefficients; *Pbest* and *Gbest* are the best local position and the best global position respectively; r_1,r_2 ∈ [0.1] are uniformly distributed random coefficients.

3. Cuckoo Search Algorithm (CSA): which imitates the behaviors of the cuckoo birds and relies on the Lévy flight search to find a suitable host nest to lay its egg on, the MPP in our case. [4]

$$X^{(t+1)} = X_i^t + \alpha \oplus L\acute{e}vy(\lambda) \quad (3)$$

where $\alpha = \alpha_0(x_{best} + x_i)$ (4)

and $L\acute{e}vy(\lambda) \approx u = l^{-\lambda}, \quad (1 < \lambda < 3)$

(5)

X_i^t is samples/eggs, *i* is the sample number, *t* is the number of iteration and α > 0 is the step size *l* is the flight length and λ is the variance. Since l < λ < 3, thus *u* has an infinite variance.

Results and Discussion

As shown in Table 1, the CSA algorithm had the highest efficiency at 99.91% and the lowest error at 0.09%. The PSO algorithm had the fastest convergence time at 0.048 seconds and the fastest settling time at 0.071 seconds. In comparison, the P&O algorithm had a slightly longer convergence time of 0.11 seconds and a slightly longer settling time of 0.15 seconds, but still achieved a high efficiency of 99.71% and a low error of 0.29.

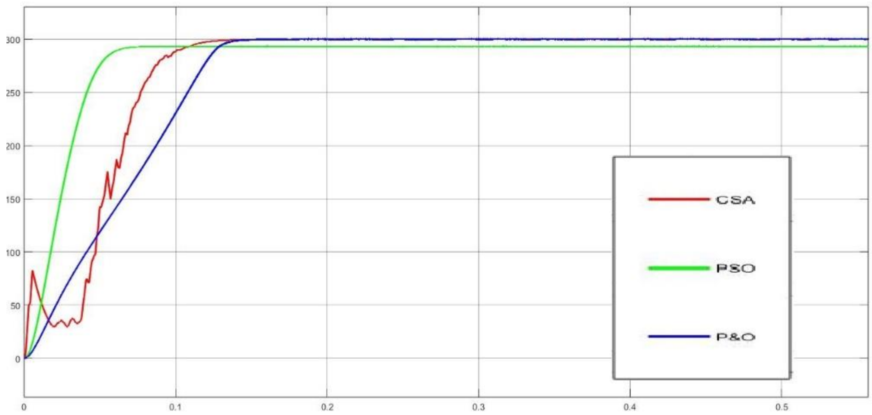

Fig. 1. Comparison of the different algorithms power output at 1000w/m^2

Table 3 Results of the comparison between the different algorimths

Algorithm	Convergence time (s)	Settling time (s)	Efficiency (%)	Error (%)

P&O	0.11	0.15	99.71	0.29
PSO	0.048	0.071	97.74	3.26
CSA	0.083	0.12	99.91	0.09

Conclusion

The metaheuristic algorithms (PSO and CSA) surpassed the conventional P&O algorithm in several key metrics, including higher efficiency, lower error rates, faster convergence time, and quicker settling time. This demonstrates that the metaheuristic algorithms offer superior performance and optimization capabilities compared to the conventional approach.

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USE of e-learning in architectural education field. Case study: students of department of architecture, Guelma's University.

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Abstarct

USE of e-learning in architectural education field. Case study : students of department of architecture, Guelma's University. HAFSI Fatma Zohra Maitre de conférences Département d'Architecture et d'urbanisme Université du 8 mai 1945, Guelma hafsi.fatmazohra@univ-guelma.dz Abstract The use of e-Learning methods and tools is getting more and more important at universities, especially after the covid-19 pandemic. Practically, the lockdown obliged higher education stakeholders in Algeria to reconsider and rethink education anew in light of the emerging challenges and opportunities imposed by e-learning. Architectural education is somewhat a specific field in which students are supposed to develop imagination aptitude mainly through the design process. Actually, an unlimited e-ressources are available on the World wide web (www), alongside with a variety of courses designed by lecturers and provided by the official e-learning platforms at the Algerian universities. The present study aims to examine the role of these e- learning resources in the improvement of architectural skills. For this, a questionnaire was designed to explore how do architecture students use e- learning in their learning process. Data were collected from architecture students at different levels. SPSS 26 software package was used in the field of questionnaires' statistical analysis. The survey's results showed that many students comprehensively relied on the Internet resources and online social networks, and few of them have actually used the University's e-learning system and e-resources. The students pointed out reasons behind the little use of E-learning system such as the system does not help them undertaking innovative activities of the design studio, overcoming troublesome design situations, and producing innovative projects. The students also mentioned a number of personal and technical shortages that limit an optimum utilization of the e-learning system. This paper argues that shortages of the present e-learning system should be dealt with; otherwise, the e-learning system, will not respond to the architecture students' innovative needs and inspirations. Keywords: E-learning, use, architectural education, architecture students, skills.

Keywords: E-learning, use, architectural education, architecture students, skills

Transforming Urban Living: The Impact of IT in Smart Cities - A Case Study Analysis

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Abstract

Smart Cities and Information Technology (IT) have emerged as a powerful and transformative combination, revolutionizing urban living worldwide. Smart cities leverage advanced technologies, such as Artificial Intelligence (AI), the Internet of Things (IoT), data analytics, and cloud computing, to optimize resources, enhance citizen services, and foster sustainability. This paper explores the symbiotic relationship between smart cities and IT, delving into case studies of successful initiatives from global urban centers. Through a systematic analysis of key findings, the study highlights the impact of IT in enhancing urban efficiency, sustainable resource management, citizen-centric services, data-driven decision-making, and fostering innovation and collaboration. The research emphasizes the crucial role of IT in shaping a more livable, resilient, and inclusive future for urban communities while acknowledging the need for ethical considerations and equitable access to technology. As cities continue to evolve, the study advocates for responsible implementation of IT-driven solutions, offering valuable insights to policymakers and stakeholders to pave the way towards smarter, greener cities in the 21st century.

Keywords: *Smart Cities, Information Technology, Urban Efficiency, Sustainability, Resilient cities*

Introduction/Background

The concept of smart cities, driven by cutting-edge Information **Technology (IT) solutions, has** emerged as a transformative force in urban development. Smart cities leverage technologies such as Artificial Intelligence (AI), Internet of Things (IoT), data analytics, and connectivity to optimize resources, enhance services, and improve the overall quality of life for citizens. The integration of IT in urban environments offers unprecedented opportunities for sustainable resource management, efficient transportation, citizen engagement, and data-driven decision-making. However, as the world urbanizes at an unprecedented pace, challenges such as environmental degradation, resource constraints, and infrastructural demands continue to mount. This research aims to explore the symbiotic relationship between smart cities and IT, delving into successful case studies of global smart city initiatives. By analyzing the transformative impact of IT in these urban centers, this study seeks to provide insights that foster responsible and equitable smart city development, addressing the pressing needs of modern urban living.

Materials and Methods (Design/methodology/approach)

In this study, we analyzed successful smart city initiatives, including Singapore's Smart Nation Initiative, Barcelona's Smart City Barcelona, Seoul's Smart Seoul 2025, Copenhagen's Copenhagen Connecting, Dubai's Smart Dubai, and Amsterdam's Amsterdam Smart City. The case study selection was based on their significance, availability of relevant data, and representation of diverse smart city domains. Data was collected from academic papers, official city websites, government publications, reputable case studies, and news articles. We employed qualitative and quantitative analysis methods to identify key performance indicators and evaluate the impact of each initiative. Comparative analysis allowed us to highlight similarities and differences, shedding light on their relative success in achieving smart city objectives. Ethical considerations were addressed, and limitations, such as data availability and potential biases, were acknowledged. This comprehensive approach ensured the accuracy and reliability of our findings, offering valuable insights into the transformative potential of IT-driven solutions in advancing smart cities.

Results and Discussion (Findings)

1. Enhanced Urban Efficiency: The case studies revealed a common theme of enhanced urban efficiency through the strategic implementation of IT. Smart cities leverage data analytics and real-time monitoring to optimize transportation systems, reducing traffic congestion and travel time. For instance, Singapore's Smart Nation Initiative utilized AI-powered traffic management and autonomous vehicles to create smoother and more efficient traffic flows, alleviating the burden on urban transportation networks. This has resulted in reduced commute times and improved overall mobility for residents.

2. Sustainable Resource Management: The integration of IT in smart cities has significantly advanced sustainable resource management. By leveraging IoT sensors and data analytics, cities like Barcelona and Copenhagen have achieved remarkable reductions in energy consumption and waste generation. Smart lighting systems in Barcelona adjust brightness based on real-time data, leading to energy savings and reduced light pollution. Copenhagen's smart irrigation system optimizes water usage in parks and gardens, ensuring water conservation during dry spells. These initiatives demonstrate the potential of IT to enhance urban sustainability and contribute to global efforts toward environmental conservation.

3. Citizen-Centric Services: The findings underscored the importance of citizen-centric services in smart cities. By harnessing IT, cities like Dubai and Amsterdam have established unified platforms that integrate data from various government departments, streamlining services and improving accessibility for citizens. Smart Dubai's deployment of blockchain technology has facilitated secure and transparent interactions with government entities, fostering a more trustworthy and efficient public administration. Such approaches demonstrate how IT can bridge the gap between citizens and governments, leading to more responsive and citizen-focused urban services.

4. Data-Driven Decision-Making: The study revealed the critical role of data-driven decision-making in smart city initiatives. Through comprehensive data collection and analysis, cities gain valuable insights into their operations and can make informed decisions to address urban challenges. Singapore's data-driven approach to waste reduction and energy optimization has led to significant improvements in resource utilization and environmental sustainability. Data analytics in Seoul has supported evidence-based policymaking, allowing the city to tackle urban issues with greater precision and efficacy. By embracing data-driven methodologies, smart cities can optimize their processes and enhance overall governance.

5.Innovation and Collaboration: The findings highlighted the need for innovation and collaboration in the development of smart cities. Each case study demonstrated how collaboration between governments, businesses, and citizens is crucial in the successful implementation of IT-driven initiatives. In Barcelona, citizen engagement played a pivotal role in shaping urban solutions, fostering a sense of ownership and pride among residents. These collaborative efforts foster innovation and create dynamic ecosystems where technology and creativity intersect to address urban challenges effectively.

Conclusion:

The study's findings present a compelling narrative of how IT-driven solutions have transformed urban living in smart cities. Through enhanced urban efficiency, sustainable resource management, citizen-centric services, data-driven decision-making, and a culture of innovation and collaboration, these cities have harnessed the power of IT to create more livable, resilient, and inclusive urban environments. The transformative impact of IT is evident in the optimized transportation systems, reduced energy consumption, and improved citizen engagement observed in these case studies.

As cities continue to grow and evolve, the adoption of IT-driven solutions becomes ever more critical in tackling urban challenges and improving the quality of life for residents. However, the study also underscores the importance of addressing ethical considerations, ensuring data privacy, and promoting equitable access to technology to avoid exacerbating existing urban disparities. By leveraging the insights gleaned from these successful smart city initiatives, policymakers, city planners, and stakeholders can forge a path toward more sustainable, efficient, and people-centric urban landscapes. The journey towards smarter cities is one of continuous learning, innovation, and collaboration, where IT serves as a catalyst for positive change and a blueprint for urban progress in the 21st century.

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Big Data: The Future of Analytics

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Abstract

The article delves into the world of Big Data Analytics and its diverse applications, revolutionizing industries across the globe. Big Data Analytics involves the extraction, processing, and analysis of vast datasets to reveal valuable insights and patterns. The abstract explores the significance of this technology in transforming decision-making processes, optimizing operations, and gaining a competitive edge. We examine its applications in diverse sectors, including healthcare, finance, marketing, and manufacturing, showcasing how data-driven approaches drive innovation and efficiency. Additionally, the article sheds light on the challenges of handling massive datasets, data privacy concerns, and the integration of Artificial Intelligence and Machine Learning to enhance analytical capabilities. Overall, this abstract provides a glimpse into the transformative power of Big Data Analytics in shaping a data-centric future.

Keywords: Big Data, Analytics, Applications, Transformative Data-driven

Introduction/Background

In the digital era, the explosion of data known as Big Data has presented organizations with unprecedented challenges and opportunities. Big Data Analytics has emerged as a powerful solution to extract valuable insights from massive datasets. It involves utilizing advanced technologies and algorithms to make informed decisions, optimize processes, and drive innovation. This article explores the transformative impact of Big Data Analytics across various industries, such as healthcare, finance, marketing, and manufacturing. However, along with its potential, it raises concerns about data privacy and ethical considerations. Understanding the role of Big Data Analytics is crucial in navigating the data-centric landscape of the modern world.

Materials and Methods (Design/methodology/approach)

The methodology used in this article is a case study approach. We will analyze several real-world examples of Big Data analytics and their applications in different industries. By examining these case studies, we will identify common themes and patterns that emerge in the use of Big Data for decision-making, optimization, and innovation. We will also explore the challenges and limitations of Big Data analytics, as well as the potential benefits and opportunities. This approach will provide readers with a practical and tangible understanding of how Big Data analytics can be applied in a variety of contexts and will highlight the key considerations for organizations looking to leverage this technology for competitive advantage.

Results and Discussion (Findings)

Big Data is a term that refers to the vast amount of structured and unstructured data generated every day. This growth in data has led to the development of new applications and technologies capable of analyzing and processing large amounts of data quickly and efficiently. The use of Big Data has become increasingly popular across multiple industries, including healthcare, finance, and retail, as it provides insights that can improve decision-making.Big Data analytics refers to the strategies, processes, technologies and techniques used to analyze massive and complex data sets known as Big Data (Chen et al., 2014). By extracting valuable insights from Big Data, businesses can gain a competitive advantage and make more informed decisions (Davenport, 2014). With the proliferation of data sources such as the Internet of Things, social media, mobile devices and enterprise applications, Big Data analytics has become increasingly important (Ghasemaghaei, 2020). Many organizations are leveraging Big Data analytics to improve operational efficiency, enhance customer experiences, develop new products and services, detect fraud, monitor business performance and gain insights that guide strategic planning (Koenig, 2018). Some of the major applications of Big Data analytics are in e-commerce, retail and customer relationship management. E-commerce giants like Amazon analyze customer browsing behavior, purchase histories and product reviews to provide customized recommendations, targeted promotions and fraud detection (Wang and Alexander, 2017). Retailers utilize Big Data analytics on point-of-sale data, social media, web traffic and customer demographic information to improve supply chain management, optimize product placements and personalize the shopping experience (Gunasekaran et al., 2017). Customer relationship management applications utilize consumer profiles, call center logs, surveys and social media data to identify high value customers, improve customer service and develop more effective marketing campaigns (Filieri, 2015).

Other key applications include fraud detection in banking and finance, risk management in insurance, precision agriculture using sensor data, predictive maintenance of infrastructure and equipment, real-time traffic monitoring for smart cities, drug discovery and precision medicine (Raghupathi and Raghupathi, 2014; Dincer and Brgers, 2018; Hashem et al., 2016; Fan et al., 2014). As data volumes and varieties continue to increase exponentially, Big Data analytics is expected to disrupt nearly every industry with new insights, opportunities and competitive threats (Jacoby, 2016). The effective utilization of Big Data now determines business success more than ever before (Davenport, 2012).

Conclusion

In conclusion, Big Data analytics has the potential to drive tremendous value and transformation for organizations. By extracting insights from vast amounts of structured and unstructured data, businesses can improve decision-making, reduce costs and increase revenues. However, realizing this potential requires overcoming challenges around data management, governance, skills, and technology. While the opportunities are immense, organizations must develop a holistic Big Data strategy, build the necessary analytics capabilities and foster a data-driven culture to truly leverage Big Data analytics for competitive advantage. With the right people, processes, and technologies in place, Big Data analytics can serve as an engine of growth, innovation, and disruption for those organizations that learn to harness its power effectively.

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A concise overview of Bias and Unfairness in ML Models

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Abstract

Bias and unfairness in machine learning (ML) models are critical issues that have garnered significant attention in recent years. In the present paper, we delve into the fundamental concepts surrounding bias and fairness in the domain of machine learning models and We present a novel framework aimed at mitigating bias in biomedical datasets.

Keywords: *bias, biomedical, unfairness, machine learning.*

Introduction

The extensive adoption of prediction-based decision algorithms by governments and organizations has sparked concerns regarding the potential biases and unfairness ingrained in these models, particularly with respect to race, gender, social class, and other sensitive factors [1, 2]. Addressing and mitigating such biases present a complex challenge as they exhibit variations across cultures and are influenced by a multitude of factors [3] [5].

Various application domains, including computer vision, natural language processing, and recommendation systems, confront distinct challenges concerning bias and unfairness. For instance, computer vision systems may encounter difficulties in accurately differentiating faces of different skin tones. Natural language processing applications can inadvertently perpetuate social biases through negative generalizations of certain words. Recommendation systems, when trained on historical data reflecting past biases, have the potential to reinforce existing inequalities.

Addressing these domain-specific challenges requires tailored solutions and a conscious effort to identify and rectify biases. Emphasizing diversity in datasets, implementing fairness-aware algorithms, and conducting thorough evaluations are essential steps toward building more inclusive and equitable AI systems in these specific application areas. Collaborative efforts from researchers, practitioners, and policymakers will be instrumental in achieving meaningful progress in this direction.

In summary, Section 2 provides a review of various bias types, while Section 3 introduces our proposition in bias and fairness detection, and Section 4 serves as the conclusion of the paper.

Categories of Bias

Bias can be categorized into three types summarized in Table (1) [4].

Table 1. Categories of bias

Class	Description
Data bias	It is a consequence of the data used to train the algorithm. This bias can arise due to historical and social inequalities that are present in the data, as well as the methods employed for data collection and preprocessing. Addressing data-induced bias requires careful examination of the training data and implementing strategies to mitigate unfair biases, promoting more equitable and unbiased outcomes.
Algorithm Bias	It results from the design of the algorithm. Unlike data-induced bias, algorithmic bias is caused by specific decisions made by the developers during the algorithm's creation. By identifying and rectifying these biased elements, it is possible to enhance the fairness and impartiality of the algorithm's outputs.
Interaction Bias	It arises from the interactions between users and the algorithm. This bias can be caused by how the algorithm is presented to users and how they choose to utilize it. Users' decisions, preferences, and actions while interacting with the algorithm can introduce biases in the outcomes.

Proposed approach in dataset bias detection

In order to effectively detect and reduce dataset bias, leading to more equitable and reliable machine learning models in biomedical applications. An architecture for a biomedical dataset bias reduction system using an ML approach is proposed in figure (1).

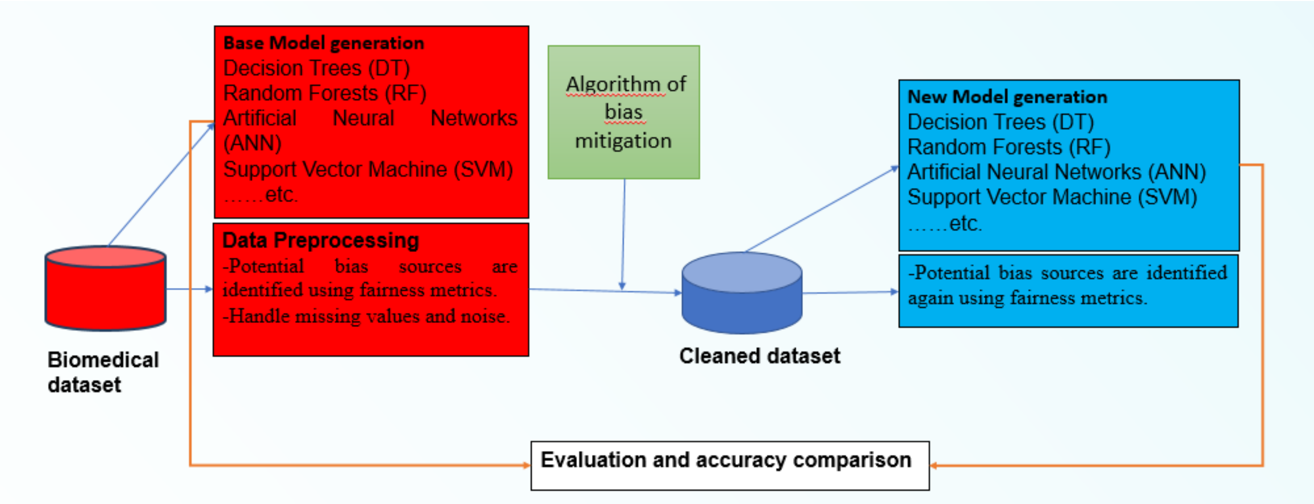

Fig. 1. Proposed approach for dataset bias detection

1) Identifying Potential Bias Sources: In this initial step, fairness metrics are used to identify potential sources of bias within the dataset. These metrics help in assessing and quantifying biases that might exist in the data.
2) Base Model Generation: After identifying potential bias sources, a base machine learning model is created using the original dataset. This model serves as baseline for measuring bias mitigation effectiveness.
3) Algorithm for Dataset Bias Mitigation: This step involves implementing algorithms to mitigate bias in the dataset. The basic idea consists of oversampling underrepresented groups, reweighting data points, or applying adversarial training to reduce bias in the model's predictions.

4) New Model Generation: Once the bias mitigation techniques are applied to the dataset, a new machine learning model is trained using the cleaned and modified dataset. This model is expected to be less biased compared to the base model created in step 2.

5) Identifying Potential Bias Sources Again: After bias mitigation, fairness metrics are once again used to assess the dataset and model to identify any remaining sources of bias.

6) Evaluation and Accuracy Comparison: This step involves evaluating and comparing the performance of the two generated models. The goal is to achieve a more equitable and unbiased model without sacrificing overall performance.

Conclusion

The paper conducts a comprehensive literature review on bias and unfairness identification methods in machine learning models. It covers some types of bias and presents an architecture for bias detection and reduction.

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Study the influence of the choice of the Similarity Measures in the Recommendation System

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Abstract

This study focuses on the use of collaborative filtering, a commonly used method in recommendation systems, to predict user preferences based on the past behavior of similar users. This approach stands out for its potential to provide personalized recommendations using only past interactions between users and items, without requiring explicit knowledge about users or items. The main objective was to evaluate the performance of different similarity measures in user-based collaborative filtering recommendation systems. The MovieLens100K dataset was used for this purpose, and eight (8) commonly used similarity measures in the recommendation literature were selected. In order to evaluate the performance of the different similarity measures, two widely used evaluation metrics, Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE), were employed. Lower MAE and RMSE values indicate better performance of the recommendation system. In conclusion, this study highlights that the choice of the appropriate similarity measure has a significant impact on the system's performance and can contribute to the development of more accurate and effective recommender systems.

Keywords: *Recommendation system, collaborative filtering, User based, Similarity measures*

Introduction

Recommender systems have become an essential tool in many online applications to personalize recommendations and enhance user experience, this makes it easier to analyze the preference of users. In this regard, recommender systems are used to recommend information and provide personalized services through analyzing the user behaviors (Chen et al., 2018). The collaborative filtering (Yu, 2015) (Yang et al., 2016) is a technique used to recommend items for users. There are a couple of popular similarity algorithms (Chen et al., 2018) that have been used in the user-based CF recommendation algorithms (Lee, Sun, & Lebanon, 2012). In this paper, we investigate the influence of the choice of the similarity measure in the collaborative filtering recommender systems using popular evaluation metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE).

Materials and Methods

In order to evaluate the performance of user-based collaborative filtering recommender systems using different similarity, we use the MovieLens dataset hosted by the GroupLens website. Several versions are available. We will use the MovieLens 100K1 dataset. This dataset mainly consists of 100000 ratings, ranging from 1 to 5 stars, from 943 users on 1682 movies. Then, we split the dataset into 80% as training set and the rest for the test set. After, we use the recommendation method to recommend a list of 50 items (Movies) to each user. Finally, to evaluate the prediction accuracy of the several methods, we employ two standard metrics: (1) the Mean Absolute Error (MAE) it is a commonly used evaluation metric for recommender systems. It is calculated by taking the absolute difference between metric for recommender systems. RMSE is calculated by taking the square root of the average of the squared differences between predicted and actual ratings across all test cases.

Results

we have investigated the influence of similarity measures on the performance of recommender systems. We compare eight (8) similarity methods such as Cosine, Pearson correlation, Euclidean distance, mean squared difference (MSD), Spearman correlation, City block CB Manhattan, Ajusted Cosine and Jaccard similarity in MovieLens 100K Dataset.

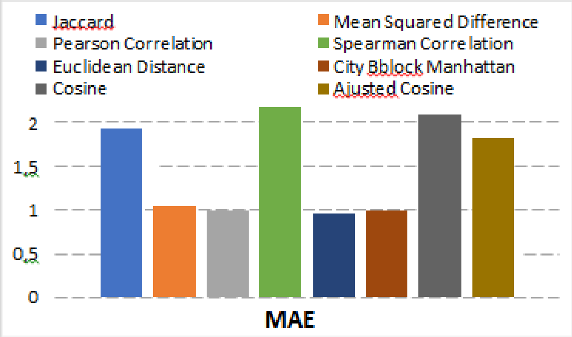

Fig.1. Comparison of deferent similarities in terms of MAE.

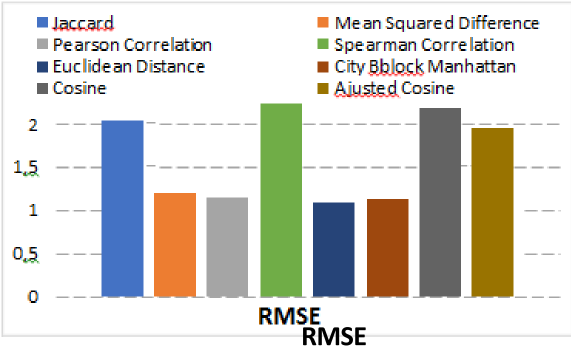

Fig.2. Comparison of deferent similarities in terms of RMSE

From the results on MovieLens dataset, we find that Spearman correlation obtain the better performance in term of MAE and RMSE than the other similarity measures

Conclusion

In conclusion, this study highlights that the choice of the appropriate similarity measure has a significant impact, and plays a critical role in the system's performance and can contribute to the development of more accurate and effective recommender systems.

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Influencers detection in online social networks

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Abstract

Online social networks (OSNs) have become an integral part of people's daily lives, resulting in a vast amount and diversity of information available for research and analysis. Detecting influential users is a significant research topic in social network analysis (SNA), it‘s played a crucial role in information dissemination within OSNs. It has various applications, including viral marketing. In this short paper, we provide a description of our thesis subject by explaining the context, research objectives, and motivations. Subsequently, we present our proposed approach and research methodology.

Keywords: *Online social networks, influential users, viral marketing, Twitter.*

1- Introduction

1-1 Context and Motivation

OSNs platforms are helping marketers tremendously in promoting their products or services largely and far less costly. Viral marketing is a relatively new form of marketing that exploits OSNs in order to promote a product, a brand, opinion, etc. Thus, identifying influencers who can trigger wider adoptions is a major challenge. Researchers in the SNA community try to solve this task by analyzing how web users influence each other and the way influence propagates through the social network. For that we aim to find a novel approach to detect the influential users in OSN which is affected by the structural and the behavioral aspects which characterize an OSN.

1-2 Research Methodology

Several methods have been proposed for identifying influencers in different OSNs. However, the majority of these methods are usually based on the users' behavior or the network structure only. It has become necessary to find effective solutions for identifying influencers considering multiple aspects of influence and use a large number of network attributes and users' characteristics. For instance, users who have the most followers are not necessarily the most influential ones; there is the possibility of buying followers and users well positioned in the network but who are inactive [1]. To address these challenges, we propose a novel framework for detecting influencers in OSNs for viral marketing context. Figure 1 below depicts the theoretical framework. Our framework is composed of three main steps, the first step **data collection and features extraction**, for the implementation of our proposed framework, we need to extract data from the OSNs. For the purpose of this study, we used twitter network, it is one of the most OSN used in the experiment data source. Twitter data can be collected using twitter API, employing either the streaming or scraping method. once the essential user and tweet attributes are selected. This step contains several tasks such as data pre-processing and the representation of the extracted data [2].

Concerning features selection, it is very important to select the best set of features that are used to calculate the users influence, it depends on the type of the OSN and the characteristics of each user and their tweets. As these selected features are helpful to measure the score of social influence of each user in the network. There are many feature classifications in the literature [3]. In our works we will use a variety of the most used features.

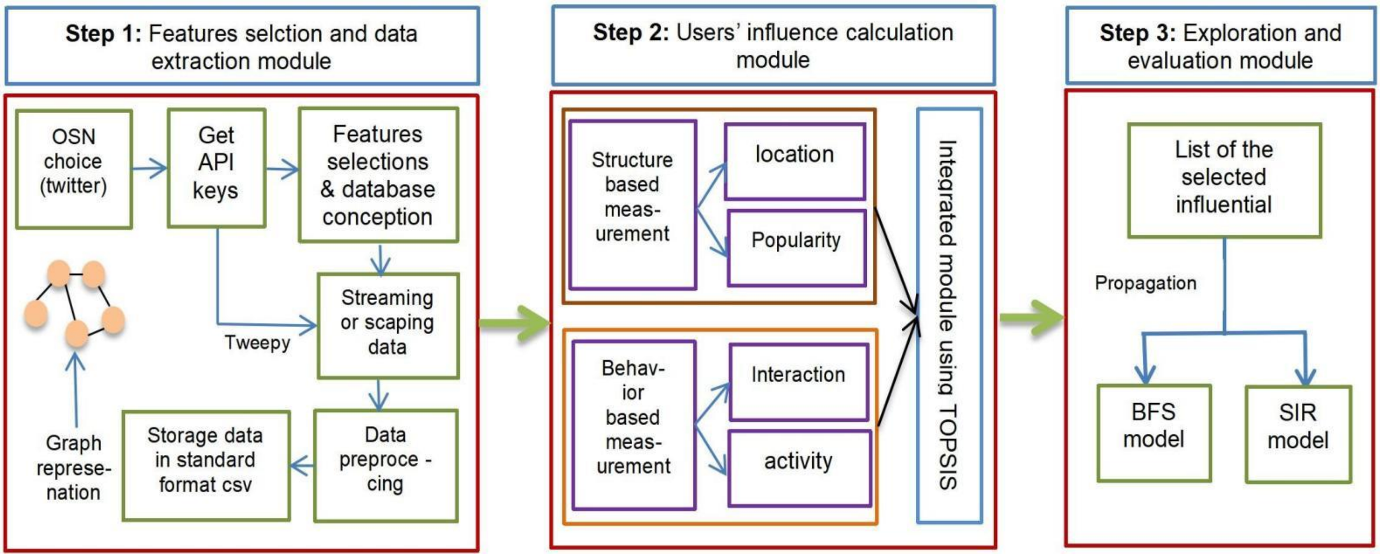

Fig.1. Conceptual framework for detection of influential users on OSN

The second step **users' influence calculation** it is a very important section in the social influence analysis, in this step we use different metrics for the calculation of users influence score, these metrics are selected depending on the features selected in the precedent section. Subsequently we, calculate the users' influence based on the structural-based measurement that rely on topological features like node connections, centrality and user positions within the network [4] and behavioral- based measurement that consider user interactions and activity such as comments, retweets, reply ...etc. [5].This analysis involves several measures such as centrality, ollowerRank, etc.To determine the set of users with the highest influence score, we integrate the results of these measures using the multi-criteria decision method Technique for Order Preference by Similarity (TOPSIS) to Ideal Solution . Finally, the e**xploration and evaluation of the set of detected influencers.** The last step we generate the set of the best users (influencers) using the Suspected Infected Recovered (SIR) and Breadth First Search (BFS) propagation models for proving her efficiency.

Conclusion

Influential users play an important role in the propagation of information in OSNs, they can attract the attention of other users. Therefore, detecting influencers is fundamental in different fields. This work aim is to propose a new framework for identifying influencers, that consider the various types of data on OSN. Twitter was chosen as the analysis data source. Future research will focus on implementingthe proposed framework and discussing the results.

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Towards an Approach for Improving Behavioral Engagement

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Abstract

Currently, in the field of education, there is a prevailing trend towards enriching the traditional pedagogical approach by introducing active learning methods, emphasizing the active participation of the learner in the manipulation of knowledge. Project-based learning is one of these methods. However, despite the crucial importance of engagement for the success of learning, both overall and specifically online, it remains relatively low in project-based learning contexts. With this in mind, we will present a new approach aimed at enhancing behavioral engagement within an online project-based learning environment. This approach is primarily based on the analysis of traces left by learners throughout their learning process.

Keywords: *online learning, project-based learning, collaboration, improvement of engagement, behavioral engagement.*

Introduction

In the realm of online education, a learner's behavioral engagement emerges as a pivotal factor for elevating their academic achievements, as supported by research (Hospel et al., 2016; Lai et al., 2021; Monteiro et al., 2021). Consequently, it becomes imperative to gauge the levels of attention, curiosity, interest, and passion among learners, as these factors play a critical role in motivating them to actively participate in the learning journey. Moreover, a robust commitment to behavioral engagement in learners manifests as active involvement, unwavering focus on assigned tasks, and a demonstrable proficiency in study and reflection skills. Within the context of project-based learning (Kokotsaki et al., 2016; Gunawan et al., 2017), learners collaborate within teams to execute projects while choosing activities that align with their preferences and interests. They adeptly collect and synthesize data from a diverse array of sources, subjecting it to analysis to distill valuable insights and knowledge. Subsequently, learners showcase their newly acquired information, putting their learning and communication abilities on display, subject to evaluation. The core objective of our endeavor is to enhance the behavioral engagement of learners within the framework of an online project-based learning environment.

A new approach to enhance behavioral engagement

Behavioral engagement plays a crucial role in the success of learners in education in general, and online learning in particular. However, nearly all existing works on engagement in the educational domain have failed to propose an approach to improve behavioral engagement in online project-based learning environments. It is within this context that our work fits in, where we propose a novel approach based on the traces left by learners during the learning process. These traces are leveraged to compute indicators of performance and engagement, which are then utilized to rank learners, generate dashboards, and provide feedback through the system, all with the aim of encouraging and motivating learners to progress.

The proposed approach is implemented in an online learning system. Within this system, we have categorized these traces into three types: communication traces, collected through the communication tools used in our system, traces of resource consultation and traces related to time management, where these traces are collected based on an individual's adherence to deadlines for urgent questions, meeting participation and project completion.

Conclusion

Project-based learning is a strategy that requires learners to organize a series of pedagogical activities that promote collaboration among the learners. To achieve this, we have proposed a new approach to help learners enhance their behavioral engagement in a project-based learning environment. The proposed approach has been implemented in a system we developed. This system collects traces of learners' interactions with well-defined activities to calculate an individual score, which is then used to generate rankings using stars, visualize progress through dashboards, and provide feedback to encourage participants and foster a sense of motivation.

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Implementing H-infinity Control on Nonlinear Systems via Non-Quadratic Lyapunov Functions

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Abstract

This work addresses robust stabilization of a nonlinear system using a Takagi-Sugeno fuzzy model. The system's complexity is simplified via sector nonlinearity techniques, resulting in a decoupled fuzzy model. A robust controller, based on the Differential Mean Value Theorem, is designed to stabilize the system, with controller gain determined by Linear Matrix Inequalities. The study's key contributions include introducing a state feedback controller for robust system stabilization and utilizing a non-quadratic Lyapunov function to reduce conservatism. An example is provided to demonstrate the approach's effectiveness.

Keywords: Takagi Sugeno fuzzy systems, mean value theorem, linear matrix inequalities, stabilization, Lyapunov fuzzy function.

Commande Synergétique Terminale d'un Système Photovolaïque

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Résumé

Une technique MPPT basée sur une approche non linéaire appelée commande synergétique terminaleest développée, afin d'optimiser le transfert d'énergie d'un générateur PV vers sa charge. Le schéma de contrôle proposé présente des caractéristiques de convergence rapide et en temps fini. Dans le butd'évaluer l'amélioration effective apportée par la commande TSC, une étude comparative par simulation numérique est réalisée.

Mots-clés: *Système photovoltaïque, commande synergétique, commande synergétique terminale,MPPT.*

Introduction

Le photovoltaïque PV est une alternative énergétique viable, utilisant l'énergie solaire, pour une production d'électricité propre et potentiellement illimitée, contrairement aux combustibles fossiles et nucléaires [Pal 13]. Le système PV est principalement composé d'un panneau solaire, d'un convertisseur DC- DC, un contrôleur MPPT et une charge résistive. Le contrôleur synergétique terminalest utilisé pour commander le convertisseur élévateur pour atteindre la puissance maximale de fonctionnement en temps fini. Des simulations sont réalisées sous l'environnement Matlab/Simulink, pour mettre en évidence la validité et la robustesse de l'approche proposée.

Commande synergétique terminale d'un système photovoltaïque

La théorie de commande synergétique (SC) est considérée comme une méthodologie puissante de conception de commande non linéaire en particulier dans sa facilité de mise en œuvre en pratique [Zer18]. Cependant, la loi de commande synergétique a été conçue sur la base d'une stabilité asymptotiqueet les trajectoires du système à commander atteignant l'équilibre en un temps infini. Dans le but d'accélérer la convergence et pour améliorer la performance de contrôle, un nouvel algorithme communément connu sous le nom de commande synergétique terminale (TSC) [Beh 21] , [Hah 21] connaît un grand succès ces dernières années. En réduisant le temps requis pour atteindre le point d'équilibre, on renforce aussi bien la convergence, ainsi que l'atténuation rapide des perturbations. Laconception d'une commande synergétique terminale assurant le fonctionnement optimal d'un système photovoltaïque (PV) est developée dans ce travail.

Résultats de simulation

Le système PV est constitué d'un générateur PV de type KC200GH-2P, d'un convertisseur élévateur DC-DC, d'une charge et du bloc de contrôle MPPT. Les résultats obtenus sont présentés pour une durée de 1 seconde.

Les résultats de simulation obtenus sont consignés dans les figures suivantes :

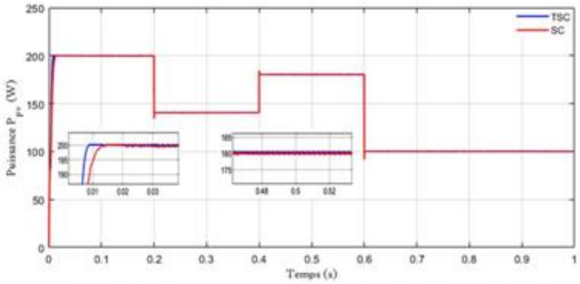

Fig. 1. Evolution de la puissance P_{pv} du panneau

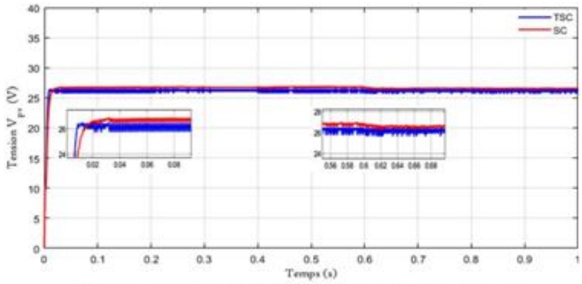

Fig. 2. Evolution de la tension V_{pv} du panneau

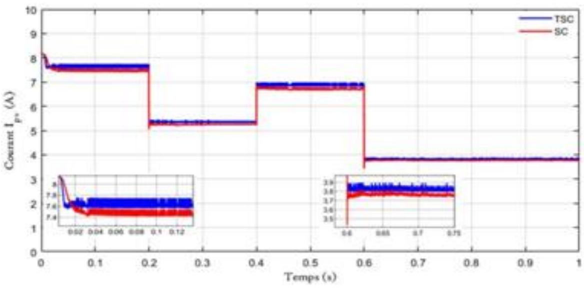

Fig. 3. Evolution du courant I_{pv} du panneau

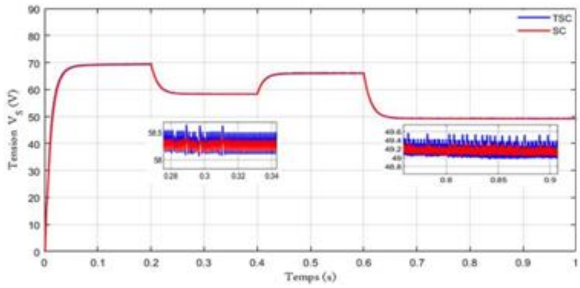

Fig. 4. Evolution de la tension de sortie V_s

À travers ces différentes simulations, il est clair que l'objectif assigné à la commande proposée est largement atteint. En effet, on peut voir que le suivi de la puissance désirée est atteint en un temps relativement inférieur à celui exhibé par la commande synergétique SC.

Conclusion

Dans ce travail, on a développé une nouvelle technique de commande basée sur l'approche synergétique pour le contrôle d'un système PV autonome. La commande synergétique est appliquée avec une nouvelle structure non linéaire de la contrainte afin d'assurer une convergence en temps finiet rapide. Cette structure de commande est capable d'assurer de bonnes performances de poursuite du PPM et de garantir la stabilité du système en boucle fermée. Les résultats de simulation obtenus, sous l'environnement Matlab/Simulink, montrent la validité de l'approche, sa robustesse et prouvent que cette technique développée permet de réduire les erreurs de trajectoire de poursuite du PPM, qui peut se traduire par la minimisation des pertes de puissance engendrées.

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PREGO : Plateforme d’apprentissage collaborative favorisant le regroupement optimisé des apprenants

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Résumé

Ce travail se situe principalement dans le contexte d’apprentissage collaboratif assisté par ordinateur (CSCL en anglais, pour Computer-Supported Collaborative Learning). Dans ce domaine de recherche, les apprenants sont regroupés pour effectuer leurs différentes activités pédagogiques (apprentissage, résolution de problèmes, etc.) selon des stratégies de regroupement. Plusieurs recherches ont été effectuées sur la gestion des groupes et leurs optimisations. L’objectif principal de ce travail est de chercher des méthodes et des techniques optimales du regroupement afin de les intégrer dans un système d’apprentissage collaboratif (CSCL) qui prend en charge le processus du regroupement intelligent des apprenants. En d’autres termes, la problématique de cette recherche peut être exprimée comme suit : étant donné un ensemble d’apprenants N et un ensemble de tâches à effectuer M (de différentes difficultés et ampleurs), nous cherchons la composition optimale des apprenants (en qualité de taille du groupe et méthode de regroupement la plus appropriée) afin de garantir un taux de succès maximal. Pour ce faire, on a utilisé une seule technique basée sur l’algorithme génétique afin d’atteindre nos objectifs.

Mots-clés: Apprentissage collaboratif, Groupement des apprenants, Optimisation, Stratégie de Regroupement, CSCL.

1. Introduction

Durant ces dernières années, plusieurs recherches ont été effectuées sur les systèmes d’apprentissage collaboratifs assistés par ordinateur(Borges et al., 2018; Khandaker et al., 2006; Wang & Hong, 2018). dans cet axe de recherche, les apprenants sont regroupés en groupes pour réaliser leurs différentes activités pédagogiques (apprentissage, résolution des exercices, réalisation de projets communs, etc.). De nombreuses recherches ont été faites sur la gestion des groupes et leurs optimisations.(Baykasoglu et al., 2007; Graf & Bekele, 2006; Ho et al., 2009; Holmberg, 2019). en d’autres termes, beaucoup de recherches ont été effectuées pour trouver des méthodes et des techniques d’optimisation de regroupement. Selon les experts, la taille des groupes et leur constitution sont encore des domaines d’étude ouverts où il n’y a pas d’une solution optimale parmi les chercheurs. En effet, alors que certaines recherches ont indiqué une taille de groupe idéale, d’autres ont trouvé et prouvé l’inverse. Alors, quelle devrait être la taille du groupe d’apprenants? Existe-t-il un lien entre la taille du groupe et le score cognitif des apprenants, le contexte d’apprentissage ou la manière de se regrouper? En d’autres termes, quels critères et éléments devrait être utilisée pour établir la manière optimale de regrouper les apprenants dans les milieux du CSCL?

Le problème qui se pose est comment trouver un moyen pour créer des groupes d’apprenants équilibrés en termes de compétences intellectuelles et pratiques. Nous devons d’abord avoir une idée du score cognitif que possède chaque apprenant afin de créer un groupe d’apprenants homogènes. De tels problèmes nécessitent d’essayer toutes les possibilités disponibles. Puisque chaque apprenant peut appartenir à n'importe quel groupe, le nombre de possibilités ne cesse d'augmenter à mesure que le nombre d'apprenants augmente. Pour cette raison, nous avons recherché des heuristiques où nous avons opté pour les algorithmes génétiques dans notre cas d'étude.

Le but de ce travail de recherche est d'arriver à un système qui peut diviser les apprenants en plusieurs groupes homogènes en termes de valeur intellectuelle et pratique. Chaque groupe peut contenir des apprenants hétérogènes pour équilibrer le travail du groupe et parvenir à la solution du projet de groupe dans un bon moment avec une grande efficacité. Comme résultats, notre système peut fonctionner sur diverses plateformes éducatives.

2. Une nouvelle approche d'optimisation du regroupement des apprenants basée sur les algorithmes génétiques

L'objectif principal de notre système est de chercher le meilleur regroupement pour chaque apprenant pour améliorer le travail collaboratif dans notre plateforme PREGO. Pour cela, nous nous intéressons aux traces cognitives des apprenants. Ces traces sont des actions effectuées par l'apprenant.

2.1 La collecte des traces et le calcul du score total

Le calcul du score total se base sur les traces suivantes :

- Discussion projet (chat room).
- Réaction envers les solutions proposées par les apprenants.
- Evaluation des éléments du groupe.

Comme les traces cognitives favorisent l'acquisition de connaissances par l'apprentissage en ligne, nous calculons le profil cognitif de chaque apprenant selon le score des traces précédemment citées.

2.2 La description de l'algorithme génétique

L'algorithme génétique utilisé est le suivant :

```
Entrée :
        - Taille de groupes (2, 3, 4),
        - Intervalle X,
        - Nombre d'itérations.
Sortie :
        Groupes.
        Début :
            1. Calcul moyen cognitif,
            2. Codage des apprenants.
            Répéter :
            1. Croisement,
            2. Mutation.
            Jusqu'à ce que le résultat soit porche à la moyenne total ou bien nombre
            d'itérations fixé.
        Fin.
```

3. Architecture du système adoptant l'approche proposée

Le système PREGO possède deux architectures : architecture globale qui présente l'interface principale et une architecture fonctionnelle qui représente ses fonctionnalités.

3.1 Architecture globale

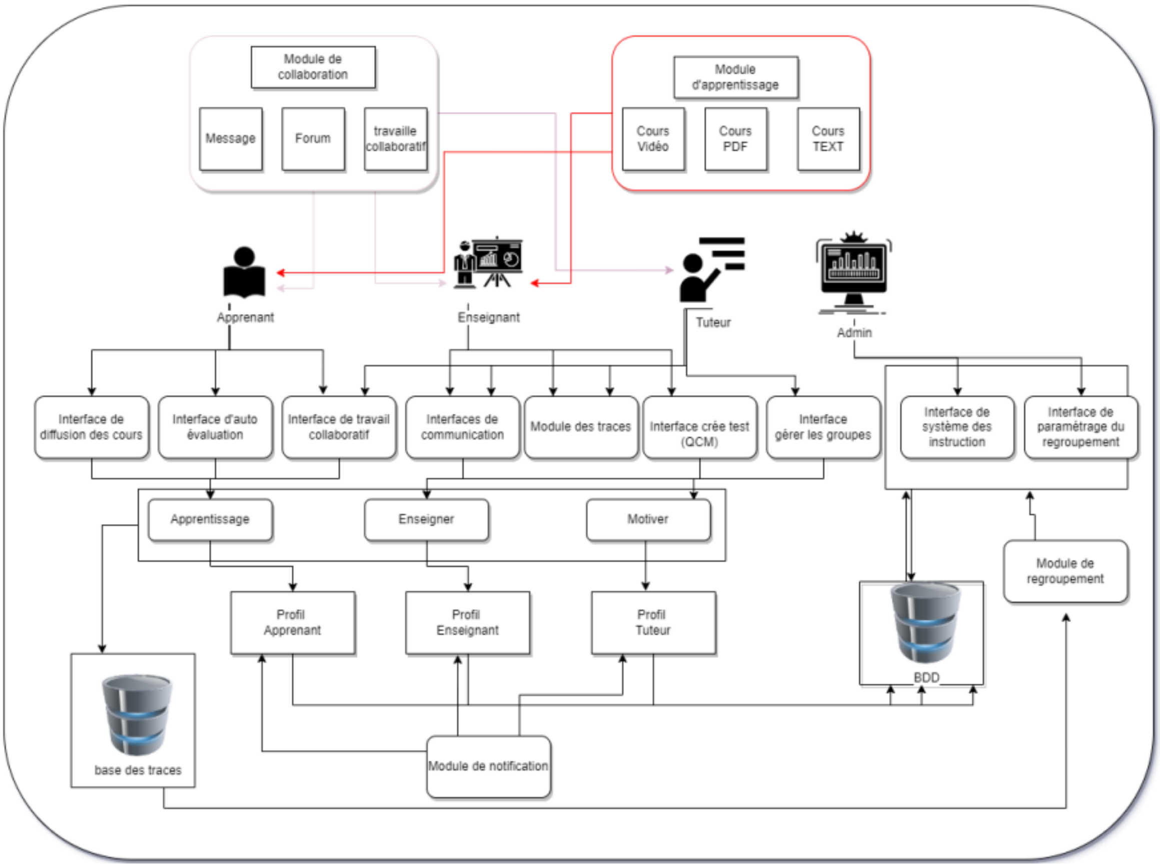

Fig 1 – l'architecture globale du système

4. Résultats et discussion (constatations)

La figure 2 suivante montre des groupes d'apprenants au début de l'activité d'apprentissage sans l'aide de l'algorithme génétique pour les classer dans des groupes au hasard.

Fig 2: – Liste des groupes des tuteurs

Nous avons choisi trois groupes et nous avons proposé à chacun d'eux un projet pour suivre leur développement et l'engagement de chaque apprenant dans le travail de groupe. Nous calculons les scores respectifs de chacun.

On remarque que les apprenants du groupe 8 ont tous fait un travail, mais leurs scores varient.

Dans le groupe 9, il y a un apprenant qui n'a soumis aucun travail. Dans le groupe 12, seuls les apprenants développent et discutent des solutions de projet.

Après ce travail, nous avons testé notre algorithme génétique pour créer des groupes de 4 membres.

On remarque qu'il y a deux groupes homogènes en termes de score (figure 3).

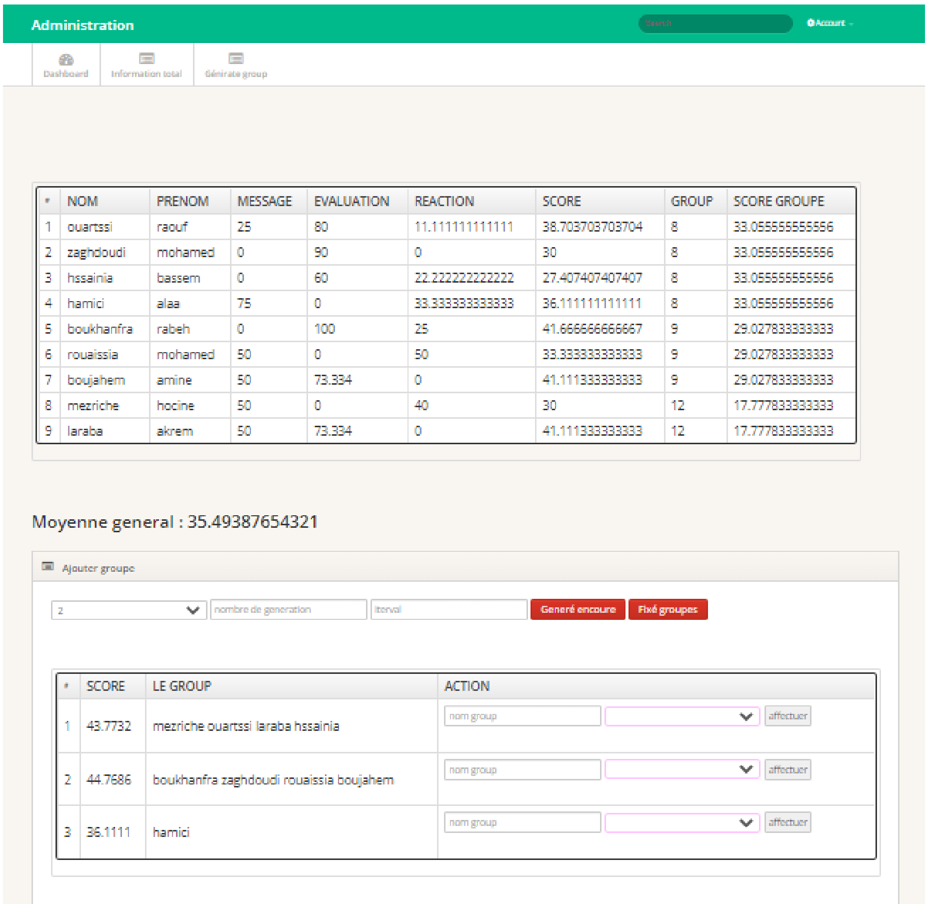

Fig 3 – Génération des groupes avec 4 apprenants

Nous avons à nouveau testé l'algorithme spécifiquement avec les apprenants de chaque groupe puis avec 3 apprenants. La figure 4 suivante présente les résultats obtenus et la convergence obtenue entre les groupes.

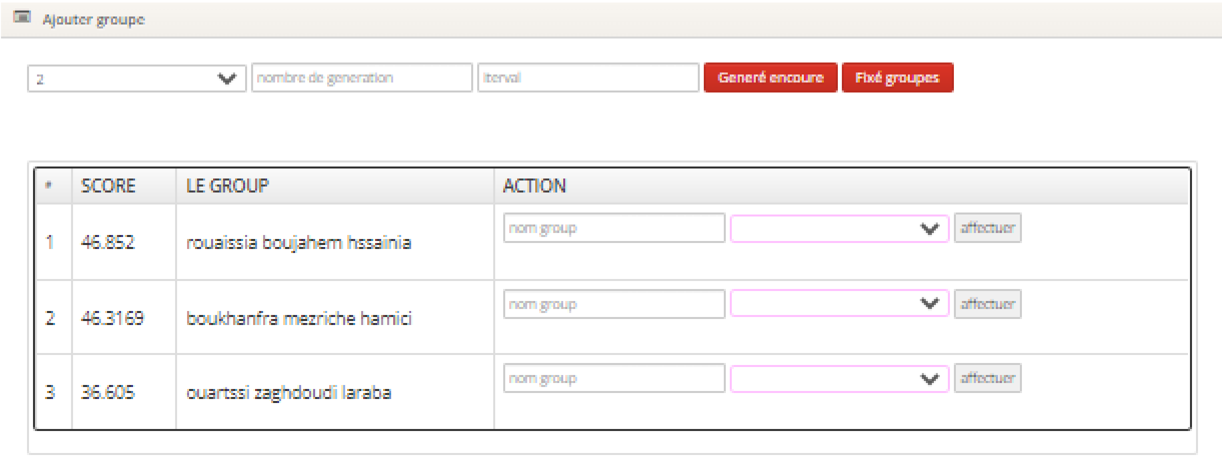

Fig 4 – génération des groupes avec 3 apprenants

Lorsqu'on divise les groupes en 2 apprenants dans chaque groupe, nous obtenons des résultats encourageants. Tous les groupes sont homogènes et ont des scores supérieurs à la moyenne.

5. Conclusion et perspectives

Dans cette étude, nous nous sommes concentrés sur la recherche d'un bon moyen d'améliorer l'agrégation des apprenants sur les systèmes d'apprentissage collaboratif. Pour ce faire, un algorithme d'amélioration génétique régénérative a été proposé pour être fonctionnel avec plusieurs variables comme le nombre d'apprenants dans chaque groupe (de 2 à 4 membres). Les résultats obtenus sont très encourageants et les groupes obtenus sont homogènes en termes de score cognitif pour les apprenants de chaque groupe.
Nous visons dans un avenir proche à augmenter les facteurs que nous avons adoptés dans le calcul du score cognitif, en plus de tester l'algorithme sur plusieurs plateformes avec différents facteurs tels que la trace sociale et la trace comportementale en travail d'équipe. Nous comptons également tester d'autres algorithmes bio-inspirés et à les comparer avec les nôtres.

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Analyse des mécanismes d'évaluation de la qualité de conception orientée objet

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La méthodologie

Résumé

Dans le domaine du génie logiciel, l'assurance de la qualité en orientée objets présente une nécessité dans le développement du logiciel. La recherche de mécanismes capables à l'évaluation de la conception des produits logiciels ajustés aux besoins personnalisés aux utilisateurs, nous a orienté vers la comparaison entre les différentes approches proposées à cette problématique en se basant sur des mesures (métriques de conception) et des caractéristiques (attributs de qualité). Dans le présent travail, nous présentons deux approches formelles, l'approche QATCH appliquant l'analyse statique benchmark afin de générer des modèles de qualité logicielle adaptés aux spécifications des parties prenantes en utilisant la prise de décision multicritère floue dans le but de modéliser l'incertitude. D'autre part, en exploitant la relation existante entre métriques et attributs de qualité, nous présentons aussi notre approche permettant d'évaluer le modèle de qualité sous forme d'automate à l'aide du model checker "Prism". Ce dernier est destiné à la vérification de l'exactitude d'un certain nombre de systèmes d'intelligence artificielle, y compris des systèmes experts, des systèmes de planification et des systèmes d'apprentissage. Cet article est dans le cadre d'une comparaison théorique de deux techniques existantes destinées à l'évaluation de la qualité logicielle.

Mots-clés: *génie logiciel, modèle d'évaluation de la qualité, métriques de la conception orientée objet, attributs de qualité, analyse statique du logiciel.*

Introduction

Aujourd'hui, l'étude de la qualité du logiciel est un sujet de recherche important en génie logiciel. La métrique de la conception orientée objets est une mesure de développement de logiciels. En d'autres termes la mesure de logicielle est un mécanisme de caractérisation, évaluation et prédiction de l'ensemble de produit logiciel (Srinivasan, K.P. & Devi). Un modèle de qualité comporte l'ensemble de mesures (métriques) orientées objets plus les caractéristiques (attributs) de qualité. Un modèle d'évaluation de qualité permet de fournir un produit de qualité élevée, destiné à répondre objectivement aux exigences de qualité. Cependant, l'évaluation de la qualité sur la base de modèle n'est pas assez développée dans la littérature (Galli et al., 2020; Sadeghzadeh Hemayati and Rashidi, 2017; Yan et al., 2017). Ainsi, les chercheurs essaient de trouver une ligne directrice avec des critères adéquats pour construire une structure de modèle de qualité offrant un modèle de qualité "complet" en fonction des métriques et des facteurs bien appropriés aux différentes applications.

Dans ce qui suit nous présentons une comparaison entre deux mécanismes d'évaluation de la qualité de la conception orientée objets.

Approche 1

QATCH, est un système intégré en trois couches (Siavvas et al). Il assiste l'utilisateur tout au long du processus d'éstimation de la qualité et de dérivation du modèle à l'évaluation de la qualité. Le modèle produit utilise une agrégation moyenne pondérée de système de calcul de la note de qualité globale du produit évalué, dont les poids sont définis sur la base de jugements d'experts. QATCH identifie les différentes mesures qui doivent être calculées et invoque l'analyse statique appropriée aux outils avec la configuration.

Approche 2

La démarche de notre proposition (Bouslama & Abdi) commence d'abord par extraire des métriques de conception OO à partir du code source du système logiciel en entrée, puis calculer les attributs de qualité considérés. Ensuite, vient l'étape de modélisation sous forme d'automate à base des métriques et des attributs de qualité. Puis, nous codifions cet automate sous un outil de model checking. La vérification et la validation du modèle offertes par l'outil choisi se fait selon une liste de propriétés en logique temporelle. Une remise en cause de la simulation est tout à fait possible dans notre démarche. Enfin, les résultats obtenus sont interprétés et validés.

Contribution

L'approche proposée par les auteurs (Bouslama & Abdi) est une approche nouvelle, cette dernière est basée sur la relation entre les métriques et les attributs de qualité. En faisant la recherche sur la modélisation de la qualité en génie logiciel, nous remarquons que la présentation du modèle QATCH dans l'article (Siavvas et al) a le même objectif traité par les auteurs (Bouslama & Abdi). Les deux articles discutent la problématique concernant l'absence de définition claire concernant l'évaluation de la qualité à travers le mapping de mesures (métriques) de la conception orientée objets aux caractéristiques (attributs de qualité) en se basant sur leurs liaisons avec les propiétés de qualité (Galli et al., 2020; Sadeghzadeh Hemayati and Rashidi, 2017; Yan et al., 2017). Dans cet article, nous comparons la méthodologie de la conception du modèle de qualité par deux approches formelles différentes ayant en faite la même architecture du modèle (voir figure 1). D'une autre part, Nous constatons aussi que le choix de l'outil d'évaluation est une suite au type du modèle proposé et la logique appliquée.

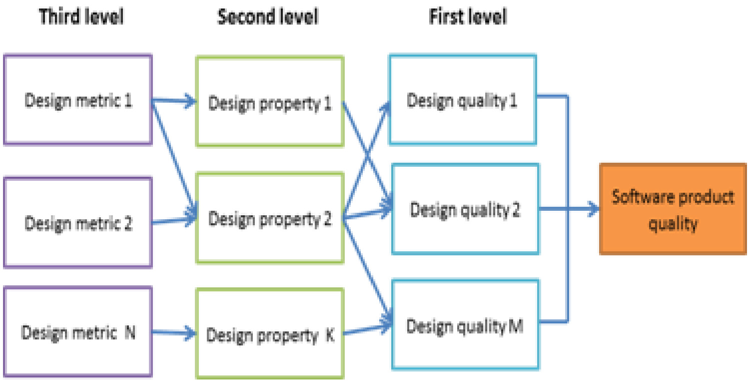

Fig. 1. Architecure du modèle de qualité

Le but de cet article est de voir les points similaires que les deux différentes approches ont envisagé pour pouvoir évaluer la qualité d'un produit logiciel sans la citation les métriques et les attributs de qualité employés dans leurs expérimentations.

Tableau comparatif

Dans le tableau suivant nous présentons une comparaison entre les différentes caractéristiques traitées par les deux approches déjà citées.

Tab1. Tableau comparatif

	Approche 1	Approche 2

Langage traité	Java	Multi langage
Analyse des données	Benchmark	Procédure de modélisation
Support de travail d'analyse	Décision multicritère floue	Logique temporelle
Modèle de qualité	Modèle fuzzy hièrarchique	Automate probabiliste
Outil d'évaluation	Outil d'analyse statique PMD	Model checker Prism
Type de mapping métriques/attributs	Statique	Statique
Type approche	Déterministe	Déterministe
Interface homme machine	interface web	Interface Prism
Type d'application	Muti projets	Muti projets

Conclusion

Nous avons présenté deux approches différentes traitant la problématique liée à l'évaluation de la qualité de la conception orientée objet en proposant deux démarches, chacune à son propre principe et ses propres idées. Nous remarquons par la suite que les deux démarches se coïncident dans la même objectivité en ce qui concerne une évaluation statique d'un modèle hièrarchique déterministe tiré à partir d'un produit logiciel, en se basant sur la relation entre les métriques et les attributs de qualité. Nous constatons aussi qu'on ne peut pas négliger la synthèse des experts par rapport au mapping des métriques aux attributs de qualité. Cette opération demande beaucoup de pertinence, mais en appliquant les mécanismes d'évaluation nous trouverons devant des résultats à évaluer et à interpréter un modèle de qualité selon une démarche adaptée aux besoins. Comme futur travail nous envisagerons une comparaison expérimentale des deux approches.

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Using CNN and the probabilistic diffusion model for image super-resolution

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Abstract

This paper proposes a powerful approach to image super-resolution that combines a convolutional neural network (CNN) and a diffusion model. The CNN is used to restore the low-resolution image to its original high-resolution state, while the diffusion model is used to remove any residual noise.

Convolutional neural network (CNN) is a type of deep learning algorithm that is commonly used for image processing tasks, such as image classification, object detection, and image segmentation. CNNs are able to learn the spatial relationships between pixels in an image, which makes them well-suited for these tasks.

Probabilistic diffusion model is a type of generative model that can be used to create new images that are similar to a given image. Diffusion models work by starting with a random image and then gradually adding noise to the image until it resembles the given image. The amount of noise that is added is controlled by a probability distribution, which is why the model is called a probabilistic diffusion model.

The proposed approach is based on the following two ideas:

1-The CNN can recover the main low-frequency content of the image. The low-frequency content of an image is the overall shape and structure of the image. It is relatively easy for a CNN to learn to recover the low-frequency content of an image.

2- The PDM (Probabilistic Diffusion Model) can remove noise from the image. The diffusion model is a type of generative model that can be used to remove noise from an image. The DPM works by starting with a random image and then gradually adding noise to the image until it resembles the given image. The amount of noise that is added is controlled by a probability distribution, which is why the model is called a probabilistic diffusion model.

The first step is to use the CNN to retrieve the low-frequency content of the low-resolution image. The output of the CNN is then used as input to the PDM. The PDM then refines the image and removes any residual noise.

In order to use the CNN and the probabilistic diffusion model for image super-resolution, follow these steps:

- Train a CNN on a dataset of high-resolution and low-resolution images.
- Use the trained CNN to restore a low-resolution image to its original high-resolution state.
- Use the output of the CNN as the input to a probabilistic diffusion model.
- Train the probabilistic diffusion model on a dataset of high-resolution images.
- Use the trained probabilistic diffusion model to further refine the image and remove any remaining noise.

An evaluation is carried out on a variety of datasets, showing that the approach outperforms several state-of-the-art methods. In addition, the approach is more robust to noise than existing methods.

Overall, the combination of CNN and the probabilistic diffusion model is a promising approach to image super-resolution. It enables high-quality image super-resolution with good robustness against noise.

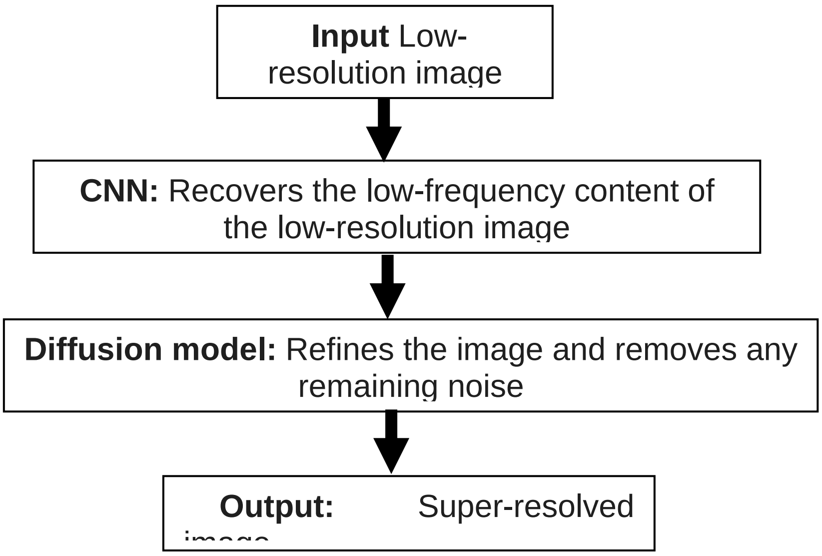

Fig. General description of the proposed approach

Keywords: *Image super-resolution, Convolutional neural network (CNN), Diffusion model, Progressive diffusion model, End-to-end training*.

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Commande MPPT Optimale d'un Système Solaire Photovoltaïque

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Résumé

Un contrôleur synergétique optimisé (OSC) est proposé pour déterminer efficacement le point de puissance maximale d'un générateur photovoltaïque adapté à la charge via un convertisseur élévateur DC-DC. L'équation dynamique du contrôleur synergétique conventionnel est modifiée pour ajuster la macro-variable de manière à ce que le point de puissance maximale (MPP) optimal soit atteint. Cette nouvelle approche est implémentée dans le logiciel Matlab/Simulink et montre une très bonne convergence en régime permanent et transitoire.

Mots-clés: *MPPT, commande synergétique optimisée, commande synergétique, système photovoltaïque.*

Introduction

L'énergie solaire semble être la source d'énergie verte la plus prometteuse en raison de son accessibilité. L'électricité produite par les panneaux solaires est cependant transférée vers la charge avec des pertes, qui sont dues aux conditions climatiques instables et aux variations de charge. Pour améliorer le rendement du système photovoltaïque, une méthode efficace connue consiste à adapter la charge à la source en intercalant un convertisseur DC-DC entre les composants [Hes 23]. Le contrôleur MPPT synergétique optimisé proposé pilote le convertisseur DC-DC de manière à ce que toute la puissance disponible soit transférée à la charge. Des simulations sont réalisées sous l'environnement Matlab/Simulink, pour mettre en évidence la validité et la robustesse de l'approche proposée.

Commande synergétique optimisée d'un système photovoltaïque

La commande synergétique (SC), un puissant outil de contrôle des systèmes non linéaires, est une technique de contrôle continue, robuste et très prometteuse, qui utilise une macro-variable qui peut dépendre de deux ou plusieurs variables d'état du système. Un choix approprié de la macro-variable garantit les performances requises [Zer 18]. Cette approche requiert cependant une bonne connaissance du modèle, et ne conduit dans sa version classique qu'à une convergence asymptotique et donc de temps théoriquement infini [Hah 21]. L'amélioration du temps de convergence et de l'erreur en régime permanent seront abordés en termes decommande synergétique optimisée (OSC) [Hai 22]. Cette approche sera développée et appliquée à un système photovoltaïque.

Résultats et discussion

Le système PV est constitué d'un générateur PV, d'un convertisseur élévateur DC-DC, d'une charge et du bloc de contrôle MPPT. Les résultats de simulation obtenus pour des éclairements et des températures variables sont résumés dans les figures et les tableaux suivants:

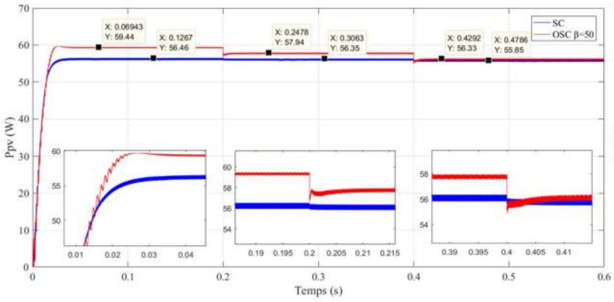

Fig. 1. Evolution de P_{pv} pour une température variable

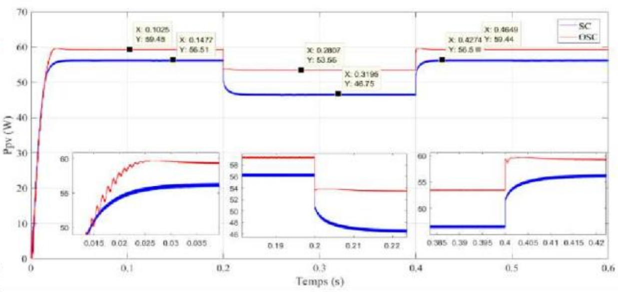

Fig. 2. Evolution de P_{pv} pour un éclairement variable

Table 1. Comparaison des puissances P_{pv} pour une température de 25°C et un éclairement de 900W/m²

Commande	P_{pv} (W)	ΔP (W)	η (%)
SC	46.75	7.11	86.79
OSC (β= 50)	53.56	0.4	99.44

Table 2. Comparaison des puissances P_{pv} pour une température de 30°C et un éclairement de 1000W/m²

Commande	Ppv (W)	ΔP (W)	η (%)
OSC (β= 50)	57.94	0.5	99.14
SC	56.35	2.09	96.42

Les résultats de simulation obtenus pour des éclairements et des températures variables, montrent clairement que le contrôleur proposé (OSC) surpasse la commande synergétique conventionnelle en régime permanent ainsi qu'en régime transitoire.

Conclusion

Dans ce travail, les développements d'une loi de commande optimisée basée sur l'approche synergétique pour la recherche du MPPT d'un système photovoltaïque sont revisités faisant ressortir la robustesse de cette dernière. Une étude comparative faite entre ces deux commandes a été réalisée prouvant l'efficacité de l'approche proposée. Ces résultats soulignent l'importance de la commande synergétique dans l'optimisation des performances des systèmes PV, en offrant une approche robuste pour maximiser la production d'énergie solaire et améliorer l'efficacité énergétique. Les résultats de simulation sont donnés pour des variations de température et d'éclairement.

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Towards an efficient Multi-Robots Search and Rescue strategy

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Extended Abstract

In the context of hazardous and hostile conditions following natural disasters, the use of multi-robot systems has become crucial as a substitute for human efforts in searching and rescuing victims. Exploring unknown environments is of paramount importance in the field of mobile robotics, serving asa foundational stage for diverse applications, including search and rescue, cleaning tasks, and foraging.

This research introduces a novel search strategy specifically designed for search and rescue operations using multi-robot systems. Inspired by the hunting behavior of Penguins, our approach combines the Penguin Search Optimization Algorithm with the Random Walk Algorithm to effectively balance global and local search behaviors of the robots. This hybridization enables the robots to perform comprehensive exploration tasks in challenging environments. A set of experiments is realizedon the ArGOS simulator, and results derived from these experiments demonstrate the effectiveness of our approach, reinforcing its potential for real-world search and rescue missions.

The proposed strategy is called : the Modified Penguin Search Optimization Algorithm (MPeSOA). Therobots are always in one of the four states: *Global Serach, Local Serach, Migration and Obstacle Avoidance*. The robots start all from the central depot and change their behaviors according the collected sensing data. In below, we explain the different behaviors of the state machine:

1. ***Global search:*** In this stage, each group of robots goes through a relocation process to transitionto a new position, guided by the LocalBest solution acquired from the previous exploration dive. The relocation is carried out using the penguin search position equation, which aids in determining the new positions for the robots. **Local Search:** Before starting the local search, the robots must await the arrivalof all group members, ensuring the collective initiation of the search procedure employing the Random Walk Algorithm (RWA).
2. **Migration State:** When the group fails to detect or rescue victims, it becomes imperativefor them to migrate and join another group that has achieved notable success in locating victims.
3. **Obstacle avoidance:** In accordance with the readings obtained by the robots sensors,if the robot identifies the presence of an obstacle, it retrieves the angle information andadjusts its movement accordingly.

We carried out four scenarios to test the performances of the proposed strategy. In the first scenario we tested the influence of robots number, in the second one, we tested the influence of the environmentsize, in the third scenario, we tested the influence of the number of the robots groups and in the last one, we tested the influence of the number of clusteres of victims. The obtained results prove the effectiveness of the proposed strategy.

Moving forward, we envision several perspectives for further enhancing this work. Firstly, we aim to extend the robot's behavior to incorporate considerations for energy

limitations. Secondly, we aspire to develop a more efficient local search strategy that surpasses the randomness of the current approach. Lastly, we aim to implement mechanisms for implicitly saving search spaces, thereby preventing redundant exploration of previously examined areas and consequently reducing the overall search time.

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Optimization of 3D Design Processes with ChatGPT Technology

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Abstract

This article proposes a new approach to create 3D designs using ChatGPT where a large language model trained by Open AI. The model is capable of generating 3D designs based on textual input provided by the user. This proposed new approach is unique in its ability to use natural language asa medium for creating 3D designs. The experimental results show the effectiveness and efficiency of the suggested approach and highlight its potential for real applications in many fields.

Keywords: *3D Design; ChatGPT; natural language processing, machine learning*

Introduction

Today, a high demand for 3D digital content for many applications such as games, architecture androbotics simulation [3]. 3D design requires training and experience. The main challenge is learning how to generate 3d material in natural language without any prior knowledge, which takes a lot of time to achieve [3].

There are now three active projects devoted to creating 3D modelling systems. These initiatives areDream fusion from Google [2], Magic 3D from NVIDIA [3], and MAV3D from Meta AI [4], for more details see [5]. They create 3D content models from 2D photos [2-4], and their attempts to create 3Dmodels and films from 2D images generated good results in terms. However, there can be certain limitations or drawbacks to the technique mentioned in [4].

One potential limitation is that the generated 3D models may not be entirely accurate or realistic, especially when the input 2D image has limited information or resolution. The proposed method alsorequires a substantial amount of training data and computational resources to create the generative model, which may make it difficult for some applications or users to implement[4].

Additionally, there may be ethical or legal concerns related to using AI and machine learning techniques for creating 3D models from images. These concerns may include issues such as dataprivacy, copyright infringement, and the potential misuse of generated 3D models.

The aim of this study to explore the potential of using ChatGPT for generating simple 3D models in Blender software, and to evaluate the effectiveness of the system in completing 3D projects based onnatural language descriptions. The results of the study provide valuable insights into the system's ability to interact with natural language and generate 3D models, and can be used as a basis for further hypothesis testing and research in this area. Overall, this study represents an initial step towards exploring the potential of natural language processing in the field of 3D modeling. This paper is organized as follows: the definition of artificial intelligence and ChatGPT are given. Then, a Block diagram of the proposed system is presented. Finally, the simulation results with a conclusion are presented.

Materials and Methods

One of the primary reasons for utilizing ChatGPT is its exceptional capability to comprehend naturallanguage, which enables users to input their requirements in a conversational format. A significant advantage of ChatGPT is its ability to generate programming code, specifically Python scripts for Blender. This feature can be leveraged to create a technique for developing 3D models from natural language descriptions using ChatGPT. Our objective is to design a methodology that can effectively translate user input into a 3D model using ChatGPT's natural language processing abilities and programming code generation feature.

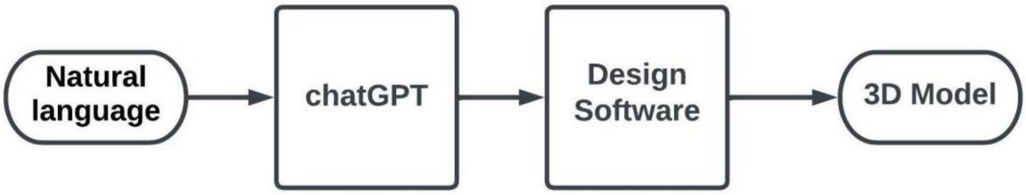

Fig. 1. The proposed model.

To evaluate the effectiveness of the system, three criteria have been established: Imagination, Achievement, and Comprehension. The Imagination criterion is met if the system can visualize the shape that is described to it. The Achievement criterion is met if the system can generate the desiredshape accurately. The Comprehension criterion is met if the system can interpret the user's requirements correctly.

To assess the system's performance, five experiments of varying levels of complexity will be conducted: Cube, Ball, Pyramid, Stack of Ten Cubes, Table, and Chair. These experiments will be conducted in a sequential manner, beginning with the easiest task and advancing to the most difficultone. The system's ability to meet the three criteria will be evaluated for each experiment to determineits effectiveness.

Results and Discussion

Based on the evaluation results of the experiments, it can be concluded that the system has a good understanding of the natural language descriptions, thus exhibiting Comprehension. Additionally, it was able to successfully generate 3D models of simple shapes with relative ease, demonstrating its ability to exhibit Imagination and Achievement. However, the system encountered difficulties with determining the location of certain shapes in the more complex objects, indicating a need for further training in this area. As complex shapes are composed of multiple simple shapes, it is possible that additional training data and modifications to the system architecture could improve the accuracy ofthe generated 3D models.

Conclusion

Based on the research and experimentation conducted, it can be concluded that the proposed model utilizing ChatGPT for creating 3D designs has demonstrated promising results. The model's ability to generate 3D models from simple textual input is impressive and has the potential to revolutionize thefield of 3D design.

As the technology continues to advance, it is expected that the potential of the proposed model will only continue to grow. Overall, this research represents a significant step forward in the field of 3D design and demonstrates the power of natural language processing in enabling new possibilities in the world of digital design.

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An ontology-based questions-answering system to support learners in online learning environments

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Abstract

Assistance in online learning environments is essential to overcoming difficulties and providing learners with more effective, inclusive, and rewarding learning experiences. The research presented in this article is part of a broader project known as SANED, which aims to provide intelligent support to individuals engaged in online learning contexts. This paper introduces an explicit support approach by providing learners with pedagogical and technical help. A natural language question-answering system linked to a domain-specific ontology is used to deliver online assistance. Learners' relevant technical inquiries are used to enrich a dynamic FAQ (Frequently Asked Questions), while pedagogical concerns are handled using the proposed domain-specific ontology. A first prototype, named OntoQAS, has been developed and is currently undergoing experimentation.

Keywords: Online learning, support, question/answer system, assistance, ontology.

Introduction

The adoption of online learning platforms has significantly increased, especially during times of crisis, such as the COVID-19 pandemic (Vidal, 2020). However, learners still face numerous challenges in their usage (Descamps et al., 2020). The most common obstacles encountered when using these systems include technology access and platform navigation, adaptation to pedagogical resources, isolation and lack of social interaction, as well as a lack of real-time feedback (Almakkari, 2020). Therefore, designers attempt to improve these platforms by incorporating tools that are specifically tailored to satisfy the needs of learners (Puustinen, 2012). Our research focuses mostly on reactive assistance (Beggari, 2017), where the learner explicitly expresses their need for help using a Question/Answer system (QAS). Indeed, various scholars have investigated the use of Question/Answer Systems in online education (Ahmed et al., 2017; Bouziane, 2019; Karpagam et al., 2018; Muhammed et al., 2017; Sweta et al., 2016). Their functionalities make them particularly relevant as they can effectively respond to the diverse questions posed by learners to their instructors. To fully capitalise on their use, they have been linked to a domain ontology in order to deliver a more effective and enriching learning experience. Numerous studies in the literature have been dedicated to Question/Answer Systems (QAS) that use ontologies in various contexts. However, there has been limited research focused on online learning systems (Abdi et al., 2018; Moussa et al., 2011; Nicola et al., 2020; Rosmayati et al., 2017; Xie et al., 2015), and even fewer have explored the use of these systems by distressed learners. In the following section, we present the overall architecture of the system, highlighting its various functionalities.

OntoQAS Support System for Online Learning

The primary purpose of this research is to develop an effective and inclusive learning environment in which learners may overcome barriers and achieve successful learning outcomes with the assistance of suitable and personalised support. The key goals of the proposed strategy are as follows:

- Provide learners with two forms of assistance: technical and educational.

- Involve teachers and administrators in assisting learners and responding to help requests and frequently asked questions.

The proposed approach was supported by an online learning system, which is divided into two subsystems. One subsystem is dedicated to learning, providing teachers and learners with the necessary tools to manage learning objects and evaluation tools. The second subsystem is in charge of technical and educational support. It will be discussed in detail in the following section.

Our assistance system, based on a question and answer (Q&A) system, enables the learner to ask for help whenever they encounter a problem. Although different types of support are available, our system focused on two essential types in particular:

- **Technical Support**: Learners may encounter technical issues related to the online learning platform, resources access, device configurations, etc. Providing crucial technical support enables swift resolution of these problems, allowing learners to focus on their studies. The learner has multiple options for seeking technical assistance. They can check the technical FAQ, or they can submit their questions to the administrator, who will respond directly. Additionally, learners can interact with others through chat or forums. The technical FAQ is continually enriched with relevant questions posed by the learners.

- **Pedagogical Support**: Learners may require guidance and pedagogical advice to understand course objectives, teaching content, learning methods, etc. Teachers can offer pedagogical support by providing clear instructions, examples, additional resources, and addressing learners' questions. The learner has two options: direct submission to the teacher or submission to the system.

  In this case, the learner provides a question or query in the natural language. The natural language pre-processing module processes this input and converts it into a format understandable by the system. Subsequently, a search is conducted in the ontological knowledge base to find relevant answers to the posed question. The ontology module is responsible for describing the structure of domain knowledge, enabling better organization and interpretation of data in the knowledge base. The integration of ontology enhances the accuracy and relevance of the responses generated for the user. Finally, the responses are generated and classified by the response generation module, and then sent back to the learner as an answer. To validate the approach, an experiment was conducted with students of the computer science department of Guelma University.

Conclusion and future work

Supporting learners throughout their educational curriculum is crucial in online learning environments. To facilitate this, our assistance management subsystem incorporates a question and answer system based on an ontology, enabling learners to access information from formal ontologies through natural language queries. These systems leverage the semantic structure and relationships between concepts defined in the ontology to gain a deeper understanding of the questions posed by learners. The initial tests of the OntoQAS prototype show promising results, and we plan to introduce new types of questions for the Q&A system. Additionally, we aim to dynamically enrich the technical FAQ using machine learning techniques.

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A New Learner Model to Predict 'Slow Learners' Using Machine Learning

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Abstract

Accurately predicting students' performance in e-learning is very important in education. With the advancement of technology and the rise of e-learning platforms, a vast amount of learning process and behavior data has been collected from students. When effectively utilized, this data can predict students' academic performance and identify those more likely to struggle in the future (Evangelista & Sy, 2022).

By applying machine learning techniques to analyze large datasets composed essentially of collected students' interaction patterns, engagement levels, time spent on different learning activities, and assessment performance, it is now possible to identify patterns and make predictions about mis-achievers and "slow learners" (Yin et al., 2021).

The creation of such a learner model begins by collecting relevant student data, including academic performance, attendance records, demographic information, and other factors that may impact learning. The predictive model is trained using the collected dataset to predict the likelihood of a student being a "slow learner." However, many challenges may be faced before reaching a descent predictive model.

The first challenge is to have a reliable data set, which happened to be collected in our previously conducted research (Boudjehem & Lafifi, 2021), which is collected through experimenting with real students. The Learner Model used in that research is used as a base model to be updated and fine-tuned using machine learning algorithms.

The second challenge is to choose among a set of several machine learning algorithms that can be employed for this purpose, such as "Decision Trees", "Logistic Regression", "Support Vector Machines", and "Neural Networks". Each algorithm has its strengths and weaknesses, and the choice of algorithm is a long and meticulous process that relies essentially on the try-error method that depends on the specific characteristics of the dataset and the desired outcome. The training process involves feeding the algorithm with the collected data, allowing it to learn the underlying patterns and relationships between the input variables and the target variable (in this case, whether a student is a "slow learner" or not). The algorithm can then predict new, unseen data based on the patterns it learned during training.

The last challenge is evaluating the learner model's performance and generalization capabilities. Cross-validation techniques assess how well the model performs on unseen data. Additionally, performance metrics such as accuracy, precision, recall, and F1-score can be used to measure the model's effectiveness in predicting "slow learners."

This paper addresses the development of a learner model to predict "slow learners" using machine learning algorithms, which hold promise for identifying students who may require additional support and interventions.

Keywords: *Slow Learners, Learning Difficulties, Early Warning Systems, Machine Learning, Distance Education.*

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Recommendation of Educational Resources based on learners' Learning Styles

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Abstract

The daily use of learning platforms has highlighted the challenges that learners face due to the constant increase in educational content, making it more difficult for them to find the most relevant resources to meet their specific needs.

The aim of this work is to improve learners' performance by recommending a set of resources according to their learning styles.This approach offers many advantages, it improves learner engagement by offering educational resources that match with their preferences. It also promotes better retention of knowledge by using learning modalities that are effective for each individual.

To maximize the effectiveness of learning, it is essential to take into account these individual preferences and adapt teaching methods accordingly, this is where the VARK model comes in.

The VARK model, stands for the four VARK modalities – Visual, Aural, Read/write, and Kinesthetic. It is developed by Neil Fleming, is a commonly used framework for understanding and categorizing learning styles. He identifies four main learning modalities: visual, auditory, reading/writing and kinesthetic. According to this model, each individual has a predominant learning style that influences how they perceive, absorb, and process information.

Understanding the learner's learning style can help teachers use teaching methods that maximize learner performance. From this fact, learners can recognize their individual learning styles to complete which study methods and resources best to help them to learn better.

In this context, our work focuses on collaborative learning styles and how these can help recommend the most appropriate collaborative learning resources to learners, with the aim of positively influencing the learning experience.

Recommender systems can provide fertile ground for e-learning software, as they can help users by presenting them with learning material that they may be more interested in, based on their preferences.

In fact, the development of a collaborative learning system integrating resource recommendation based on VARK learning styles can play a crucial role in providing a personalized learning experience tailored to the needs of each learner. Based on the responses of learners to the VARK questionnaire, we recommend the most suitable resources.

To validate the proposed approach, a computer-assisted collaborative learning system was implemented called RA-Learning Style. The process of the proposed approach are illustrated in the following figure.

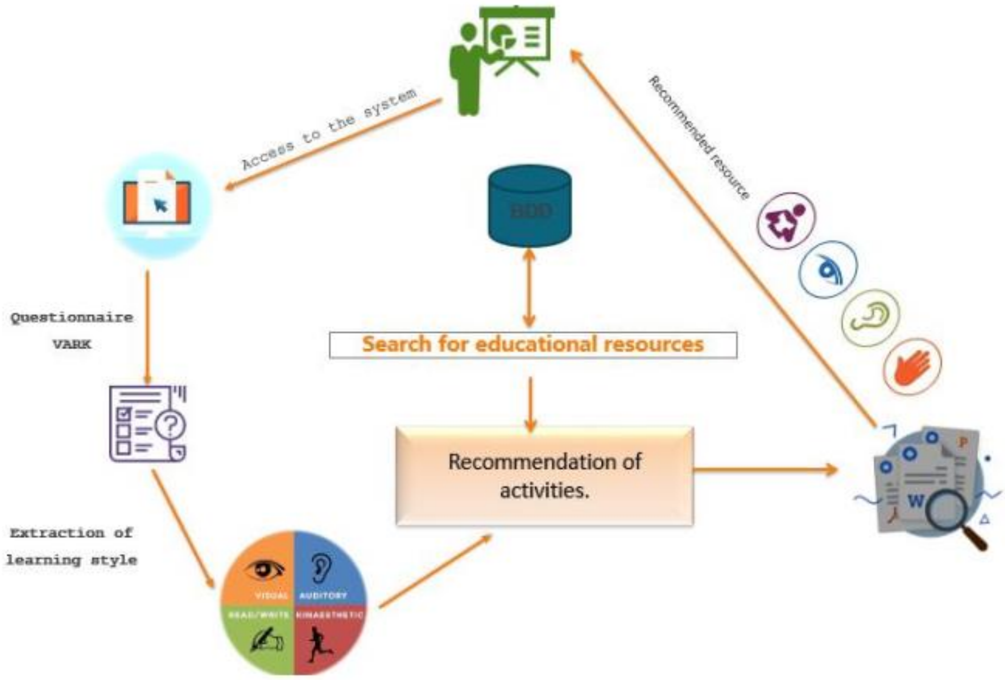

Fig.1. The process of the proposed approach

The steps involved in the proposed approach are follows:

1- First , the learner interact with the system,
2- Then, the learner ansewer on the VARK questionnaire
3- According to his anwer,we extract his learning style,
4- Based on his learning style, we recommend a set of educational resources from the database.

Keywords: *Systems, Learning, Computer-assisted Collaborative Learning, Educational resources, Learning Styles*

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Privacy-preserving blockchain-based federated learning for for Arrhythmia detection

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Abstract

This paper proposes a secure and intelligent heart disease detection application for distributed Edge architecture in smart IoHT. The proposed block chain and federated learning-based Differential Private (DP) approach addresses privacy concerns in heart disease prediction. The FL approach uses a differentially private gradient exchange with a noise-adding mechanism, enhancing data privacy and trust without aggregation servers. The lightweight CNN-LSTM neural network model is applied to process time series ECG data, constructing a decentralized FL-based Arrhythmia detection system.

Keywords: *Federated learning; Blockchain; Local differential privacy; Arrhythmia detection; Smart healthcare system.*

Introduction

The main contributions of this paper are summarized as follows:

1. Design of an early warning system for ECG anomalies using CNN-LSTM, which uses CNN to capture the spatial features of time series data and uses LSTM to capture the temporal features of time series data.

2. We reinforce the privacy of participating clients by applying differential privacy to prevent privacy leakage from clients local gradients.

3. We exploit the blockchain to promote the application of FL for ECG anomalies in a decentralized manner to eliminate the single point of failure threat associated with the aggregation server in the vanilla FL approach for edge devices in IoHT.

Proposed Approach

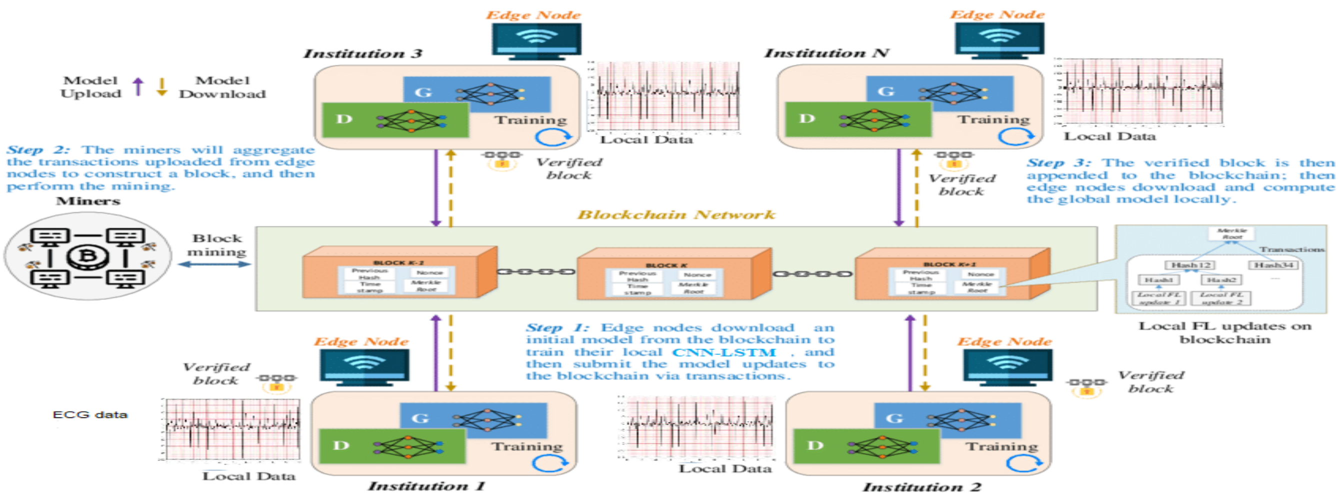

Fig. 1. Flowchart of blockchain based-federated-learning for Arrhythmia detection

Results and Discussion

The primary Experimental results show that FL-based CNN-LSTM model achieves 10.04% lower MAE than AE and VAE with SVD, accurately detects ECG anomalies, and protects patient data privacy.

	Model	Architecture	Learning Strategy	Blockchain	Privacy Preserving	MAE	MSE	RMSE
[1]	ResNet	Decentralized	Semi-supervised Learning	+	-	8.28	107.16	11.45
[2]	1D-CNN	Centralized	Supervised Learning	-	-	8.68	115.52	13.24
[3]	AE and VAE with support vector data description	Decentralized	supervised Learning	-	+	8.26	99.82	11.60
Ours	CNN-LSTM	Decentralized	Semi-supervised Learning	+	+	7.96	101.49	11.04

Table. 5. Summary of comparison using diabetes datasets with existing methods.

Conclusion

The study proposed a blockchain-based safe FL framework for Arrhythmia detection from ECG signal. It aims at protecting ECG data privacy, leveraging the CNN-LSTM model, and implementing decentralized poisoning attacks security.

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Density-Based Overlapping Community Detection

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Abstract

The field of social network analysis has recently gained significant importance, with a primary focus on detecting communities within social networks. Communities are comprised of closely interconnected nodes that maintain looser connections to the broader network. Identifying these communities is essential for comprehending network evolution. This study introduces innovative paradigms aimed at enhancing the precision of overlapping community detection. Our approach for detecting overlapping communities is centered around nodes with high node density values. This method not only reduces complexity but also surpasses existing methodologies in terms of both accuracy and performance, as demonstrated through rigorous evaluations on real networks and synthetic benchmarks.

Keywords: Local density, Community Detection, Social Networks, Clustering, Overlapping nodes.

Introduction

The foundations of mathematics have given rise to a complex realm known as graph theory, a domain where nodes and edges intertwine to depict intricate relationships among entities (Tutte, 2001). These networks weave a diverse tapestry of relationships encompassing friendships, professional alliances, familial connections, and the interactions transpiring across digital platforms (Fortunato, 2010). Social Networks encompass a concept in organizational psychology that revolves around the establishment and maintenance of social connections, offering pathways to access information and resources (Breuer, 2019).

The concept of community detection transcends a singular domain, it's akin to a compass guiding decision-making across various fields, the communities can be disjountes or overlapping (Palla, 2005). Whether unraveling societal dynamics, devising effective marketing strategies, or conducting intricate network analysis, community detection remains a pivotal tool. In essence, community detection serves as a specialized instrument, enabling us to navigate and comprehend the intricate realm of social networks. However, finding an optimal solution to the graph partitioning task remains a challenge, often classified as NP-complete, particularly for extensive graphs (Girvan, 2004). Nonetheless, a diverse array of heuristic algorithms has emerged to provide satisfactory solutions in many scenarios.

The proposed algorithm for overlapping community detection

Our approach hinges on calculating node influence through local density assessment. We initiate the process by identifying nodes with high density and subsequently gather their neighboring nodes, continuing this iterative procedure until all nodes within the graph have been incorporated. Following this, we employ clustering techniques to delineate overlapping communities that were discovered during this process. These communities may eventually evolve into either disjoint or overlapping final communities.

1. Calculate Node Density:

Calculate the density for each node in the network. Node density typically refers to the number of connections a node has with its neighbors.

2. **Sort in Descending Order:**

Arrange the nodes in descending order based on their calculated densities. This step helps identify the most densely connected nodes first.

3. **Select the First Element:**

Choose the first node from the sorted list. This node is the densest node in the network and serves as a starting point for community detection.

4. **Search in Depth:**

Starting from the densest node, explore neighboring nodes up to a depth of 2 in the network. This means you're looking at nodes that are directly connected to the densest node and their immediate neighbors.

5. **Allocation of Nodes to Communities:**

As you visit nodes during the depth-2 search, add them to a "community" set. These nodes are considered part of the same community as the densest node.

6. **Reallocating Nodes Overlapping Several Communities:**

In cases where some nodes overlap with multiple communities, we address this by assigning these overlapping nodes to a single community based on the number of neighbors they have within each community. If an overlapping node has an equal number of neighbors in multiple communities, it is considered an overlapping node.

7. **Displaying Identified Communities:**

Finally, we present the communities that have been identified through this process. These communities, which can either be disjoint or overlapping, are formed based on the presence of dense nodes and their connections within the network.

These steps outline a process for detecting overlapping communities within a social network or any network where nodes represent entities and connections represent relationships. The ultimate goal is to identify meaningful groups of nodes that exhibit dense interconnections within the network.

Haut du formulaire

Conclusion

The focal point of this study was the intricate task of unveiling concealed communities nested within the complex fabric of social networks. The investigation discerned that the clustering of users into cohesive communities constitutes an often-unseen dimension of social network dynamics. In response to this profound revelation, a panorama of algorithms, including notable contenders like Louvain and Girvan (Girvan, 2004), was proposed within the academic discourse to excavate these latent structures. In this study, we introduce a novel model that regards the number of neighbors of important nodes as a crucial element in community detection.

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From recognition to generation: facial expression transfer with StyleGan2

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Abstract

Facial image manipulation is an important task in computer vision, and has made considerable progress in recent years. One of the applications of these manipulations is the transfer of facial expressions, which can be used in the field of facial animation, as well as for augmenting face databases in face recognition systems. In this paper, we focus on the facial expression transfer problem, which aims to generate a synthetic face with the same expression as the input face. For this purpose, we first aim to recognize facial expressions utilizing a CNN, which then feeds this expression into a GAN generator. We conducted experiments with two GAN generators: the robust, pre-trained StyleGAN2 and an enhanced version of StyleGAN2-ADA. Our system for facial expression detection was trained on the FER2013 dataset, achieving a 65% score. Meanwhile, the StyleGAN2-ADA generator underwent training using a modified version of the FER2013 dataset.

Keywords: *Facial expression recognition, CNN, StyleGAN2, StyleGAN2- ADA, Facial expression transfer.*

Introduction

Face manipulation and facial expression recognition have acquired significant importance in the field of computer vision due to the availability of large-scale public databases and the rapid progress of deep learning techniques, in particular generative adversarial networks, which has encouraged researchers to become actively involved in this area.

Face manipulation can be used to modify images or even videos, synthesize entire faces, manipulate specific attributes, or exchange identities or facial expressions (Tolosana et al. 2020).

To achieve the facial expression transfer task, we first designed a facial expression recognition system in order to then use its result as input for the output face generation. To this end, we proposed two distinct uses of two StyleGAN generators, the first being pre-trained and the second having been trained by us.

Materials and Methods

To generate a synthetic face that replicates the facial expression made by a source face, we train two independent networks (as shown in Figure 1): a facial expression recognition network and an expressive face generation network. The first network is trained to recognise and generate a label of the expression expressed by the input face, while the second is trained to generate a synthetic expressive face from the label generated by the first network. Once the two networks have been trained, they can be combined to generate the synthetic expressive face from the real source face.

One of the most successful models for image generation is StyleGAN(Karras, Laine, et Aila 2019). Since its appearance in 2019, it has been the basic model for various applications in several fields. We, therefore, choose it as our base model.

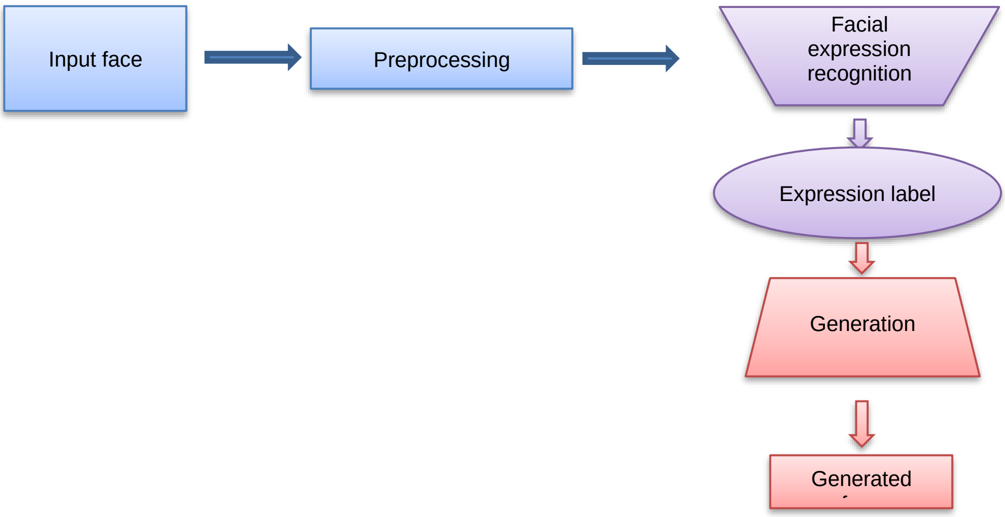

Figure 1 : Block diagram of the proposed facial expression transfer system.

The CNN used for facial expression recognition consists of a set of convolutional blocks (four blocks) and a fully connected block. For the convolutional blocks, each comprises a convolutional layer which is followed by batch normalisation and then a max pooling layer, each of these layers has non-linear rectification ('Relu'), while the fully connected block consists of three fully connected layers with 256, 512 and 7 outputs, while the last layer adopts the Softmax activation function.

For the second phase, which generates a synthetic image of a face from a label representing a class of facial expression (Ekman et Friesen 1971): joy, anger, disgust, fear, surprise, sadness and neutral expression, we integrated the predicted expression of the input face as a condition for the generator. However, the StyleGan2 model is not a conditional model, which is why we had to consider another conditional model. In fact, the aim is to exploit the class information as an additional control to increase the quality of the face generation. With this in mind, we opted for the StyleGAN2 model with adaptive data augmentation (ADA), which is a state-of-the-art method for generating unconditional and class-conditional images in a data-limited context.

Results and Discussion

Firstly, the facial expression recognition module generates a facial expression label from a source frontal facial image, using a CNN network trained on the FER-2013 database (Goodfellow et al. 2013). The resulting label is then used by the face generation module to build a synthetic face with the same expression as the source face, using a generator from the StyleGAN2 model. We use StyleGAN2 in this work because it achieves state-of-the-art visual quality on high-resolution images with minimal artefacts.

After the training phase, the results obtained are shown in Figure 2. It is clear that the images produced are not very accurate. However, the facial expressions generated are similar in appearance to the expressions on the input faces, despite this poor quality due to the model's lack of training.

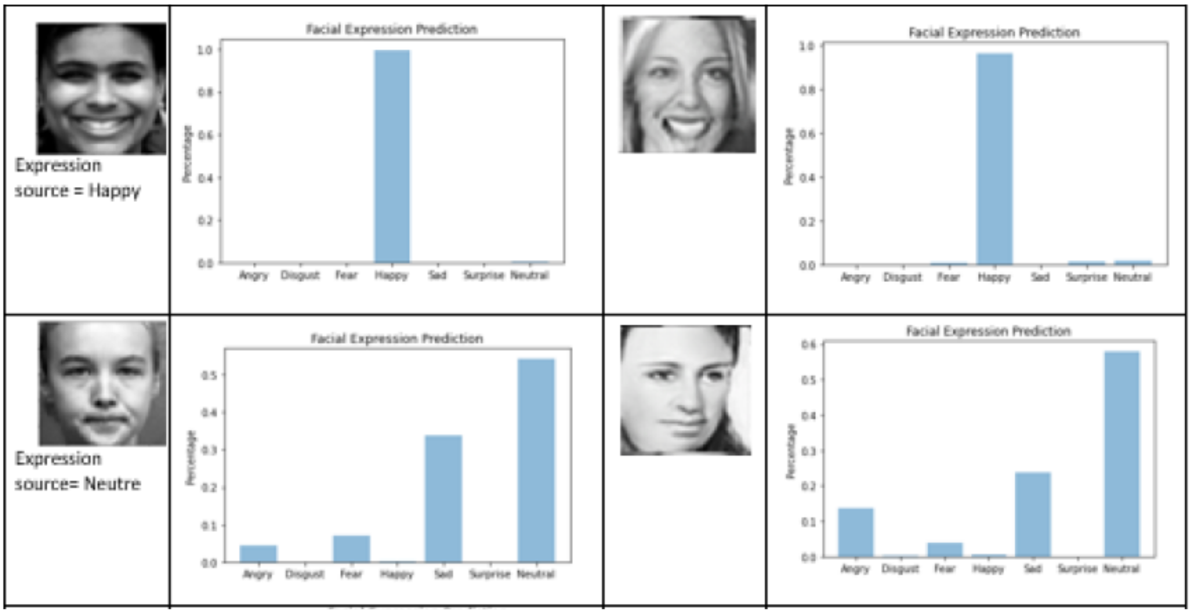

Figure 2: Face generation results.

Conclusion

In order to convey complex emotions through facial animations, the transfer of facial deformations between characters is highly requested by industry and research, with the aim of minimising manual and repetitive tasks. Our study focuses on the transfer of expressions from a real face to a synthetic face. By recognising the emotion on a source face, we can generate a synthetic face displaying that emotion without having to manually detect facial cues or match faces. Our tests underline the effectiveness of our method, which produces expressive, high-quality synthetic faces without manual intervention.

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Assessment of Learners' Academic Performances using Learning Analytics Techniques

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Extended Abstract

Nowadays, Learning Analytics has proven to be a remarkable success in various fields, such as agriculture, health, meteorology, and education is certainly no exception. In the field of E-Learning, Learning Analytics serves to enhance the learning process by assessing learners' performance in advance and adapting the pedagogical approach to address any encountered challenges. Siemens et al. (2011) define Learning Analytics as "The measurement, collection, analysis, and reporting of data about learners and their contexts, with the purpose of comprehending and optimizing learning and the environments in which it takes place." The objective of this work is to enhance learner performance in a distance learning environment through the analysis of learning data or the traces left by learners during their educational activities, employing Learning Analytics techniques. To achieve this, we have implemented an e-learning platform named EPAA (EPAA: Analyse des Performances Académiques des Apprenants) to gather and analyze learning data.

The proposed approach consists of four managers: (i) the trace collection manager, (ii) the performance assessment manager, (iii) the performance visualization manager, and (iv) the feedback manager.

During the learning process, the traces of learners interacting with the EPAA system are systematically recorded by the trace collection manager. Based on the collected data, the performance assessment manager evaluates cognitive level, social level, behavioral engagement, affective engagement, and positivity levels. Mathematical formulas have been developed to calculate learner performance indicators. To convey this information effectively through visual representations, dashboards are employed for visualizing these indicators. These dashboards are thoughtfully designed to foster awareness, reflection, and understanding, empowering learners to establish goals and track their progress toward achieving them. Once the indicators have been computed and presented visually, the feedback manager utilizes them to automatically provide learners with feedback aimed at enhancing their performance. The feedback manager generates these returns based on a predefined set of rules that are triggered by the indicators calculated by the performance assessment manager.

The steps involved in the proposed approach are illustrated in Figure 1.

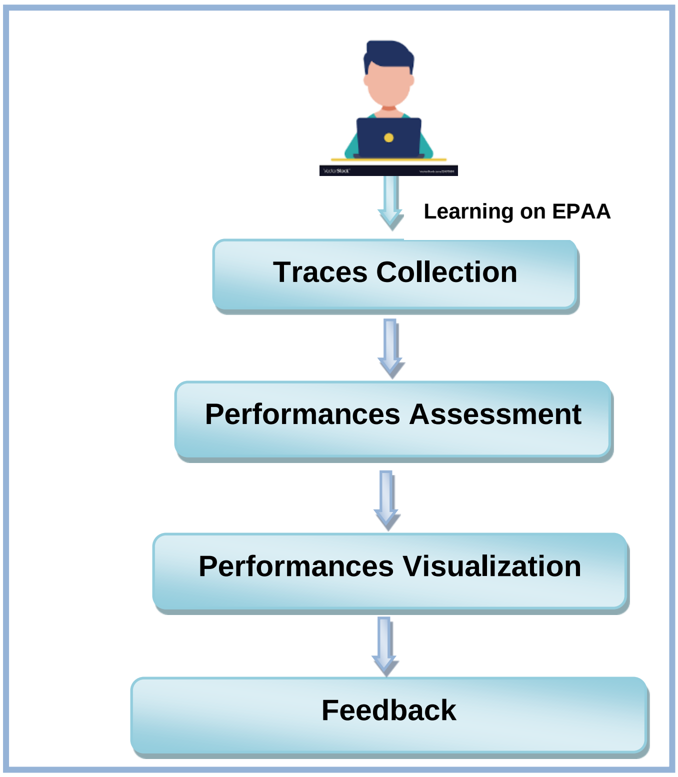

Figure 1: The steps of the Proposed Approach

The use of Learning Analytics has enabled us to offer personalized feedback to learners and suggest targeted interventions to enhance their academic performance. This promotes a more individualized approach to education, customizing teaching strategies to meet the specific needs of each learner. As part of our future work, we plan to implement a predictive method for forecasting learners' future performance.

Keywords: *Learning Analytics, academic performance, performance assessment, trace, dashboards, learner.*

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Arabic Speech Augmentation for Mispronunciation Detection

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Abstract

The need to learn several languages keeps rising, and pronunciation is the most challenging aspect of learning a language. Herein, the pronunciation assessment is an important part of CAPT (Computer Assisted Pronunciation Training) systems that tries to identify mispronunciations and give students instructive feedback. Mispronunciation detection is mainly addressed as a classification task. Thus, the availability of data is a key component. In this work, we tackle Arabic mispronunciation detection, however, Arabic lacks such resources. To overcome this issue, we used relevant speech augmentation techniques to artificially expand the speech samples. A support vector machine classifier is used to assess the proposed techniques. The use of augmentation techniques led to an improvement in accuracy of around 49% and the false rejection rate was drastically reduced.

Keywords: Computer Assisted Language Learning (CALL), Computer Assisted Pronunciation Training (CAPT), Arabic Language, Mispronunciation Detection, Speech Augmentation, Support Vector Machine (SVM).

Introduction

The need to learn a foreign language keeps rising. Pronunciation is the most difficult aspect of language learning. Practice time is one of the most important success factors in learning a second language (Engwall, 2012), students should spend as much time as they can studying with trained teachers. Unfortunately, this service is too expensive and not always available. Computer-Assisted Language Learning (CALL) systems use technology to help learners acquire a second language due to its flexibility in enabling students to enhance their language skills in a stress-free environment at their convenient time and pace. Herein, Computer-Assisted Pronunciation Teaching (CAPT) is a component of CALL systems that focuses on pronunciation. Its primary component is pronunciation assessment, which attempts to identify mispronunciations and offer learners informative feedback.

The mispronunciation detection task is mainly addressed as a classification problem (Hu et al., 2017; Necibi and Bahi, 2015; Shahin and Ahmad, 2019), where classes stand for well-pronunciation and mispronunciation. In both cases, the availability of dedicated corpora is a sine qua noncondition to train the classifier. Herein, it is worthy to notice the scarcity of nonnative labeled corpora, this is particularly true for low-resource languages in CAPT such as Arabic. On the other hand, it is more likely to encounter well-pronounced speech than deviant one, which leads to the class imbalance issue; a dataset is imbalanced if the classification categories are not equally represented. To overcome the scarcity of dedicated nonnative speech corpora and the imbalanced dataset, this work suggests the use of speech augmentation techniques to expand available corpora (Ko et al., 2015). Data augmentation is a technique that increases the amount of data by creating additional synthetic data from the existing data seen during training (Li et al., 2022), it aims to cover the problem's space as much as possible by augmenting the data and creating further samples derived from the original data set, so that the generalization of the model can be improved (Schlüter and Grill, 2015).

In this study, we adapt the techniques presented in (Kharitonov et al., 2021) for audio data augmentation to model phoneme deletion and suprasegmental errors, and we suggest an algorithm to model phoneme insertion. Phoneme insertion and deletion are the most seen pronunciation errors at the segmental level. The proposed method is evaluated in the context of Algerian pupils learning Arabic pronunciation. The dataset includes both well-pronounced speech sequences and mispronounced ones; it also includes the evaluation of the available samples, and it is freely accessible (Bahi and Necibi, 2020). The classification model is a support vector machine (SVM), used as a classifier to assess the incoming speech as well or mispronounced.

The use of audio augmentation techniques artificially expands the training dataset by creating modified versions of the available pronunciations, which is expected to improve the SVM model performances and allow large-scale experiments.

This paper addresses the issue of scarcity of nonnative speech corpora dedicated to CAPT applications. The related work on speech data augmentation and mispronunciation detection is presented in the next section. Section 3 presents the various stages of the proposed pronunciation error detection system. Section 4 reports the obtained results and discusses them. Finally, the conclusion underlines the findings of research such as bringing augmentation techniques to rebalance classes and producing samples that mimic ground truth pronunciations.

Related work

Mispronunciation detection:

Although mispronunciation detection can be carried out using a rule-based approach (Abdou and Rashwan, 2014) or a confidence measure-based approach (Franco et al., 1997; Necibi and Bahi, 2015; Witt and Young, 2000), it is mainly viewed as a classification problem where the pronunciation to be assessed is classified as either "correct" or "incorrect". Thus, conventional classification methods such as SVM, decision trees, artificial neural networks (ANN), etc. have been applied.

An acoustic phonetic feature-based SVM classifier was proposed by (Maqsood et al., 2016), only five Arabic phonemes were selected to train the SVM model(ث, ح,ص,ض,ظ) on a small private dataset with a total of 500 samples collected from 100 speakers.

Nazir et al. (2019), performed a binary classification at the phoneme level by training k-nearest neighbor (KNN), SVM, and ANN classifiers after extracting different features from the audio recordings. The speech dataset proposed in this work was collected from 400 Pakistani speakers including the 28 Arabic phonemes, the total number of samples being 11,164.

In (Akhtar et al., 2020), the performance of the extracted features was estimated using three different classifiers: KNN, SVM, and random forest. The study was conducted on a private dataset comprising a total of 2170 samples collected from 30 speakers.

Data augmentation (DA)

Data augmentation aims to solve the problem of data scarcity by creating more samples when we have a small dataset. On the other hand, it increases the models' robustness by covering more regions of the problem space, significantly improving accuracy. Data augmentation can also reduce the most common issue of overfitting (Ko et al., 2015; Schlüter and Grill, 2015).

Jaitly and Hinton (2013) were the first to use DA in speech recognition. They augmented the speech dataset by transforming spectrograms generated from the TIMIT corpus and thus improved the recognition accuracy. Fukuda et al. (2018) proved that by using data augmentation techniques the recognition of Latin American and Asian accented speech was significantly improved. Arakawa et al., (2019) applied pitch shift, time stretch, and time shift on a private Japanese dataset to train a deep neural network-based real-time voice conversion.

Even though Arabic suffers greatly from the lack of data, DA for speech data, particularly in the field of mispronunciation detection, is rarely adopted. To train a sequential deep learning model, Ziafat et al., (2021) augmented their private dataset of the 28 Arabic phonemes and short vowels using pitch variation technique to enhance the accuracy of the binary classification. Asif et al. (2022) addressed the isolated Arabic alphabet, each of the 29 Arabic alphabet letters (including "Hamzah" as a separate phoneme). The used dataset of 4872 audio files was augmented with noise injection, time-shifting, and changing speed for each original audio to perform classification.

An Arabic Mispronunciation Detection System

This work aims to provide Arabic learners with an automatic mispronunciation detection system according to the classification approach. The classification is performed by a support vector machine, and the speech is represented as a collection of Mel Frequency Cepstral Coefficients (MFCC) (Figure 1).

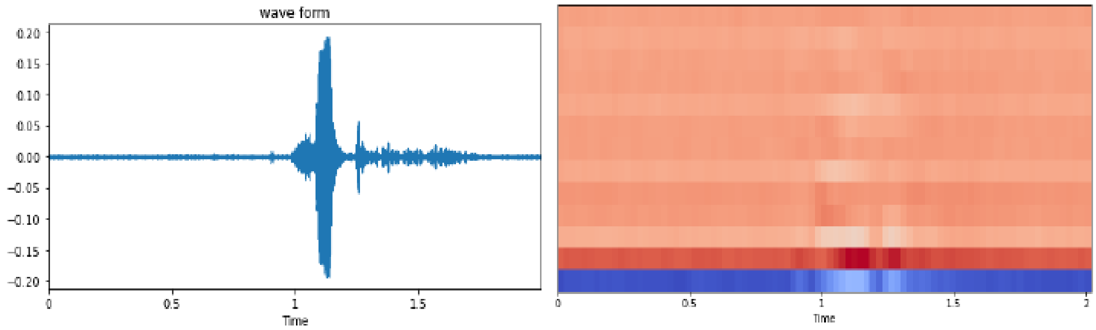

Fig. 1. A waveform representation of the Arabic word /ʃukran / and its corresponding MFCCs representation

Support Vector Machine (SVM)

As MFCCs are high-dimensional features, the SVM classifier was chosen for its effectiveness in high-dimensional spaces. Support vector machines appeared in the middle of the nineties (Cortes and Vapnik, 1995). They are based on the intuitive concept of maximizing the margin of separation between two competing classes; the margin is defined as the distance between the decision hyperplane and the support vector closest training examples. Given two classes of examples, the goal of the SVM is to find a hyperplane that separates the data and maximizes the distance between the two classes. When the training data is linearly separable, SVMs provide a linear separation such that all examples in the training set are correctly classified. Otherwise, data are mapped to a new space of higher dimensionality allowing their separation by a hyperplane; this transformation implies a kernel function. Common kernel functions include linear, polynomial, and Gaussian. This allows SVM to achieve high accuracy in high-dimensional spaces and reduces computational complexity. SVM can train on large datasets, achieve high accuracy with small datasets, and is robust to noise and outliers.

For this study, three kernels were considered: the linear, the polynomial, and the radial basis function (RBF). The linear kernel is mainly used in text classification while the polynomial kernel is suitable for image processing. The RBF is a general-purpose kernel. However, to train an SVM model, a huge number of labeled examples is required, and for CAPT applications, the scarcity of dedicated corpora is a crucial issue.

Arabic dataset

For this study, the used dataset includes both “correct” and “wrong” nonartificial pronunciations (Bahi and Necibi, 2020). The pronunciations are from nine pupils aged from 5 to 8 years; each of them uttered a set of 16 sequences (words or groups of words). The chosen words include some difficulties to learners such as the long vowels and the words written with more than one connected component. The sequences are not too long and do not include strange words (Table 1).

Table 1. List of the considered words

#	Sequences in Arabic	Phonetic transcription	Translation	#	Sequences in Arabic	Phonetic transcription	Translation
1	صباح الخير	s`aba:ħu ʔalxajr	Good Morning	9	مسّن	Mussin	Aged
2	إلى اللقاء	ʔila ʔalliqa:ʔ	Good bye	10	متأخر	mutaʔaxir	Late
3	ليلة سعيدة	lajlatun saʕi:datum	Happy Night	11	فارغ	fa:riʁ	Empty
4	من فضلك	min fad`lik	Please	12	ثقيل	θaqi:l	Heavy
5	شكرا	ʃukran	Thanks	13	أسفل	ʔasfal	Down
6	جميل	ʤami:l	Beautiful	14	داخل	da:xil	Inside
7	قبيح	qabi: ħ	Ugly	15	بداخل	bida:xil	Inside of
8	قريب	qari:b	Near (close)	16	خارج	xa:riʤ	Outside

Figure 2 reports the distribution of the samples according to the available speech sequences. It shows the inequality between the two considered classes (Well-pronounced / Mispronounced).

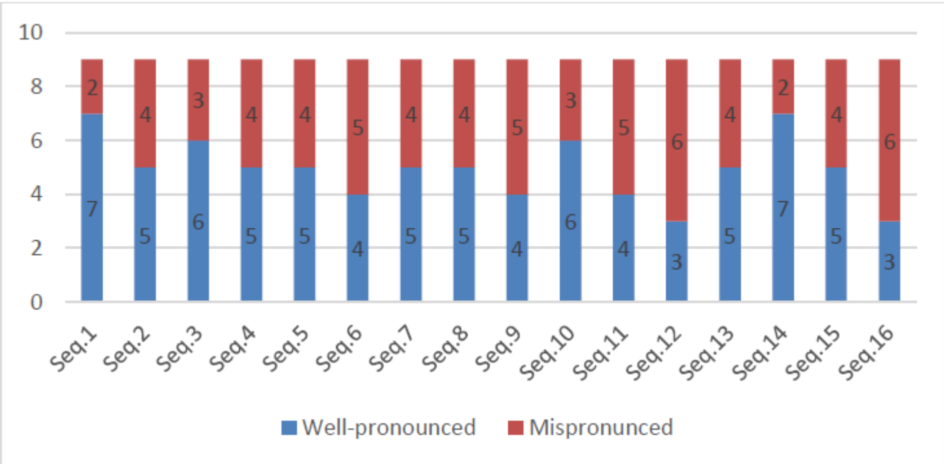

Fig. 2. Distribution of well-pronounced and mispronounced samples

Speech augmentation

To overcome limitations related to the scarcity of ground truth samples including both "good" and "bad" pronunciations, several techniques issued from audio augmentation were applied to artificially and accurately expand the training dataset. Audio augmentation can be applied in two ways according to the audio representation. The direct augmentation tackles the raw audio in the waveform representation, and the spectrograms' augmentation concerns the frequency representation of the audio. For our purpose, the direct augmentation is adopted. The expansion is performed by applying domain-specific techniques to samples from the training data that create new and different training examples. In our case, new samples also serve to rebalance the dataset, as shown in Figure 3. First, two augmentation techniques were applied: Pitch shifting and time stretching (Kharitonov et al., 2020).

Time stretching is the process of changing the speed/duration of a sound without affecting its pitch. To modify the speed of a signal, we resample the signal. Two additional copies of the original training data were created by modifying the speed to 90% and 110% of the original rate. Pitch shifting is the process of changing the pitch of a sound without affecting its speed.

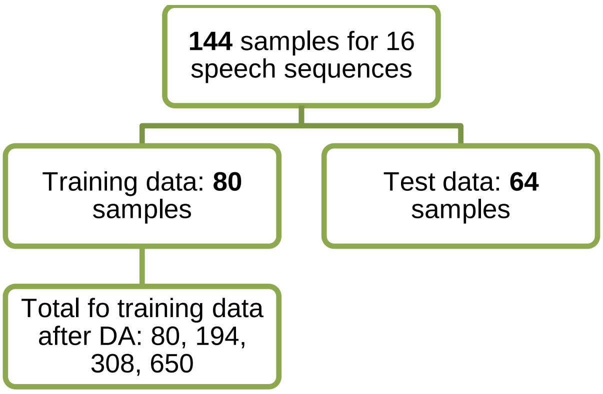

Fig. 3. Distribution of the samples in traing / test datsets

Figure 4 shows the distribution of the samples among the training and the test datasets as well-pronounced (Well-P) or mispronounced (MisP).

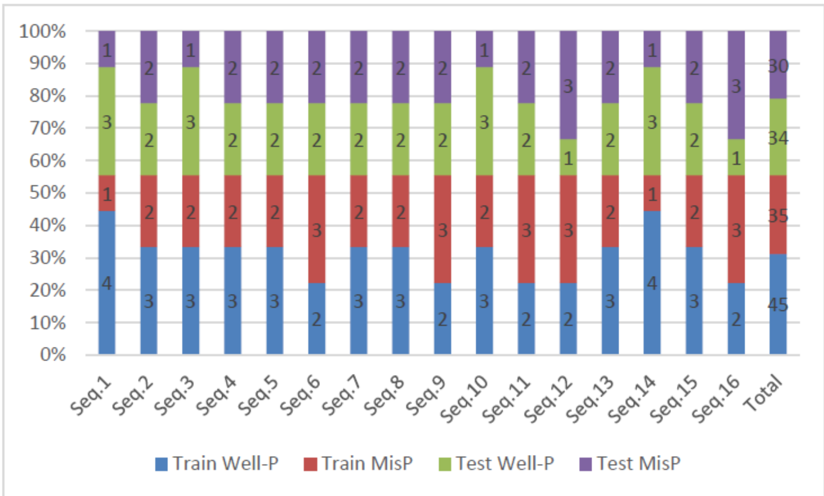

Fig. 4. Distribution of the well-pronounced and mispronounced samples among the training and the test dataset.

Results and Discussion

When using data augmentation, accuracy is a critical criterion for assessing classification tasks. It measures the rate of correct predictions across all samples.

First, we trained the SVM using the ground-truth training dataset, Table 2 reports the obtained results according to the three kernels.

Table 2. Results of the detection with the initial training data

Accuracy	Linear kernel	Polynomial kernel	RBF kernel
Traning datset	100%	81%	80%
Test dataset	48%	58%	58%

Figure 5 shows the confusion matrices for the three kernels over the test samples. It can be seen that the mispronounced samples are mainly classified as well-pronounced, this can be explained by the imbalanced dataset in favor of well-pronounced samples. Thus, the SVM predicts the minority class instances inaccurately.

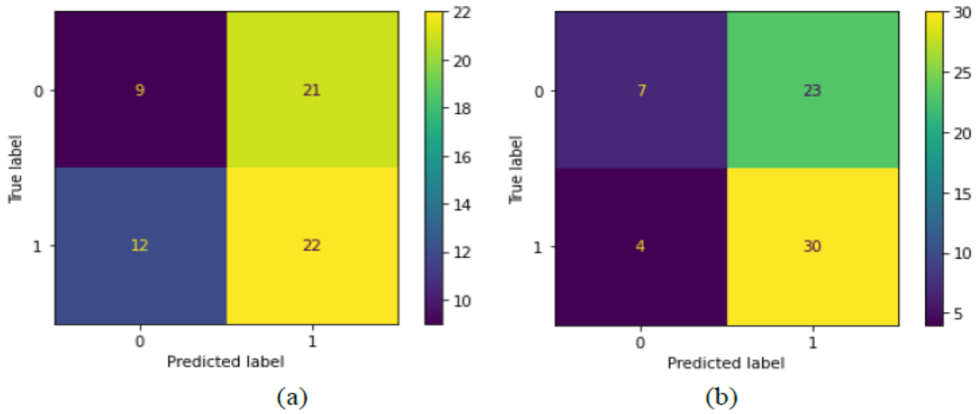

Fig. 5. Confusion matrices over the test data for the (a) linear kernel and (b) the polynomial and RBF kernels.

For the following experiments, we augmented the training dataset using several audio augmentation techniques, Figure 6 reports the obtained results according to the training set size.

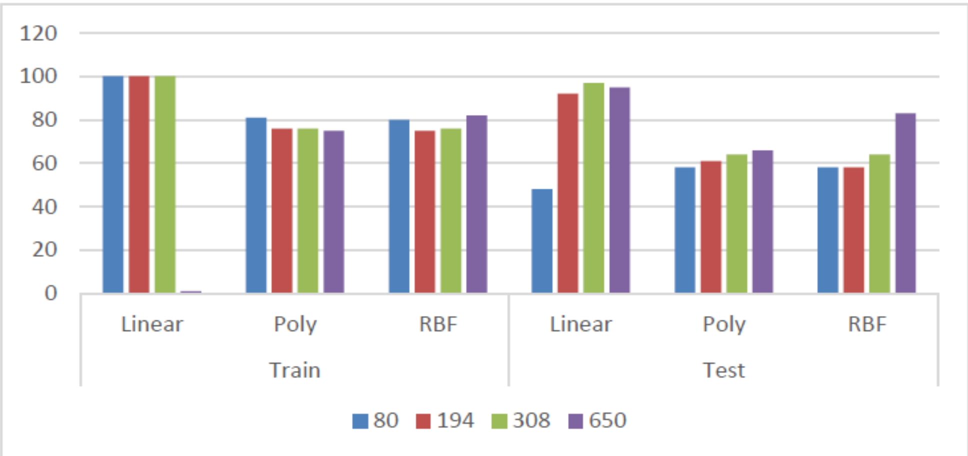

Fig. 6. Accuracy of the mispronunciation detection according to the training size.

Figure 6 shows an improvement in the accuracy for all the kernels over the test dataset. In particular, for the linear kernel, the accuracy grows from 48% to 97%. The following table reports the false rejection rate over the test samples. We can particularly notice that with the growth of the training dataset size, the false rejection rate (FRR) is reduced to zero.

Table 3. The false rejection rate on the test samples according to the training set size

Kernel	80	194	308	650
Linear	35%	0%	0%	0%
Polynomial	12%	6%	0%	0%
RBF	12%	0%	0%	0%

Conclusion

The implementation of reliable CAPT applications relies on the availability of a huge amount of annotated/rated speech corpora. For low-resource languages such as Arabic, such corpora are almost non-existent. Moreover, in the CAPT context, most of the time, speech corpora are class-imbalanced.

This paper tackles the scarcity of CAPT-dedicated speech corpora and the inherent imbalanced class issue as well. The proposed method is to artificially expand the training dataset. To assess the proposition, we study the influence of data augmentation on the classification performances in terms of accuracy and false rejection rate. By generating fresh data points, data augmentation increases the training dataset and lessens the overfitting. The results show the positive impact of speech augmentation techniques that improve accuracy and significantly reduce the false error rate.

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Artificial Group Teaching Optimization Algorithm with Information Sharing for Li-ion Battery parameters estimation

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Abstract

In the realm of parameter optimization, Artificial Teaching Algorithms have emerged as powerful tools to tackle challenging parameter estimation problems. Artificial Teaching Algorithms draw inspiration from the process of human group teaching mechanism. This article focuses on the novel Artificial Group Teaching Optimization Algorithm with Information Sharing (ISGTOA) for precise parameter estimation of the Extended Thevenin model in Li-ion batteries. ISGTOA adopts a collective intelligence approach, where individuals form groups and share valuable information during the optimization process. Through real-world battery tests, the effectiveness of ISGTOA in parameter estimation was assessed. The results demonstrate exceptional estimation accuracy with an average Root Mean Square Error (RMSE) of 2.513e-03 and a fast iteration speed. Moreover, the narrow spread reflected in the Standard Deviation (SD) of 1.143e-03 confirms the robustness and stability of the estimated parameters. This showcases the ISGTOA potential to revolutionize energy storage optimization and contribute to sustainable and reliable energy solutions.

Keywords: *Artificial inteligence, Group Teaching Optimization Algorithm, information sharing, parameters optimisation, Li-ion battery.*

Introduction

Artificial Teaching Algorithms has garnered significant attention as a promising approach to tackle the challenges of parameter optimization. These algorithms, inspired by human teaching and learning processes, have demonstrated remarkable capabilities in various optimization domains. Their ability to mimic collaborative problem-solving and knowledge sharing makes them an attractive choice for intricate parameter estimation tasks. Artificial Teaching Algorithms encompass a diverse range of optimization techniques. These algorithms leverage various teaching strategies to improve their performance and efficiency in solving complex problems.

The Teaching-Learning-Based Optimization (TLBO) algorithm stands as the fundamental core from which the next generation of Teaching-Learning-Based algorithms naturally emerges and flourishes. Introduced by (R. V. Rao et al., 2011), TLBO is a nature-inspired metaheuristic optimization algorithm that draws inspiration from the teaching and learning processes in a classroom. In this algorithm, the better-performing individuals (teachers) share their knowledge with the lesser-performing ones (students) to improve the overall population's performance. TLBO is recognized for its rapid convergence rate and has been put forth for both benchmark functions and real-world models (Chen et al., 2015; Gómez Díaz et al., 2022; Venkata Rao, 2016). Nevertheless, TLBO can exhibit susceptibility to local optima in the context of intricate optimization problems (Zhang & Jin, 2020). In pursuit of enhancing TLBO's effectiveness, multiple variants have been introduced. Elitist TLBO (R. V. Rao & Patel, 2012), modified TLBO for multi-objective optimization (R. V. Rao & Patel, 2013), improved TLBO by combining global and local search methods (Chen et al., 2015), chaotic TLBO with Levy flight (He et al., 2016) and hybrid TLBO and harmony search algorithm (Talatahari et al., 2020) are examples of advanced variations and extensions of the original TLBO algorithm , each tailored to address specific optimization challenges.

Recently, (Zhang & Jin, 2020) introduced the group teaching optimization algorithm (GTOA) based on their exploration of human behavior within group training contexts. Similar to TLBO, GTOA draws

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inspiration from classroom teaching dynamics. However, a notable distinction between the two lies in their approach: TLBO replicates traditional teaching methods, while GTOA focuses on group teaching strategies. Specifically, GTOA tailors teaching methods based on students' knowledge acceptance disparities, whereas TLBO uses a uniform approach for all students. GTOA incorporates self-learning and peer interaction during the student phase, whereas TLBO solely focuses on student-student interaction. An ability grouping phase is unique to GTOA, absent in TLBO. In TLBO, the best student assumes the role of teacher, whereas GTOA employs a teacher allocation mechanism linked to the top three students.

Nonetheless, GTOA might encounter challenges when addressing intricate optimization problems as it lacks communication between exceptional and average groups, potentially leading to local optimal solutions. To enhance GTOA's performance, an enhanced version has been introduced by (Zhang & Chi, 2023), referred to as the Group Teaching Optimization Algorithm with Information Sharing (ISGTOA). This variant aims to bolster GTOA's efficacy by leveraging the reuse of individuals within the two established archives.

This article delves into the importance of Artificial Teaching Algorithms in the context of parameter optimization for Li-ion battery model, with a specific focus on the novel Artificial algorithm: ISAGTOA. Accurate battery models are vital for efficient performance prediction and optimal operation of electric vehicles and renewable energy systems (Merrouche et al., 2022; Shu et al., 2021). The primary objective of ISAGTOA is to enhance the accuracy and efficiency of parameter estimation for the Extended Thevenin model, there by empowering researchers and engineers to unlock the full potential of Li-ion batteries.

This article offers dual contributions. Firstly, it presents the novel ISGTOA applied for the first time to extract the parameters of an extended Thevenin Lithium-ion Battery model. Secondly, it showcases the algorithm's efficacy by applying it to a high-quality battery test profile grounded in real-world driving data.

Throughout the article, we present a comprehensive evaluation of ISGTOA using real-world Li-ion battery data. The results highlight its exceptional accuracy, with a minimum Root Mean Square Error (RMSE) of 2.51313505e-03 and a narrow spread indicated by the Standard Deviation (SD) of 1.14311269e-03. Moreover, the algorithm's fast iteration speed positions it as a powerful tool for practical implementation, where timely parameter estimation is crucial for optimizing battery performance in real-time scenarios.

By exploring the benefits of ISGTOA, this article aims to contribute to the growing body of research in energy storage optimization and foster advancements in battery management systems and renewable energy integration. Ultimately, accurate parameter estimation using Artificial Teaching Algorithms promises to propel the development of sustainable and reliable energy solutions, paving the way for a greener and more energy-efficient future.

Methods

A- Group teaching optimization algorithm (GTOA)

The concept of the Group Teaching Optimization Algorithm draws inspiration from the mechanics of group teaching (Zhang & Jin, 2020). GTOA's fundamental premise revolves around enhancing the overall knowledge of a collective by emulating the dynamics of group teaching, encompassing the best, average, and worst segments of a student body (Figure. 1). GTOA framework amalgamates deterministic and stochastic methods alongside computational intelligence techniques, creating a user-friendly platform for students to practically apply acquired theories, verify concepts, and conduct feature comparisons among various optimization methodologies.

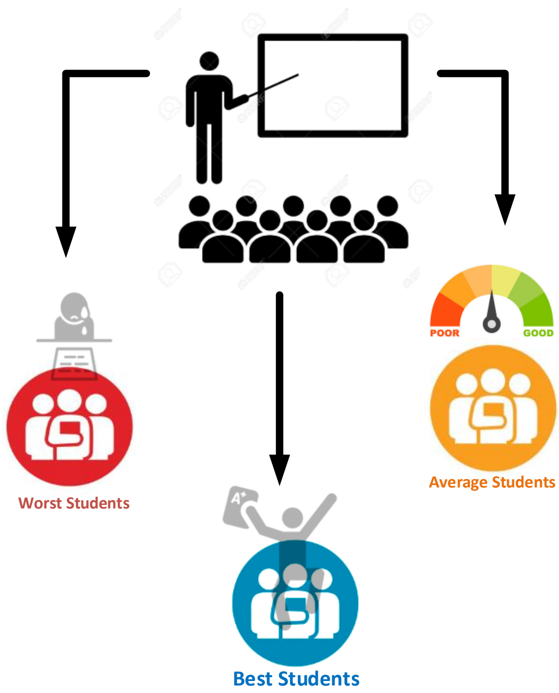
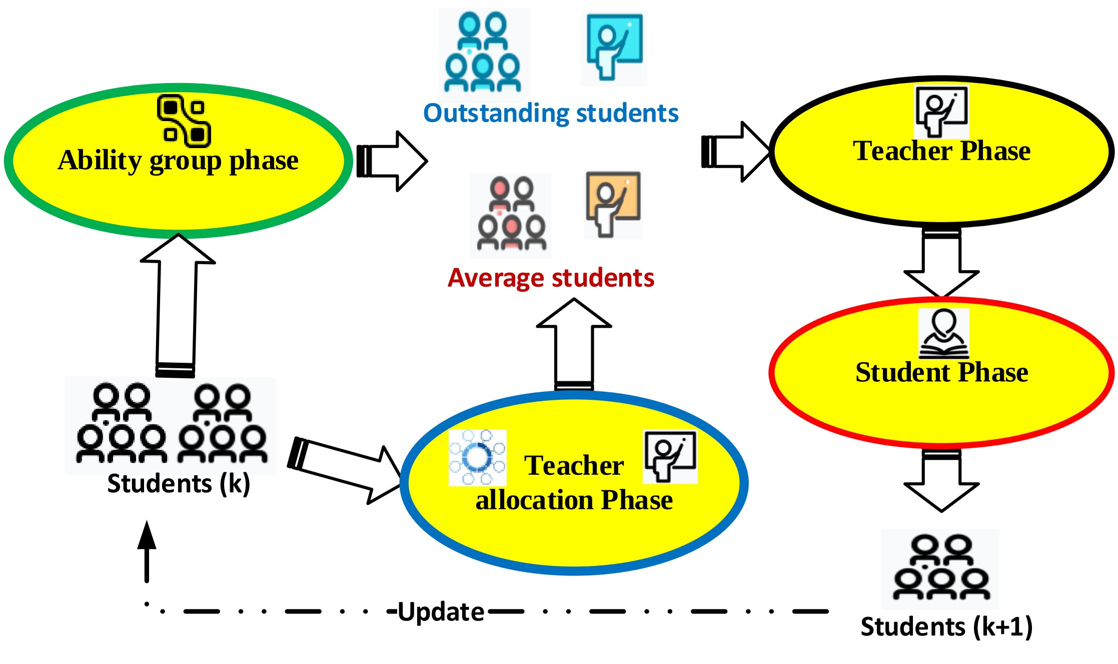


Figure 1 Inspiration of GTOA

The practical implementation of group teaching can be intricate, especially when accounting for the diverse potential within students. To make group teaching applicable as an optimization technique, a foundational assumption is made wherein:

- the **population** corresponds to the best, average, and worst student groups;
- the **decision variables** corresponds to the subjects provided to students;
- the **fitness values** corresponds to the students' knowledge levels.

As shown in Figure. 2, the components of GTOA include ability grouping phase, teacher phase, student phase and teacher allocation phase. The **four** phases are introduced in detail in the following sections.



GTOA Phases

Figure 2 Fundamental phases of GTOA

1- Ability group phase

In GTOA, the distinguishing factor among students lies in their capacity to assimilate knowledge. The objective of the ability grouping phase is to partition all students into two equal-sized groups, i.e. outstanding group X_o^t and average group X_a^t, with:

$$\begin{cases} X_o^t = \{X_{o,1}^t, X_{o,2}^t, X_{o,3}^t, \dots., X_{o,N/2}^t\} \\ X_a^t = \{X_{a,1}^t, X_{a,2}^t, X_{a,3}^t, \dots., X_{a,N/2}^t\} \end{cases}$$; Determined by their aptitude for acquiring knowledge.

Where, N is the number of all the students and t is the current number of iterations.

Note that, the ability of accepting knowledge of one student is evaluated by the fitness function.

2- Teacher phase

During the Teacher phase, distinct teaching plans are devised for both the average group and the outstanding group. In GTOA, the teacher prioritizes enhancing the knowledge of the outstanding group as they possess a strong capacity to absorb information. This approach facilitates collective knowledge improvement within the outstanding group, enabling each student to augment their knowledge (Zhang & Jin, 2020).

$$X_{o,teacher,i}^{t+1} = \boldsymbol{X_{o,i}^t} + a \times \left(\boldsymbol{T^t} - F \times \left(b \times \boldsymbol{M^t} + c \times \boldsymbol{X_{o,i}^t}\right)\right), i = 1,2, \dots\dots., N/2 \qquad \text{Eq.1}$$

$$\boldsymbol{M^t} = \frac{1}{N/2} \sum_{i=1}^{N/2} X_{o,i}^t \qquad \text{Eq.2}$$

$$b + c = 1 \qquad \text{Eq.3}$$

Where $\boldsymbol{T^t}$ is the knowledge of teacher at time t, $\boldsymbol{M^t}$ is the mean knowledge of the outstanding group at time t, F is the teaching factor that decides the teaching results of the teacher, $X_{o,teacher,i}^{t+1}$ is the knowledge of student i at time t in the outstanding group by learning from his or her teacher, and a, b and c are there random number in the range [0,1]. According to the original reference of GTOA (Zhang & Jin, 2020), the value of F can be either 1 or 2.

The teacher's focus lies in enhancing the knowledge of individual students within the average group. Consequently, each student in the average group can augment their knowledge through this personalized approach.

$$X_{a,teacher,i}^{t+1} = \boldsymbol{X_{a,i}^t} + 2 \times d \times \left(\boldsymbol{T^t} - \boldsymbol{X_{a,i}^t}\right),\ i = 1,2, \dots\dots., N/2 \qquad \text{Eq.4}$$

Where $X_{a,teacher,i}^{t+1}$ is the knowledge of student i at time t in the average group by learning from his or her teacher, and d is a random number in the range [0,1].

Note that one student may not gain knowledge by the teacher phase, which can be addressed by (take the minimum problem as an example)

$$\begin{cases} X_{o,teacher,i}^{t+1} = \begin{cases} X_{o,teacher,i}^{t+1}, & f\left(X_{o,teacher,i}^{t+1}\right) < f(X_{o,i}^t) \\ X_{o,i}^t, & f\left(X_{o,teacher,i}^{t+1}\right) \geq f(X_{o,i}^t) \end{cases} ;\ i = 1,2, \dots\dots., N/2 \\ X_{a,teacher,i}^{t+1} = \begin{cases} X_{a,teacher,i}^{t+1}, & f\left(X_{a,teacher,i}^{t+1}\right) < f(X_{a,i}^t) \\ X_{a,i}^t, & f\left(X_{a,teacher,i}^{t+1}\right) \geq f(X_{a,i}^t) \end{cases} ;\ i = 1,2, \dots\dots., N/2 \end{cases} \qquad \text{Eq.5}$$

3- Student phase

In the student phase, knowledge acquisition takes place after class hours. During their spare time, students have two distinct methods to gain knowledge: self-learning and engaging in interactions with their peers, which can be expressed as:

$$X_{o,student,i}^{t+1} = \begin{cases} X_{o,teacher,i}^{t+1} + e \times (X_{o,teacher,i}^{t+1} - X_{o,teacher,j}^{t+1}) + g \times (X_{o,teacher,i}^{t+1} - X_{o,i}^{t}), if\ f(X_{o,teacher,i}^{t+1}) < f(X_{o,teacher,j}^{t+1}) \\ X_{o,teacher,i}^{t+1} - e \times (X_{o,teacher,i}^{t+1} - X_{o,teacher,j}^{t+1}) + g \times (X_{o,teacher,i}^{t+1} - X_{o,i}^{t}), if\ f(X_{o,teacher,i}^{t+1}) \geq f(X_{o,teacher,j}^{t+1}) \end{cases}$$

$i = 1,2, \dots \dots, N/2$ Eq.6

$$X_{a,student,i}^{t+1} = \begin{cases} X_{a,teacher,i}^{t+1} + e \times (X_{a,teacher,i}^{t+1} - X_{a,teacher,j}^{t+1}) + g \times (X_{a,teacher,i}^{t+1} - X_{a,i}^{t}), if\ f(X_{a,teacher,i}^{t+1}) < f(X_{a,teacher,j}^{t+1}) \\ X_{a,teacher,i}^{t+1} - e \times (X_{a,teacher,i}^{t+1} - X_{a,teacher,j}^{t+1}) + g \times (X_{a,teacher,i}^{t+1} - X_{a,i}^{t}), if\ f(X_{a,teacher,i}^{t+1}) \geq f(X_{a,teacher,j}^{t+1}) \end{cases}$$

$i = 1,2, \dots \dots, N/2$ Eq.7

where e and g are two random numbers in the range [0,1] with uniform distribution,

$X_{o,student,i}^{t+1}$ is the knowledge of student i from outstanding group at time t by learning from the student phase and $X_{a,student,i}^{t+1}$ is the knowledge of student i from average group at time t by learning from the student phase. The student j ($j \in \{1,2, \dots\dots i-1, i+1, \dots\dots N\}$) is randomly selected. In Eqs 6 and 7 the second item and the third item on the right stand for learning from the other student and self-learning, respectively.

In addition, one student may not gain knowledge by the student phase, which can be addressed by (take the minimum problem as an example)

$$X_{o,i}^{t+1} = \begin{cases} X_{o,teacher,i}^{t+1}, & f(X_{o,teacher,i}^{t+1}) < f(X_{o,student,i}^{t+1}) \\ X_{o,student,i}^{t+1}, & f(X_{o,teacher,i}^{t+1}) \geq f(X_{o,student,i}^{t+1}) \end{cases}, i = 1,2, \dots \dots, N/2 \quad \text{Eq.8}$$

$$X_{a,i}^{t+1} = \begin{cases} X_{a,teacher,i}^{t+1}, & f(X_{a,teacher,i}^{t+1}) < f(X_{a,student,i}^{t+1}) \\ X_{a,student,i}^{t+1}, & f(X_{a,teacher,i}^{t+1}) \geq f(X_{a,student,i}^{t+1}) \end{cases}, i = 1,2, \dots \dots, N/2 \quad \text{Eq.9}$$

4- Teacher allocation phase

The effectiveness of a sound teacher allocation mechanism is pivotal in enhancing students' knowledge. In GTOA, the teacher allocation mechanism is inspired by the hunting behavior in grey wolf optimizer (Mirjalili et al., 2014), which can be defined by:

$$T^t = \begin{cases} X_{first}^t, & f(X_{first}^t) \leq f(\frac{X_{first}^t + X_{second}^t + X_{third}^t}{3}) \\ \frac{X_{first}^t + X_{second}^t + X_{third}^t}{3}, & f(X_{first}^t) > f(\frac{X_{first}^t + X_{second}^t + X_{third}^t}{3}) \end{cases} \quad \text{Eq.10}$$

Where X_{first}^t, X_{second}^t and X_{third}^t are the first, second and third best students, respectively. Note that, to accelerate convergence of GTOA, outstanding group and average group share the same teacher.

B- Group teaching optimization algorithm with information sharing (ISGTOA)

In this paper, a novel metaheuristic method named Group Teaching Optimization Algorithm with Information Sharing (Zhang & Chi, 2023) is introduced for Btattery model parameters optimization.

Compared with GTOA, ISGTOA keeps the inherent advantage of not introducing any control parameters while concurrently enhancing the optimization performance of GTOA.

The common features of both GTOA and ISGOTA can be summarized as follows:

- Both algorithms solely depend on the fundamental parameters, namely population size and terminal condition, for the optimization process.
- The search mechanism in both algorithms comprises four phases: ability grouping, teacher, student, and teacher allocation phases.

The main difference between GTOA and ISGTOA is that there are two archives introduced in ISGTOA to increase the communication between outstanding group and average group as shown in Figure. 3. The archives $\boldsymbol{A}$ and $\boldsymbol{B}$ are introduced to teacher phase and student phase respectively.

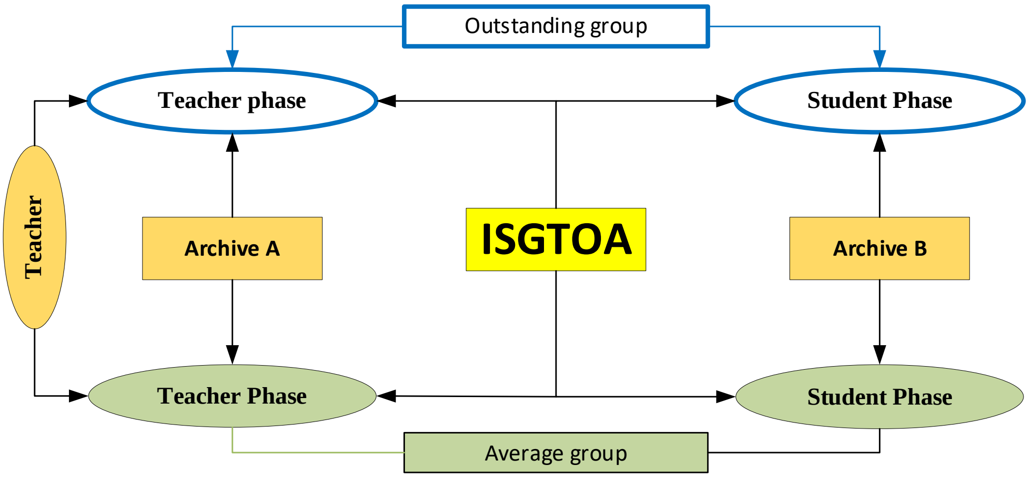


Figure 3 Fundamental elements of ISGTOA including the archives $\boldsymbol{A}$ and $\boldsymbol{B}$

Archive A

In GTOA, the teacher phase of outstanding group and average group is guided by the "teacher". If "teacher" gets trapped in local minima, the whole population with high probability finds the local optimal solution. Thus, to avoid this challenge, an archive A with N individuals is built and then a mutation strategy is designed. The teacher phase of outstanding group in ISGTOA can be denoted by:

$$X_{o,teacher,i}^{t+1} = \begin{cases} \boldsymbol{X_{o,i}^t} + a \times \left(\boldsymbol{T^t} - F \times \left(b \times \boldsymbol{M^t} + c \times \boldsymbol{X_{o,i}^t}\right)\right), if\ f(\boldsymbol{X_{o,i}^t}) > M_{cost}^t \\ \boldsymbol{X_{o,i}^t} + ceil(1 + |\eta|) \times \xi \times (A_i^t - \boldsymbol{X_{o,i}^t})\ , otherwise \end{cases} \quad \text{Eq.11}$$

$$i = 1,2, \dots \dots, N/2$$

Where η and ξ are two random numbers with standard normal distribution, M_{cost}^t is the average fitness value of the outstanding group, and $ceil(.)$ is a function that maps one number to the least integer than or equal to itself. $\boldsymbol{A^t}$ can be computed by:

$$\boldsymbol{A^t} = permuting(X^t) \quad \text{Eq.12}$$

Where $permuting(X^t)$ is a random shuffling function. In other words, A^tcan be obtained by randomly sorting for the individuals in the population X^t, $M_{o,cost}^t$ is the average fitness value of the outstanding group, which can be computed by;

$$M_{o,cost}^t = \frac{1}{N/2}\sum_{i=1}^{N/2} f(X_{o,i}^t) \quad \text{Eq.13}$$

The teacher phase of average group in the proposed (ISGTOA) can be expressed by

$$X_{a,teacher,i}^{t+1} = \begin{cases} \boldsymbol{X_{a,i}^t} + 2 \times d \times \left(\boldsymbol{T^t} - \boldsymbol{X_{a,i}^t}\right), & if\ f(\boldsymbol{X_{a,i}^t}) > M_{a,cost}^t \\ \boldsymbol{X_{a,i}^t} + ceil(1 + |\eta|) \times \xi \times (A_i^t - \boldsymbol{X_{a,i}^t})\ , & otherwise \end{cases} \quad \text{Eq.14}$$

$$i = 1,2, \dots \dots, N/2$$

Where $M_{a,cost}^t$ is the mean fitness value of the average group that can be computed by:

$$M_{a,cost}^t = \frac{1}{N/2}\sum_{i=1}^{N/2} f(X_{a,i}^t) \quad \text{Eq.15}$$

Archive B

An archive $\boldsymbol{B^t}$ is built to save the promising solutions and its maximum length is the same with the number of individuals in $\boldsymbol{X^t}$,i.e.

$$\boldsymbol{B^t} = \{\boldsymbol{b_1^t}, \boldsymbol{b_2^t}, \ldots\ldots\ldots\ldots, \boldsymbol{b_N^t}\}$$

The update mechanism of archive $\boldsymbol{B^t}$ can be described as follows.

When one individual can find a better solution $\boldsymbol{X}^*$in the teacher phase or student phase, this solution $\boldsymbol{X}^*$will be viewed as a promising solution. At this moment, if the length of archive $\boldsymbol{B^t}$ is less than the maximum length, $\boldsymbol{X}^*$ will be saved to archive $\boldsymbol{B^t}$; otherwise, two solutions are selected from archive $\boldsymbol{B^t}$ and the worst one of the selected two solutions is replaced with $\boldsymbol{X}^*$.

In ISGTOA, the student phase in the outstanding and average group can be written, respectively as:

$$X_{o,st,i}^{t+1} = \begin{cases} X_{o,tr,i}^{t+1} + e \times (X_{o,tr,i}^{t+1} - X_{o,tr,j}^{t+1}) + g \times (b_m^t - \boldsymbol{X_{o,i}^t}), if\ f(X_{o,tr,i}^{t+1}) < f(X_{o,tr,j}^{t+1});\ f(b_m^t) < f(\boldsymbol{X_{o,i}^t}) \\ X_{o,tr,i}^{t+1} - e \times (X_{o,tr,i}^{t+1} - X_{o,tr,j}^{t+1}) + g \times (b_m^t - \boldsymbol{X_{o,i}^t}), if\ f(X_{o,tr,i}^{t+1}) \geq f(X_{o,tr,j}^{t+1});\ f(b_m^t) < f(\boldsymbol{X_{o,i}^t}) \\ X_{o,tr,i}^{t+1} + e \times (X_{o,tr,i}^{t+1} - X_{o,tr,j}^{t+1}) - g \times (b_m^t - \boldsymbol{X_{o,i}^t}), if\ f(X_{o,tr,i}^{t+1}) < f(X_{o,tr,j}^{t+1});\ f(b_m^t) \geq f(\boldsymbol{X_{o,i}^t}) \\ X_{o,tr,i}^{t+1} - e \times (X_{o,tr,i}^{t+1} - X_{o,tr,j}^{t+1}) - g \times (b_m^t - \boldsymbol{X_{o,i}^t}), if\ f(X_{o,tr,i}^{t+1}) \geq f(X_{o,tr,j}^{t+1});\ f(b_m^t) \geq f(\boldsymbol{X_{o,i}^t}) \end{cases}$$

Eq.16

With: $X_{o,st,i}^{t+1} = X_{o,student,i}^{t+1}$ is the knowledge of student i from outstanding group at time t by learning from the student phase.

$X_{o,tr,i}^{t+1} = X_{o,teacher,i}^{t+1}$ is the knowledge of student i at time t in the outstanding group by learning from the teacher phase.

$$X_{a,st,i}^{t+1} = \begin{cases} X_{a,tr,i}^{t+1} + e \times (X_{a,tr,i}^{t+1} - X_{a,tr,j}^{t+1}) + g \times (b_m^t - \boldsymbol{X_{a,i}^t}), if\ f(X_{a,tr,i}^{t+1}) < f(X_{a,tr,j}^{t+1});\ f(b_m^t) < f(\boldsymbol{X_{a,i}^t}) \\ X_{a,tr,i}^{t+1} - e \times (X_{a,tr,i}^{t+1} - X_{a,tr,j}^{t+1}) + g \times (b_m^t - \boldsymbol{X_{a,i}^t}), if\ f(X_{a,tr,i}^{t+1}) \geq f(X_{a,tr,j}^{t+1});\ f(b_m^t) < f(\boldsymbol{X_{a,i}^t}) \\ X_{a,tr,i}^{t+1} + e \times (X_{a,tr,i}^{t+1} - X_{a,tr,j}^{t+1}) - g \times (b_m^t - \boldsymbol{X_{a,i}^t}), if\ f(X_{a,tr,i}^{t+1}) < f(X_{a,tr,j}^{t+1});\ f(b_m^t) \geq f(\boldsymbol{X_{a,i}^t}) \\ X_{a,tr,i}^{t+1} - e \times (X_{a,tr,i}^{t+1} - X_{a,tr,j}^{t+1}) - g \times (b_m^t - \boldsymbol{X_{a,i}^t}), if\ f(X_{a,tr,i}^{t+1}) \geq f(X_{a,tr,j}^{t+1});\ f(b_m^t) \geq f(\boldsymbol{X_{a,i}^t}) \end{cases}$$

Eq.17

Where $\boldsymbol{b_m^t}$ is a solution selected from the archive $\boldsymbol{B^t}$, note that when Eq.16 or Eq.17 is used, two solutions are first selected randomly from archive $\boldsymbol{B^t}$ and the better one is equal to $\boldsymbol{b_m^t}$.

Extended Thevenin model for Li-ion battery

Given the functional demands of the Battery Management System (BMS), precise battery modeling becomes indispensable for achieving optimal battery performance management and detecting potential abuse incidents. Among the various model-based techniques, equivalent circuit models (ECMs) which is a mathematical/electrical model used to represent the electrical behavior of Lithium-ion batteries, find widespread application in BMSs owing to their capacity to represent the electrical characteristics of batteries in a meaningful and physically relevant manner. ECMs present numerous benefits, such as their simplicity, ease of processing, and moderate computational demands (Wang et al., 2021). This research paper focuses on optimizing the parameters of the extended Thevenin ECM, known for its favorable compromise between complexity and accuracy. The model is presented in Figure 4, comprising two RC branches in series with the internal ohmic resistance R0 and an Open Circuit Voltage source (Voc).

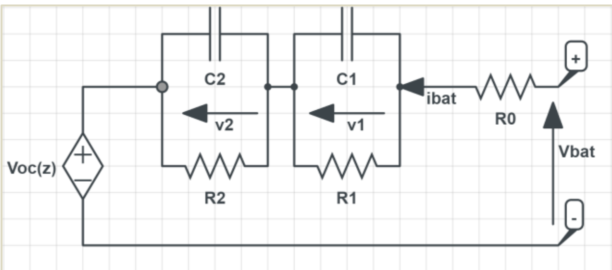


FIGURE 4: Extended Thevenin battery model Schematic

The extended Thevenin model can be formulated using discrete-time, to facilitate its integration into a final algorithm, as follows:

$$z[k+1] = z[k] - \frac{\eta \Delta t}{Q_C} i_{bat}[k] \quad \text{Eq.18}$$

$$v_i[k+1] = e^{\frac{-\Delta t}{R_i C_i}} v_i[k] + R_i \left(1 - e^{\frac{-\Delta t}{R_i C_i}}\right) i_{bat}[k] \quad \text{Eq.19}$$

$$v_{bat}[k] = V_{oc}(z[k]) - R_0 i_{bat}[k] - \sum_{i=1}^{i=2} v_i[k] \quad \text{Eq.20}$$

where v_{bat} is the terminal battery voltage, i_{bat} is the input/output current, z is the State of Charge (SoC), v_i denotes the voltage of the corresponding RC branch, i is the number of the RC branch (which is 1 or 2 in our case), Δt is the sampling period, R_i and C_i are resistance and capacitor of the corresponding RC branch, η is the charge coefficient (assumed to be 1 in this article), and Q_C is the battery nominal capacity (Ah).

The relationship between Voc and SOC, being non-linear, can be mathematically represented as a sixth-order polynomial exponential function:

$$V_{oc} = a_0 + a_1 z + a_2 z^2 + a_3 z^3 + a_4 z^4 + a_5 z^5 + a_6 z^6 \quad \text{Eq.21}$$

where, $a_0 \ldots\ldots a_6$ are polynomial coefficients.

Results and Discussions

The overarching framework, in its general form, commences with the selection of the Battery model (in this case, the Extended Thevenin model), followed by data collection, the choice of optimization algorithm (ISGTOA in this context), and ultimately concludes with the identification of model parameters.

As discussed earlier, the chosen Extended Thevenin RC model involves the internal resistance R0, and two serially connected RC pairs, along with parameters of Voc(z). To ensure precise identification of battery parameters, our proposed approach relies on the high-accuracy dataset used in Ref. (Li et al., 2020, 2022). The main specifications of the Samsung 35e LiB used for testing are depicted in Table 1. The selected optimization algorithm, ISGTOA, is employed to optimize the twelve parameters of the ECM, namely R0, R1, C1, R2, C2, a0-a6.

TABLE 4: Main specifications of the tested LiB

TABLE III. Specification	TABLE IV. Description	TABLE V. Figure
TABLE VI. Type/ Anode / Cathode	TABLE VII. lithium-ion Graphite / NCA	TABLE VIII. 
TABLE IX. Producer code	TABLE X. Samsung INR18650-35e	
TABLE XI. Nominal voltage	TABLE XII. 3.6 V	
TABLE XIII. Typical capacity	TABLE XIV. 3400 mAh	
TABLE XV. Dimensions	TABLE XVI. 18.55mm x 65.25mm	

The utilized test profile is grounded in real-world driving data, encompassing discharging currents reaching up to 8 A and charging currents up to 2 A. The Digatron battery tester directly collected the battery's measured currents (depicted in Figure 5) and voltages (discussed in the subsequent subsection), employing a sampling period (Δt) of 0.1 seconds. SOC calculations were conducted using the Coulomb counting method. It's notable from Figure 5 that the SOC data is predominantly confined to higher SOC values, approximately between 83 and 79%.

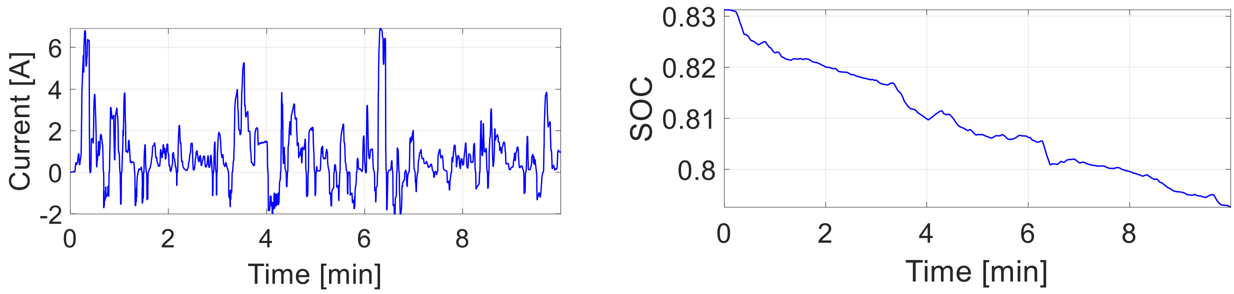


FIGURE 5: Current and SOC variations under Real world tests

The primary objective of ISGTOA is to achieve convergence towards the optimal point, which signifies the best-fitting ECM parameters capable of minimizing the objective function. In this research, the chosen objective function is the RMSE, employed to efficiently diminish the discrepancy between the battery's estimated voltage Vest, derived from the potential parameters, and the real-world experimental voltage Vexp obtained from data.

To comprehensively evaluate the behavior and performance of the ISGTOA-based estimation algorithm, ten runs of the algorithm were conducted (Figure 6). This multi-run approach aids in gauging the algorithm's stability and its dependability in parameter estimation. The deviation indices of the ISGTOA algorithm, encompassing minimum, mean, and maximum values, are reported as 2.51313505e-03, 5.68390940e-03, and 3.23167139e-03, respectively. These indices provide valuable insights into the algorithm's capability to minimize disparities between the estimated parameters and the actual experimental data. The Standard Deviation (SD) index, standing at 1.14311269e-03 in this instance, signifies the distribution or spread of the deviation values. A lower standard deviation indicates closer proximity of the estimated parameters to the true values, reflecting stability level.

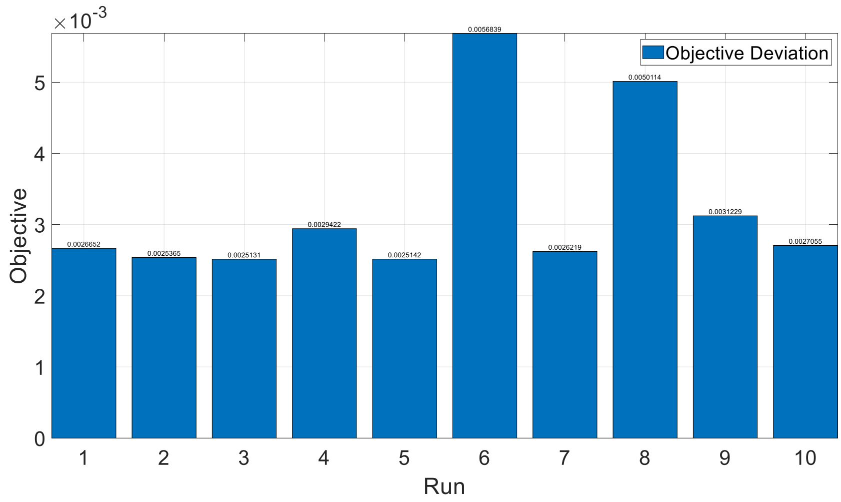


FIGURE 6: Objective deviation values across the 10 Runs of ISGTOA

Figure 7 offers a comparative illustration between the experimental voltage measurements and the voltage estimated corresponding to the minimum RMSE of 2.51313505e-03 through the ISGTOA-based estimation algorithm. This graphical depiction facilitates an evaluation of the estimation method's accuracy.

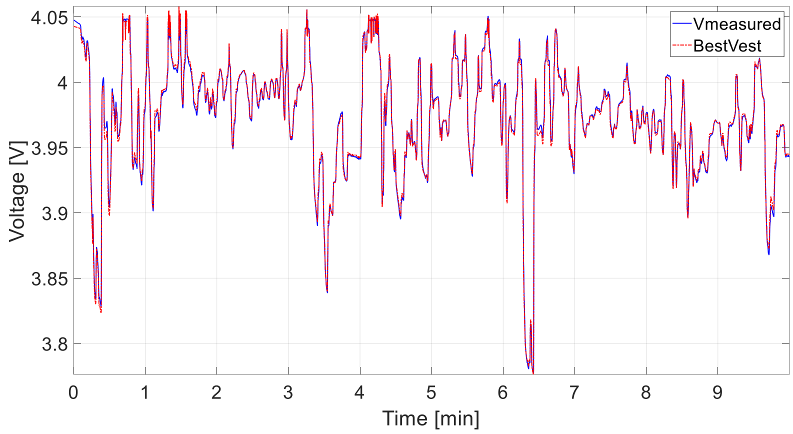


FIGURE 7: Comparative illustration between the estimated Voltage with the ISGTOA optimized parameters and the measured voltage

Figure 8 visually presents the convergence pattern of the ISGTOA algorithm concerning the iteration count. It vividly displays how the algorithm iteratively enhances and refines its estimates over the course of its execution. This observation of convergence behavior yields insightful data regarding the algorithm's effectiveness and rapidity in identifying optimal solutions. The findings underscore that the ISGTOA algorithm attains a low RMSE with a relatively modest number of iterations, implying its swift and efficient convergence towards precise parameter estimation.

The optimal optimization parameters, as identified by the ISGTOA method, are outlined in Table 2. These parameters stem from the 3rd algorithm run, resulting in a minimum RMSE of 2.51313505e-03. This outcome underscores the proficiency of the ISGTOA algorithm in successfully identifying optimal parameter values for the third-order ECM.

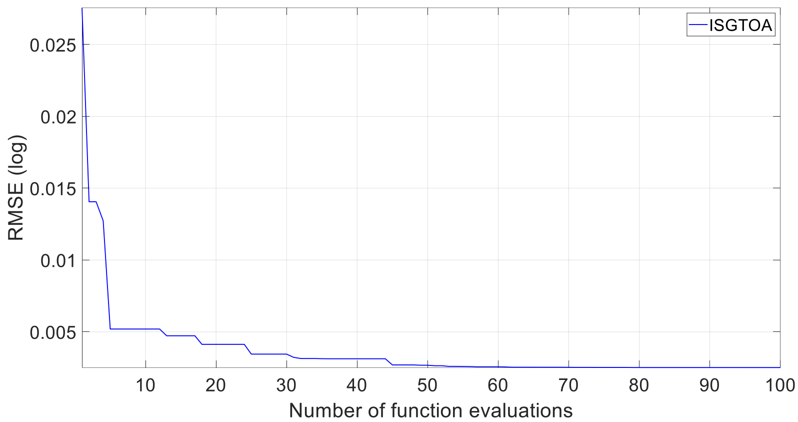


FIGURE 8: Convergence speed of ISGTOA

TABLE 5: Main specifications of the tested LiB

Parameters	values
R0 (Ω)	0.02722846103
R1 (Ω)	0.01191401674
C1 (F)	1067.729911
R2 (Ω)	0.03977627972
C2(F)	10000.22366
a0	3.213924044
a1	0.9971379652
a2	-0.0003632852121
a3	0.0004488901315
a4	-2.414205372e-06
a5	8.456727134e-06
a6	-3.995831792e-08

Conclusion

This article centers on the innovative Artificial Group Teaching Optimization Algorithm with Information Sharing (ISGTOA), designed specifically for precise parameter estimation of the Extended Thevenin model in Li-ion batteries. ISGTOA embraces a collective intelligence paradigm, where individuals coalesce into groups, actively sharing critical insights during the optimization process. Through rigorous real-world battery tests, the efficacy of ISGTOA in parameter estimation was comprehensively evaluated. The results unequivocally underline its exceptional accuracy in estimation, showcasing an average Root Mean Square Error (RMSE) of 2.51313505e-03 coupled with swift iteration speed. The remarkable precision evidenced by the narrow spread, as indicated by the Standard Deviation (SD) of 1.14311269e-03, affirms the robustness and reliability of the derived parameters. These findings collectively illuminate the transformative potential of ISGTOA in reshaping energy storage optimization and making tangible contributions to sustainable and dependable energy solutions. This article aligns with existing literature, further affirming that the emergence of Artificial Teaching-Learning Algorithms marks a significant stride and a potent tool in addressing intricate parameter estimation challenges.

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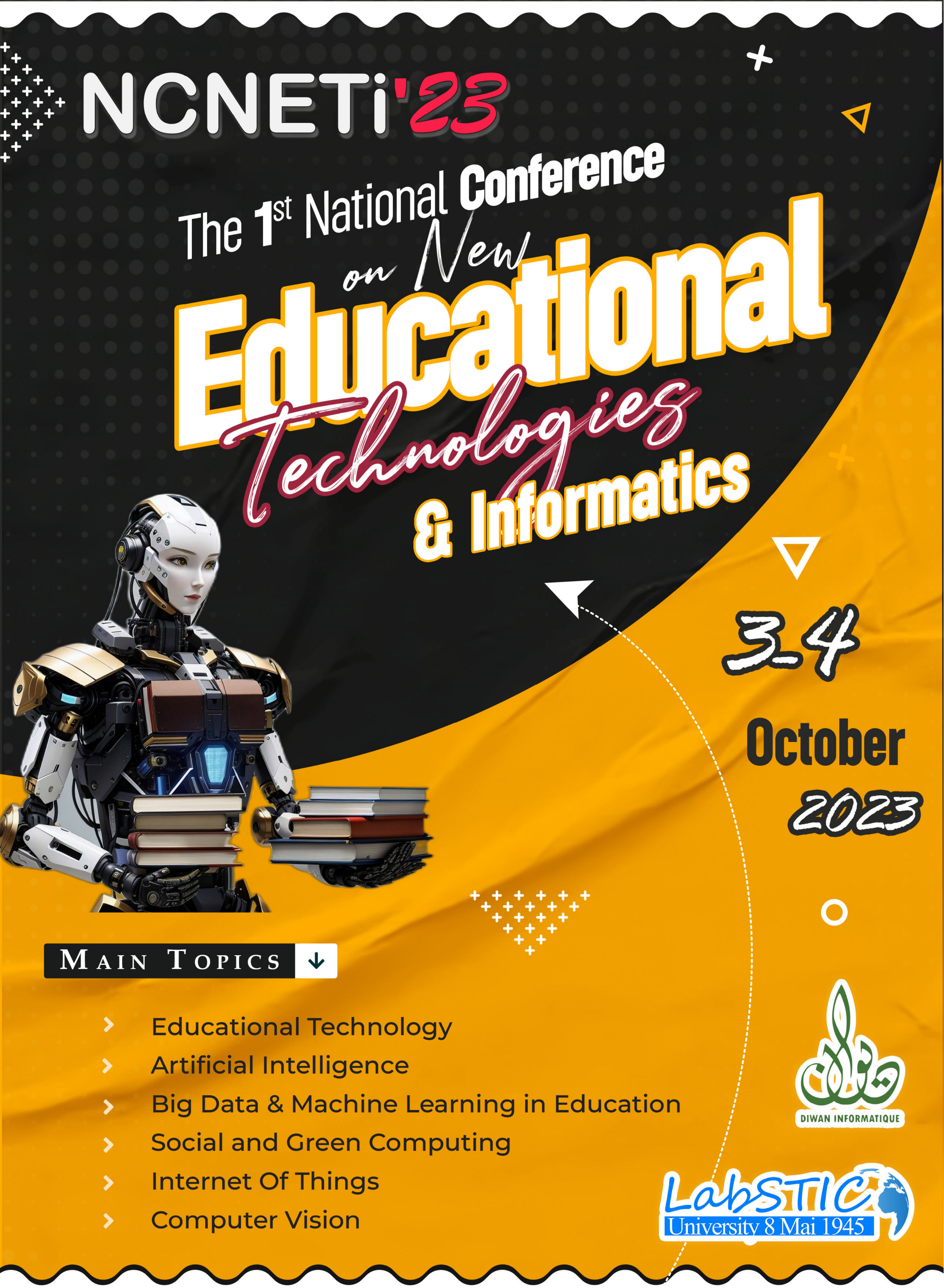
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