4th International Conference

MAiTRI SUMMIT 2026

MAchine inTelligence for Research & Innovations

May 8 - 9, 2026

पूर्वोत्तर क्षेत्रीय विज्ञान और प्रौद्योगिकी संस्थान, निरजुली, ईटानगर, अरुणाचल प्रदेश, भारत

North Eastern Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh, INDIA



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SOUVENIR cum Book of Abstracts

Editors

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Dr. Kurmendra
Prof. Luis Martínez López
Dr. Himanshu Gupta
Dr. Om Prakash Verma
Dr. Tarun K. Sharma

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MAchine inTelligence for Research & Innovations (MAiTRI2026)

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North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Itanagar, Arunachal Pradesh, India

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Dear Participants and Researchers,

Welcome to the book of abstracts for MAiTRI2026! In this compilation, we embark on a journey through the diverse realms of soft computing, exploring its profound importance in addressing real-life challenges.

The aim of MAiTRI2026 summit is to promote the research advancement in the theory and realization of Machine inTelligence covering topics such as Machine Learning, Deep Learning, Quantum Machine Learning, Real-time Computer Vision, Pattern Recognition, Natural Language Processing, Statistical Modeling, Autonomous Vehicles, Human Interfaces, Computational Intelligence, and Robotics. The International Conference is a one of the leading international conferences dedicated to bringing together a significant number of diverse scholarly events for presentation within the conference program. Events will run over a span of time during the conference depending on the number and length of the presentations. With its high quality, it provides an exceptional value for students, academics and industry researchers.

International Conference on MAiTRI aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Applications of Machine InTelligence for Research & Innovations include the development and demonstration of Intelligent and Autonomous Robots (IAR), Unmanned Aerial Vehicle (UAV), Autonomous Underwater Vehicle (AUV), autonomous water surface vehicles (ASVs), Autonomous Land Vehicles (ALV), Swarm Robots, Humanoid Robots, and Autonomous Household Robots.

As you peruse these abstracts, envision the tangible impact of Machine Learning in versatile domains. Witness how these techniques transcend mere theory, actively contributing to solutions for societal challenges.

We extend our deepest appreciation to the contributors whose research showcased here represents a collective effort to bridge the gap between theoretical brilliance and practical application. Together, we forge a path towards a future where soft computing plays an integral role in shaping a smarter, more adaptive world.

Thank you for being a part of this journey.

Best Regards,

Conference Organizing Committee



MAchine inTelligence for Research & Innovations (MAiTRI2026) is now **Four years** International conference.

The **objective of MAiTRI** is to provide a common platform to researchers, academicians, scientists and industrialists working in the area of machine learning to share and exchange their views and ideas on the theory and application of soft computing techniques in multi-disciplinary areas.

The **aim of the conference** is to highlight the latest advances, problems and challenges and to present the latest research results in the field of soft computing with a link to scientific research and its practical implementation. MAiTRI especially encourages the young researchers at the beginning of their career to participate in this conference and invite them to present their work on this platform.

Previous MAiTRI conference was successfully organized at the following venue

MAiTRI2023:	Dr. B R Ambedkar NIT, Jalandhar, India.	(September 1 - 3, 2023)
MAiTRI2024:	NIT Srinagar, Jammu & Kashmir, India.	(June 21 – 23, 2024)
MAiTRI2025:	KIIT Bhubaneshwar, Odisha, India.	(August 1 – 2, 2025)

4th in the series, MAiTRI2026 held at North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Itanagar, Papum Pare district, in the Indian state of Arunachal Pradesh, India, INDIA in hybrid mode during May 8 – 9, 2026.

MAiTRI2026 is organized in technical collaboration with Dr B R Ambedkar NIT, Jalandhar, Punjab, India; Shobhit University Gangoh and Science, Technology, Engineering and Management (STEM) – Research Society.

The conference had 8 keynote lectures presented by eminent academicians and practitioners from different parts of the world. Totally, 92 technical papers under 12 different themes of the conference were presented during the conference in 18 oral presentation sessions. We are thankful to Springer Plc., for giving us opportunity to publish the proceedings in Lecture Notes in Networks and Systems (LNNS). All papers submitted to MAiTRI2026 had undergone a peer-review process and subsequently revised before being finally accepted.

The credit of the success of the MAiTRI Series, goes to our Mentors, Keynote & Invited Speakers, Chief Guests, Guest of Honor(s), Members of the advisory board (National & International), Program Committee members, Springer Team as a publishing partner (in particular Mr. Aninda Bose, Executive Editor – Interdisciplinary Applied Sciences; Research Publishing – Books), all the Author(s), participants and the reviewer's board. We sincerely appreciate your continued support, encouragement and trust in us. We look forward to have this wonderful support in the coming MAiTRI Series as well.

Looking forward to have your significant contribution in MAiTRI Series.



Message from the Conveners

Dear Colleagues and Distinguished Participants,

It is with great pleasure and enthusiasm that we welcome you to the Fourth International Conference on Machine Intelligence for Research & Innovations (MAiTRI2026), to be held at the North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Itanagar, Papum Pare district, in the Indian state of Arunachal Pradesh, India, INDIA in hybrid mode during May 8 – 9, 2026.

Following the success of the inaugural MAiTRI conference, we are excited to once again bring together leading researchers, academics, and industry professionals from around the globe to discuss and explore the latest advancements in machine intelligence. Our conference aims to foster an environment of knowledge sharing, collaboration, and innovation, pushing the boundaries of research and practical applications in this dynamic field.

MAiTRI2026 promises an engaging program, featuring keynote speeches from world-renowned experts, insightful panel discussions, and presentations of cutting-edge research. Attendees will have the opportunity to network with peers, gain insights into emerging trends, and explore potential collaborations. The conference will cover a diverse range of topics, including but not limited to artificial intelligence, machine learning, data science, robotics, and their applications across various industries.

We are honored to host this prestigious event in the picturesque region of Arunachal Pradesh, known for its rich cultural heritage and breathtaking natural beauty. We hope that you will not only benefit from the academic and professional interactions but also take the time to enjoy the serene landscapes and warm hospitality that Srinagar has to offer.

We extend our heartfelt gratitude to the organizing committee, sponsors, and all participants for their contributions and support in making MAiTRI2026 a successful and memorable event. We look forward to your active participation and to a stimulating and enriching conference experience.

Warm regards,

Conveners, MAiTRI2026



Invited Talks



Prof. (Dr.) Xiao-Zhi Gao
School of Computing, Faculty of Science, Forestry and Technology
University of Eastern Finland, Finland

Prof. Xiao-Zhi Gao received his B.Sc. and M.Sc. degrees from the Harbin Institute of Technology, China in 1993 and 1996, respectively. He obtained his D.Sc. (Tech.) degree from the Helsinki University of Technology (now Aalto University), Finland in 1999. He is now working as a professor of data science at the University of Eastern Finland, Finland. Prof. Gao has published more than 500 technical papers on refereed journals and international conferences, and his current Google Scholar H-index is 55. His research interests are nature-inspired computing methods (e.g., neural networks, fuzzy logic, evolutionary computing, swarm intelligence, and artificial immune systems) with their applications in optimization, data mining, machine learning, networking, control, signal processing, and industrial electronics.



Prof. (Dr.) Samarendra Dandapat
Department of Electronics and Electrical Engineering
Indian Institute of Technology Guwahati
Guwahati, Assam, India

Prof. Samarendra Dandapat is a distinguished Professor (HAG) in the Department of Electronics and Electrical Engineering at IIT Guwahati, where he has been a faculty member since 1997. An alumnus of IIT Kanpur (Ph.D.) and IIT BHU (M.Tech), his expertise lies at the intersection of Biomedical Signal Processing and Medical Image Computing, with a focus on cardiovascular signals and AI-driven healthcare diagnostics. Beyond his research, which includes over 200 published papers, he has been a pivotal administrative leader, serving as the Dean of Administration at IIT Guwahati and the Founder Dean of IIT Patna. He currently leads the Center for Sports and Healthcare Engineering, bridging advanced engineering with medical technology.





Mr. Aninda Bose
Executive Editor
Interdisciplinary Applied Sciences, Computational Intelligence, Energy
Springer Nature London

Mr. Bose is presently working as Executive Editor with Springer Nature. Mr. Bose is part of the Global Acquisition Team at Springer Nature and responsible for acquisition of scientific content across the globe. He is responsible for acquisition of content in Interdisciplinary Applied Sciences. He has more than 26 years of industrial experience in marketing and different fields of publishing. Mr. Bose has completed Masters in Organic Chemistry from Delhi University and Masters in Marketing Research from Symbiosis Institute of Management Studies, Pune. Mr. Bose has delivered more than 160 invited talks on Scientific Writing and Publishing Ethics in reputed Universities, International Conferences and Author Workshops. He has published books for secondary level in Chemistry and is a member of American Chemical Society, USA.



Prof. Nilanjan Dey
Department of Computer Science and Engineering,
Techno International New Town, Kolkata, India.
Visiting Fellow, WC Laboratory,
Department of Biomedical Engineering, University of Reading, UK.

Prof. Nilanjan Dey (Senior Member, IEEE) received the B.Tech., M.Tech. in information technology from West Bengal University of Technology and Ph.D. degrees in Electronics and Telecommunication Engineering from Jadavpur University, Kolkata, India, in 2005, 2011, and 2015, respectively. Currently, he is Professor with the Techno International New Town, Kolkata and a visiting fellow of the University of Reading, UK. He has authored over 380 research articles in peer-reviewed journals and international conferences, and 40 authored books. His research interests include medical imaging and machine learning. Moreover, he actively participates in program and organizing committees for prestigious international conferences, including World Conference on Smart Trends in Systems Security and Sustainability (WorldS4), International Congress on Information and Communication Technology (ICICT), International Conference on Information and Communications Technology for Sustainable Development (ICT4SD) etc. He is also the Editor-in-Chief of International Journal of Ambient Computing and Intelligence, Associate Editor of IEEE Transactions on Technology and Society and series Co-Editor of Springer Tracts in Nature-Inspired Computing and Data-Intensive Research from Springer Nature and Advances in Ubiquitous Sensing Applications for Healthcare from Elsevier etc. Furthermore, he



was an Editorial Board Member of Complex & Intelligence Systems, Springer, Applied Soft Computing, Elsevier and he is an Editorial Board Member of IEEE Data Descriptions, International Journal of Information Technology, Springer, International Journal of Information and Decision Sciences etc. He is a Fellow of IETE and member of IE, ISOC etc.



Dr. Koushik Guha
Department of Electronics & Communication Engineering
National Institute of Technology Silchar

Dr. Koushik Guha is an Associate Professor and Head of the Department of Electronics and Communication Engineering at National Institute of Technology Silchar, Assam, India. He received his B.Tech. degree in Electronics and Communication Engineering from Techno India under West Bengal University of Technology, India, and his M.Tech. degree in Elec-tronics and Communication Engineering (RF & Microwaves) from The University of Burdwan, West Bengal, India. He obtained his PhD from National Institute of Technology Silchar with a doctoral thesis titled "Design and Modeling of RF MEMS Shunt Switch." Recently, he has also been appointed as a Visiting Professor at University of Trento, Italy. His research interests include MEMS/NEMS, Bio-MEMS, medical instrumentation, smart sensing systems, energy harvesting, IoT sensors, and VLSI design. He has published over 200 research papers in reputed international journals and conferences, authored five books and more than 45 book chapters, and holds seven patents. Dr. Guha has successfully led and executed several national and international research projects funded by Department of Science and Technology and Department of Biotechnology, along with international collaborations with institutions in Italy, Tyndall National Institute (Ireland), and Indo-Russia joint research programmes. Under the Ministry of Electronics and Information Technology funded Chip-to-Startup (C2S) programme, his team co-developed a neural amplifier front-end IC for brain–machine interface applications, which was recognised among the Top 20 "Made in India" chips un-veiled by the Hon'ble Prime Minister of India, Narendra Modi, during SEMICON India 2025. Dr. Guha has received several prestigious recognitions including the Distinguished Faculty Award 2021, the IETE R. S. Khandpur Award 2022, and the ISSS–IISc Young Scientist Award 2021. He is a Senior Member of IEEE, Senior Member of INAE, and Fellow of IETE. He also serves as Associate Editor of Microsystem Technologies (Springer Nature), Editor of IETE Journal of Research (Taylor & Francis), and a member of the Editorial Board of Scientific Reports (Springer Nature). Dr. Guha has inspired and nurtured a strong passion for research among students and faculty. He currently leads the National MEMS Design Centre at National Institute of Technology Silchar and, as Head of the Department of Electronics and Communication Engineering, has been instrumental in strengthening the department's research ecosystem, international collaborations, and global academic visibility. Under his leadership, the department has witnessed significant academic and research progress and continues to emerge as a strong contributor to cutting-edge research in electronics, MEMS, and interdisciplinary technologies.





Dr. Rajeev Kanth
Principal Lecturer (Yliopettaja- in Finnish)
Savonia University of Applied Sciences, Finland

Dr. Rajeev Kanth received a Doctor of Science (D.Sc.) in Information and Communication Technology from the University of Turku, Finland, in 2013. He has been working as a Principal Lecturer (Yliopettaja- in Finnish) at the Savonia University of Applied Sciences, Finland, where he focuses on teaching and research on the Internet of Things (IoT). He has been an Adjunct Professor at the Department of Computing, University of Turku, Finland, and a Visiting Professor at Hebei University of Environmental Engineering, China. He is currently a senior member of the IEEE. Previously, he worked at the Indian Space Research Organization (ISRO), Ahmedabad, India, and the Royal Institute of Technology (KTH), Stockholm, Sweden, where he was a researcher and a senior research scientist, respectively. He has over 25 years of experience working in academic and research institutions. His current research interests include the Internet of Things, big-data analytics, artificial intelligence, and wireless cloud and edge computing. He has published more than 95 scientific articles in peer-reviewed conference proceedings and refereed computer science and communication technology journals. Some of the recent and ongoing research and development projects are UCNDRONE (funded by the Finnish Ministry of Education), VLEFACT (EU Erasmus Plus-funded project), and AIQUSEC (Business Finland).



. **Dr. Manoj Kumar**
Department of Electronics Engineering
Indian Institute of Technology (IIT), Dhanbad

Dr. Manoj Kumar is currently an Assistant Professor in the Department of Electronics Engineering at the Indian Institute of Technology (Indian School of Mines), Dhanbad. Before joining IIT(ISM), Dhanbad, he completed his PhD in Electrical Engineering from IIT Delhi and his M.Tech in Electrical Engineering from IIT Kanpur. His current research interests include graph machine learning, graph coarsening, optimization algorithms, KV Caching Compression, and federated learning. He has published papers in top-tier AI/ML conferences and journals, including ICML, JMLR, TMLR, ACM TKDD, UAI, WWW, MICCAI, NeurIPS, and others.





Dr. Deepak Gupta
Research Scientist, National Library of Medicine (NLM),
National Institutes of Health (NIH), USA

Dr. Deepak Gupta is a Research Scientist at the National Library of Medicine, part of the National Institutes of Health, USA. His work focuses on developing AI systems for healthcare, particularly at the intersection of natural language processing and multimodal learning. He is interested in how machines can better understand and generate medical information for consumers by combining signals from text, images, and video. His research has explored problems such as medical question answering, evidence-grounded generation, and multimodal reasoning, with the goal of making AI systems more reliable and useful for real-world healthcare and scientific applications. He has published in leading conferences such as ACL, EMNLP, and COLING, as well as journals including Knowledge-Based Systems, Expert Systems with Applications, the Journal of Biomedical Informatics, and Scientific Data. In addition to his research contributions, he is actively involved in the broader research community. He has served in organizational and leadership roles, including as an Area Chair for conferences such as COLING and LREC, and has chaired sessions at venues like International Conference on Artificial Intelligence in Medicine. He is also a lead organizer of the CL4Health workshop and has contributed to advancing community efforts in biomedical NLP and AI.



Dr. Firos A
Department of Computer science and Engineering
Rajiv Gandhi (Central) University, Doimukh, Arunachal Pradesh

Dr. Firos A is an Associate Professor in the Department of Computer Science and Engineering at Rajiv Gandhi University, Arunachal Pradesh, India, where he has been serving since 2010. Prior to his academic career, he gained industry experience working in multinational companies (MNCs) in roles such as Software Developer, which provided him with strong practical insights into real-world computing systems. His research interests include Fuzzy Logic, Artificial Intelligence, Machine Learning, Data Science, and their applications in decision-making and smart systems. He has authored more than 100 research publications indexed in SCI, Scopus, UGC CARE, and other peer-reviewed journals, reflecting his significant academic contributions. He is a Senior Member of IEEE and a Member of IEI, highlighting his professional recognition and engagement with leading



engineering and technology communities. In addition to his publication record, he has actively contributed to the academic community as a member of editorial boards and as a participant in numerous conferences and seminars. His work spans interdisciplinary domains such as decision-making systems, cybersecurity, and cloud computing, and he is also actively involved in various research projects. Furthermore, he has supervised over 40 students across undergraduate, postgraduate, and PhD programs, demonstrating his commitment to teaching, mentorship, and academic excellence.



Dr. Om Prakash Verma
Department of Instrumentation and Control Engineering
Dr. B. R. Ambedkar NIT Jalandhar
Punjab, India

Dr. Om Prakash Verma is presently associated with Dr. B R Ambedkar National Institute of Technology Jalandhar, Punjab, India since January 2018 as an Assistant Professor in the Department of Instrumentation and Control Engineering. He has almost 11 years of teaching experience. He did his Ph.D. from IIT Roorkee, M.Tech. from Dr. B R Ambedkar NIT Jalandhar and B.E. from Dr. B R Ambedkar University Agra. He is presently working on ISRO Sponsored Project as a PI. He has edited a book on Soft Computing: Theories and Applications and has been a potential reviewer of several International Journals of high repute. He has published more than 30 research papers in SCI/Scopus/ESI indexed Journals. He has published recently published a paper in Renewable & Sustainable Energy Reviews, (IF: 12.110). He has guided 4 M.Tech Students and supervising 6 PhD Students.





Message from the Director, NERIST

It gives me immense pleasure to extend my warm greetings to all participants, distinguished speakers, researchers, academicians, and industry professionals attending the **4th International Conference on MAchine inTelligence for Research & Innovations (MAiTRI-2026).**

I am particularly delighted to witness the growing application of Artificial Intelligence (AI) and Machine Learning (ML) across diverse domains, ranging from agriculture and healthcare to communication systems and smart infrastructure. Such advancements highlight the transformative potential of intelligent technologies in addressing real-world challenges and driving sustainable development.

The North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Arunachal Pradesh stands as a premier institution dedicated to the advancement of technical education and research in the North Eastern region of India. Serving as a vital academic and innovation hub, NERIST plays a crucial role in empowering the youth of the North Eastern states by providing quality education, promoting research tailored to regional needs, and addressing challenges related to infrastructure, connectivity, and sustainable development. Through its continuous efforts, the institute significantly contributes to the socio-economic growth and technological progress of the region.

I commend the Department of Electronics and Communication Engineering and the organizing committee for their dedicated efforts in organizing this international event. Such initiatives greatly enrich the academic environment and strengthen collaborative research endeavors.

I am confident that MAiTRI-2026 will lead to meaningful discussions, inspire new ideas, and create opportunities for impactful collaborations. I encourage all participants to actively engage in the sessions and make the most of this valuable platform.

I extend my best wishes for the grand success of the conference and hope it leaves a lasting impact on all participants.

With best wishes,

Prof. Narendranath S
Director, NERIST

DIRECTORATE OF RESEARCH :: ASSAM VETERINARY AND FISHERY UNIVERSITY
KHANAPARA :: GUWAHATI-781022



Message from the Guest of Honour

I am pleased to be associated with the *4th International Conference on Machine Intelligence for Research & Innovations (MAiTRI-2026)* and extend my warm greetings to the organizers, participants, and distinguished delegates.

In recent years, the rapid advancement of Artificial Intelligence and Machine Learning has significantly transformed the landscape of research and innovation. Their growing applications across agriculture, veterinary sciences, and allied sectors are enabling data-driven decision-making, improving disease diagnostics, optimizing resource utilization, and strengthening sustainable rural livelihoods. Such technological interventions are particularly relevant for regions like the North East India, where context-specific solutions can bring substantial socio-economic impact.

As a representative of Assam Veterinary and Fishery University, I strongly believe that interdisciplinary collaboration between engineering, life sciences, and agricultural domains is essential to translate emerging technologies into practical, field-level solutions. Platforms like MAiTRI-2026 play a crucial role in fostering such collaborations, encouraging knowledge exchange, and inspiring young researchers to address real-world challenges.

I commend the Department of Electronics and Communication Engineering, NERIST, and all associated partners for organizing this important conference and creating an avenue for meaningful academic and research interactions. I am confident that the deliberations and outcomes of this conference will contribute significantly to innovation-driven development.

I extend my best wishes for the grand success of MAiTRI-2026.

30/4/2026

(**Probodh Borah**)
Director of Research
Assam Veterinary and Fishery University
Khanapara, Guwahati-781 022



Message from the Dean (Academic), NERIST

It gives me great pleasure to extend my greetings to all participants of the *4th International Conference on Machine Intelligence for Research & Innovations (MAiTRI 2026)*, being organized at the North Eastern Regional Institute of Science and Technology (NERIST).

As an institution committed to academic excellence, NERIST continuously strives to foster an environment that encourages innovation, critical inquiry, and interdisciplinary learning. The MAiTRI conference series has evolved into a significant academic platform for the dissemination of knowledge and the exchange of ideas across diverse domains of science and engineering.

The theme of MAiTRI 2026, centered on Machine Intelligence, highlights the transformative potential of technologies such as Artificial Intelligence, Internet of Things (IoT), and intelligent healthcare systems. These emerging areas are redefining the boundaries of research and innovation, enabling solutions to complex societal and technological challenges.

The *Book of Abstracts* reflects the academic rigor, diversity, and relevance of the research contributions received from participants across institutions. It is encouraging to witness the enthusiastic participation of researchers, academicians, and students contributing to this scholarly endeavor.

I commend the organizing committee for their dedicated efforts in successfully organizing this conference. I also extend my best wishes to all participants for a fruitful and intellectually enriching experience.

Prof. Sarsing Gao
Dean (Academic)
NERIST



Message from the Dean (Research & Development), NERIST

It is a matter of great pleasure to see that the Department of Electronics and Communication Engineering, North Eastern Regional Institute of Science and Technology (NERIST, is organizing *4th International Conference on Machine Intelligence for Research & Innovations (MAiTRI 2026*)

In the present era, Machine Intelligence has emerged as a cornerstone of research and technological advancement. The convergence of Artificial Intelligence, IoT, data analytics, and intelligent healthcare systems is enabling innovative solutions to address real-world challenges across diverse sectors, like healthcare, agriculture, environmental monitoring, and smart infrastructure.

The MAiTRI conference series has consistently provided a dynamic platform for fostering interdisciplinary collaboration and promoting high-quality research. The fourth edition continues this legacy by bringing together leading researchers, academicians, and industry experts to share their insights and advancements.

I extend my heartfelt congratulations to the Department and the organizing committee for hosting **MAiTRI2026** and for publishing the abstract proceedings.

Prof. Madhu Bala Sharma
Dean (Research & Development)
NERIST



Message from the HoD ECE

It gives me great pleasure to announce that the Department of Electronics and Communication Engineering, North Eastern Regional Institute of Science and Technology (NERIST), is organizing the 4th International Conference on Machine Intelligence for Research and Innovation (MAITRI 2026) on 8th and 9th May 2026.

In the present era of rapid technological advancement, machine intelligence has emerged as a key enabler across diverse domains, including communication systems, signal processing, automation, and intelligent decision-making. MAITRI 2026 aims to provide a vibrant platform for researchers, academicians, industry professionals, and students to share their insights, exchange ideas, and present innovative research findings in these emerging areas.

The conference is envisioned to foster collaboration and promote interdisciplinary research, bringing together experts from across the globe to deliberate on contemporary challenges and future directions in machine intelligence and allied fields.

I sincerely appreciate the dedicated efforts of the organizing committee, faculty members, and student volunteers who have worked tirelessly to make this event possible. I also extend my gratitude to all authors, speakers, and participants for their valuable contributions and enthusiastic participation.

I am confident that MAITRI 2026 will be a great success and will significantly contribute to advancing research and innovation in the field of Electronics and Communication Engineering.

I warmly welcome all the participants and extend my best wishes for a productive and enriching conference.

Prof. Joyatri Bora Hazarika
HoD and General Chair, MAiTRI2026
Department of Electronics and Communication Engineering (ECE)
North Eastern Regional Institute of Science and Technology (NERIST)



Message from the Organizing Chair

It is my distinct honor and privilege to welcome you to the *MAiTRI 2026 International Conference*, being organized at the North Eastern Regional Institute of Science and Technology (NERIST).

MAiTRI 2026 is conceived as a multidisciplinary platform that fosters rigorous academic discourse and promotes cutting-edge research across domains such as Artificial Intelligence, Internet of Things (IoT), healthcare technologies, data science, and emerging interdisciplinary fields. The conference aims to address contemporary scientific and societal challenges through innovative, technology-driven solutions, with a particular emphasis on sustainable and inclusive development.

The integration of intelligent systems, connected devices, and advanced computational methodologies is rapidly transforming sectors including healthcare, environmental monitoring, agriculture, and smart infrastructure. In this context, MAiTRI 2026 endeavors to facilitate meaningful interactions among researchers, academicians, industry experts, and practitioners, thereby catalyzing collaborative research and translational innovation.

This *Book of Abstracts* represents a curated compilation of scholarly contributions that reflect both the depth and diversity of ongoing research efforts. Each submission has undergone a careful review process to ensure academic rigor and relevance to the conference themes. The volume stands as a testament to the commitment of the research community toward advancing knowledge and developing impactful solutions.

I extend my sincere appreciation to all contributing authors for their valuable research contributions, to the reviewers for their meticulous evaluation, and to the members of the organizing and technical committees for their unwavering dedication and professionalism. I also gratefully acknowledge the support of our sponsors and institutional collaborators.

I am confident that MAiTRI 2026 will serve as a significant forum for intellectual engagement, knowledge exchange, and the initiation of future research collaborations. I wish all participants a highly productive and enriching experience.



Dr. Chitranjan Kumar Rai
Organizing Chair, MAiTRI 2026
Assistant Professor,
Department of Electronics and Communication Engineering (ECE)
North Eastern Regional Institute of Science and Technology (NERIST)



Message from the Organizing Chair

It gives me immense pleasure to welcome you to the **4th International Conference on MAchine inTelligence for Research & Innovations (MAiTRI 2026)**, hosted at the North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Arunachal Pradesh.

MAiTRI 2026 serves as a dynamic platform that brings together researchers, academicians, industry professionals, and students to exchange ideas and explore emerging trends in machine intelligence and its diverse applications. In today's rapidly evolving technological landscape, advancements in artificial intelligence and related domains are playing a transformative role across sectors, and this conference aims to foster meaningful discussions and collaborations in these areas.

The enthusiastic participation from contributors across the country and abroad reflects the growing significance of interdisciplinary research and innovation. The conference has been carefully designed to encourage knowledge sharing, promote scientific dialogue, and provide opportunities for networking among participants from varied backgrounds.

Organizing an event of this scale is a collective effort. I extend my sincere appreciation to all authors, reviewers, speakers, session chairs, and members of the organizing team for their dedication and support. I also gratefully acknowledge the encouragement and guidance from the institute authorities and partner organizations.

I am confident that MAiTRI 2026 will provide an enriching experience to all participants and will contribute to advancing research and innovation for the benefit of society.

I wish the conference great success and hope that it leads to impactful outcomes and lasting collaborations.

(Dr. Kurmendra)
Organizing Chair, MAiTRI 2026

Mentor(s):	**Prof. Leo Joskowicz** **Director, CASMIP Lab, Hebrew University of Jerusalem, Israel** **Prof. Sankar Kumar Pal** National Science Chair, GoI; President, ISI; Distinguished **Scientist** and Former Director **Prof. Ajit K. Verma** Western Norway University of Applied Sciences, Norway **Prof. C. W. Ahn** GIST, South Korea
Chief Patron:	**Prof. Narendranath S.** Hon'ble Director, North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Arunachal Pradesh
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Organizing Chair(s):	**Dr. Chitranajan Kumar Rai** Department of Electronics & Communication Engineering, NERIST, Nirjuli, Arunachal Pradesh **Dr. Kurmendra** Department of Electronics & Communication Engineering, NERIST, Nirjuli, Arunachal Pradesh **Dr. Om Prakash Verma** Dept. of ICE, NITJ **Dr. Tarun K. Sharma** Shobhit University Gangoh
Organizing Secretary:	**Prof. Rajesh Kumar** Department of Electronics & Communication Engineering, NERIST, Nirjuli, Arunachal Pradesh **Dr. Ashok Kumar Ray** Department of Electronics & Communication Engineering, NERIST, Nirjuli, Arunachal Pradesh **Dr. Jitendra Rajpurohit** Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune **Dr. Deepak Panwar**



MAiTRI2026 ORGANIZING TEAM

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325	SPOT-Based Active Learning for Efficient Deep Neural Network Training in Cybersecurity Threat Detection	Aditya Raj (SRM Institute of Science and Technology)*; Devyash Jain (SRM Institute of Science and Technology, Ramapuram Campus); Syed Furqan Ahmad Razvi (SRM Institute of Science and Technology, Ramapuram Campus); Sathya Priya S. (SRM Institute of Science and Technology, Ramapuram Campus)
326	MSTAN: Multi-Task Spatio-Temporal Attention Network for Student Engagement Behaviour Detection in Online Learning	Atharva Jamdar (COEP Technological University)*
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332	Design and Analysis of Intelligent Fractional Order PID Controller in Speed Control of DC Motor Using Metaheuristic Algorithm	Hrishikesh Sarma (University of Science and Technology Meghalaya)*; Palash Mukul Das (University of Science and Technology Meghalaya); Priyanko Protim Gohain (University of Science and Technology Meghalaya)
337	Deep Machine Learning-Driven Intrusion Detection with a Statistically-Robust Three-Stage Feature Selection	Raghupathi Manthena (VNRVJIET); Radhakrishna Vangipuram (VNRVJIET)*



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338	Local Interpretable Model-Agnostic Explanation Based Feature Selection for Detection of High-rate and Low-rate Network Attacks	Eswar Sai Singh Rajput (VNRVJIET); Radhakrishna Vangipuram (VNRVJIET)*; Sravan kiran Vangipuram (VNRVJIET); Sreenivasa Rao Annaluri (VNRVJIET); Peram Prashanthi (CMR Engineering College); Swetha Gottiparthy (CMR Engineering College)
339	Safety Assistance and Guidance Engine	Arijit Dutta (Symbiosis Institute of Technology, Pune)*; Ravi Kumar Sharma (Symbiosis Institute of Technology, Pune); Devank Upadhyaya (Symbiosis Institute of Technology, Pune); Amit Shrikar Vuppuluri (Symbiosis Institute of Technology, Pune); Arnav Bhardwaj (Symbiosis Institute of Technology, Pune); Amol Dhumane (Symbiosis Institute of Technology, Pune)
343	Deep Learning-Based Deep fake Image Detection using Transfer Learning and Hybrid Architecture	AMOL DHUMANE (SYMBIOSIS INSTITUTE OF TECHNOLOGY, PUNE); Jitendra Rajpurohit (SYMBIOSIS INSTITUTE OF TECHNOLOGY, PUNE)*; Priyanka Paygude (Bharati Vidyapeeth); priya shelke (VIT Pune); parikshit mahalle (vit); Tarun Sharma (Shobhit University)
344	Mutation Analysis of Human Deoxyhaemoglobin (PDB: 4HHB) with Machine Learning and Structural Biology	Priya Shelke (Vishwakarma Institute Of Information Technology)*; Anish Takawale (Vishwakarma Institute of Information Technology, Pune, India); Shravani Pande (Vishwakarma Institute of Information Technology, Pune, India); Manjiree Sanap (Vishwakarma Institute of Information Technology, Pune, India); Amol Dhumane (Vishwakarma Institute of Information Technology, Pune, India); Jitendra Rajpurohit (Symbiosis)
349	Multimodal Stress Detection and Adaptive Music Recommendation via Hybrid Audio-Visual Signal Fusion	Sampa Das (New Horizon College of Engineering)*; Thiruvikram Karthikeyan (New Horizon College of Engineering); Arijit Datta (SRM University-AP); Pragati Tripathi (New Horizon College of Engineering Bengaluru)



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350	Performance Analysis of Repairable Water Purification System	Shruti Gupta (Poornima Institute of Engineering and Technology, Jaipur-302022, Rajasthan); Ajay Kumar (Raffles University, Neemrana, Rajasthan)*; Poonam Rani (Electrical Engineering, Skill Department of Green Technology, SFET, Shri Vishwakarma Skill University, Palwal-121102, Haryana); Vandana Swami (Raffles University, Neemrana, Rajasthan); Mohit Yadav (University Institute of Sciences, Chandigarh University, Mohali-140413, Punjab); Krishan Kant Sharma (University Institute of Engineering, Chandigarh University, Mohali-140413, Punjab)
353	Deepfake Detection in Multilingual Indian Videos	Aryan rana (sharda university)*; Devanshi Sharma (Sharda university); Saransh Aggarwal (Sharda university); Gaurav Raj (Sharda university)
354	An Interpretable Ensemble Learning Framework for Cardiovascular Risk Prediction Using Explainable AI	Kaustubh Khandelwal (Manipal Institute of Technology)*; Himanshu Gupta (Manipal Institute of Technology); Arul Elango.G (Manipal Institute of Technology)
364	Self-Supervised Contrastive Multimodal Graph Transformer For Financial Time-Series Prediction	KIRAN S (SRM Institue of Science and Technology)*; Surya Prakash B M (SRM Institue of Science and Technology); Keshore T (SRM Institue of Science and Technology)
367	A Comparative Study of Machine Learning Models for Cardiovascular Disease Prediction with Feature Engineering	Y Shireesha Gowda (Manipal Institute of Technology, Manipal)*; Himanshu Gupta (Manipal Institute of Technology, Manipal)
368	A Multi-Class Parasite Detection Framework in Blood Smears Using EfficientNet-B3 and Multi-Phase Fine-Tuning	Adwait Devadas (SRMIST); Abhinav S (SRMIST)*; Svadhit S (SRMIST); Subashis Mete (SRMIST); J Jospin Jeya (SRMIST)
370	Analysis of IoT-based Smart Fire Detection System	Mohit Yadav (Department of Mathematics, University Institute of Sciences, Chandigarh University, Mohali-140413, Punjab, India)*; Shubham Dalal (Department of Computer Science Engineering, University Institute of Engineering, Chandigarh University, Mohali-140413, Punjab,India); Himanshu Yadav (Department of Computer Science Engineering,



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371	A Lightweight Drone-Bird Detection Framework Using YOLOv11n with Enhanced Loss Optimization	Sahil Sandal (Dr B R Ambedkar National Institute of Technology, Jalandhar)*; Sourabh Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar); Om Prakash Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar)
372	AI-Driven Multi-Band Hyperspectral Framework for Non-Ferrous Metal Classification in E-Waste Recycling	Nilanshu Nilay (Dr B R Ambedkar National Institute of Technology, Jalandhar)*; Sourabh Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar); Om Prakash Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar)
374	A Hybrid Deep Learning Framework for Real-Time Network Intrusion Detection: Integrating CNN-LSTM, and Multi-head Self-Attention Mechanisms	Mohit Yadav (Department of Mathematics, University Institute of Sciences, Chandigarh University, Mohali-140413, Punjab, India)*; Shourya Gupta (Department of Computer Science Engineering, University Institute of Engineering, Chandigarh University, Mohali-140413, Punjab, India); Manit Patidar (Department of Computer Science Engineering, University Institute of Engineering, Chandigarh University, Mohali-140413, Punjab, India); Ajay Kumar (Department of Mathematics, School of Engineering &



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378	SMS Spam Detection in Bangla and Assamese Using Handcrafted Feature Engineering	Ramanujam Elangovan (National Institute of Technology Silchar)*; Ananya Das (National Institute of Technology Silchar); Aditya Sah (National Institute of Technology Silchar); Abirami A M (Thiagarajar College of Engineering)
379	Intelligent Career Guidance Systems: Integrating Generative AI, Skill Gap Analysis, and Hybrid Job Recommendations	Dr. Shiv Kant (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR)*; Dr. Aman Ahmad Ansari (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR); Faraz Ozair (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR); Wasim Akhter (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR); Mohd. Umar Khan (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR); Om Raikwar (Greater Noida Institute Of Technology (GNIOT), Greater Noida, Delhi/NCR)
380	Fixed-Size Chunking Outperforms Tuned Semantic Methods in QA Retrieval: A SQuAD Benchmark Study	Satyartha Shukla (Dr B R Ambedkar National Institute of Technology, Jalandhar)*; Shashank Shashank (Dr B R Ambedkar National Institute of Technology, Jalandhar); Sourabh Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar); Om Prakash Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar)



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381	Latency-Aware RAG: Characterizing the Tradeoff Between Retrieval Depth and Effectiveness	Shashank Shashank (Dr B R Ambedkar National Institute of Technology, Jalandhar)*; Satyartha Shukla (Dr B R Ambedkar National Institute of Technology, Jalandhar); Sourabh Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar); Om Prakash Verma (Dr B R Ambedkar National Institute of Technology, Jalandhar)



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16 Alzheimer's Disease Classification Using Deep Learning Based Attentional Models

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Aim: Alzheimer's Disease (AD) is a leading cause of dementia, where early detection is critical. Automating AD classification from structural MRI is challenging due to subtle brain changes and imbalanced clinical data.
Purpose: This paper proposes a novel deep learning architecture for AD classification on the OASIS-1 dataset. The model enhances a custom convolutional neural network with residual connections and Squeeze-and-Excitation (SE) attention, utilizing a focal loss function to address class imbalance. The proposed approach was benchmarked against pre-trained models, including DenseNet121, MobileNetV2, and VGG19.
Results: The proposed architecture achieved a classification accuracy of 99.98%, significantly outperforming the baseline models. Validated by confusion matrices and ROC curves, the method proves to be highly effective and stable.
Conclusion: While further studies are needed to address the heterogeneity of neuroimaging data for universal application, this work presents a promising step towards reliable, automated AD diagnosis.

19 Model Order Reduction of High-Order LTI Systems by Using Conventional and Optimization Methods

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Real-world dynamic systems often result in high-order mathematical models that are computationally intensive to analyze, simulate, and control. To facilitate efficient controller design and real-time implementation, it becomes necessary to obtain lower-order representations that retain the essential characteristics of the original system. In this paper, a hybrid Model Order Reduction (MOR) approach is proposed in which the denominator of the reduced model is formulated using pole clustering, ensuring stability and preservation of dominant dynamic modes. The numerator coefficients are then optimized using a Genetic Algorithm (GA) by minimizing the Integral Squared Error (ISE) between the unit step responses of the original and reduced models. This optimization ensures close time domain matching while maintaining numerical robustness. Simulation results demonstrate that the proposed method yields stable reduced-order models with significantly reduced computational complexity and minimal approximation error across first, second, and third order reductions.

20 A Clustering Algorithm to Reduce the Cost Function of LEACH-C in WSN — SRF Approach

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The Wireless Sensor Networks (WSNs) are essential in view of their wide range of applications, particularly in military and environmental monitoring. The optimized energy consumption improves data transmission efficiency in WSN. By proposing a centralized clustering technique for the LEACH protocol, which improves the consumption of energy for the WSN. The cost function is optimized using simulated annealing, reinforcement learning, and fuzzy



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logic. The results of Simulation show that the average energy usage of WSN is 30-40 percent lower than that of the LEACH protocol.

22 Soily: Crop Recommendation Using Satellite Imagery for Western Maharashtra with Machine Learning Algorithm

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Choosing the right crops for their farm is biggest problem for the farmers because of change in climates and lack of proper soil information. To overcome this problem, we have developed Soily – Crop recommendation system by using the digital soil mapping and satellite imagery for the western Maharashtra region temporarily. It collects real time soil data such as pH, NPK, organic carbon and moisture from sources like soilGrids and sentinel -2 satellites. The data is compared with the existing dataset which contains as same parameters of soils which are needed to predict the crop. Soily has other features like generating reports of recommended things and parameters of soil and also suggests which fertilizers should be used for that particular recommended crop. This will reduce the time for checking the soil contents manually, taking critical decision about choosing crops and will also help to enhance the agricultural productivity.

27 A Hybrid Retrieval-Augmented Generation Architecture for Context-Rich Dialogue Generation

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Big Models (LLMs) have become incredibly successful in natural language processing and natural language generation. Nevertheless, they are not applicable in knowledge-intensive areas due to the presence of hallucinations, where the answers sound natural but do not have a basis in facts. The Retrieval-Augmented Generation (RAG) solves this problem by basing the outputs of LLM on external knowledge bases. The majority of available RAG systems use mainly the semantic retrieval by vectors that tend to disregard the relational and structural context between documents. In this paper, Hybrid Retrieval-Augmented Generation (Hybrid RAG) acts as a framework which combines dense vector-based retrieval with graph-based relational retrieval to improve contextual consistency and factual accuracy in dialogue generation. The system proposed will consist of tools that merge semantic embeddings being kept in a vector database, and the knowledge graph traversal, after which a single prompt fusion strategy will be employed. A large number of experiments on a variety of datasets (resumes, technical documents, research papers and legal texts) have shown that the hybrid approach has significantly better



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BERTScore, semantic similarity, and ROUGE-L as well as more hallucinations are reduced. The results confirm the applicability of hybrid retrieval in constructing context-aware, dialogue-systems for chat-purposes.

39 An Intelligent Consensus-Based Droop Control Strategy for Robust Autonomous Microgrid Operation

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Presently, parallel-connected distributed generators (DGs) have been shown to be energy-efficient and sustainable in autonomous operation. Maintaining consistent, effective operations amid changing conditions is critical. Therefore, this work introduces a consensus-based droop control approach to address these concerns. The proposed approach helps parallel-connected distributed generators (DGs) work together to share power and maintain stable voltage levels. By adopting a consensus-based control strategy, all DG units follow a common reference value, which supports balanced load sharing and consistent voltage regulation. This coordination strengthens the system's overall stability and reduces short-term power mismatches caused by fluctuations in generation capacity. The simulation results presented in this study indicate that the consensus-driven droop control method can effectively improve the reliability and dynamic performance of autonomous microgrids.

43 Learning based models, Perspectives in Medical Imaging: A Comparative Analysis of Image Super Resolution

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In medical science, high-quality images are crucial for diagnosing various diseases. Nowadays, super-resolution is a significant step in this field, enabling us to understand diseases through improved images. Due to the irregular maintenance of the machines, the images are of poor quality, which worsens the patient's condition. In most cases of supervised learning, a paired dataset is not always available. Additionally, using different scanners can reduce generalisation capability, which leads to overfitting. To overcome these limitations, newer models have been explored, including weakly supervised, semi-supervised, and self-supervised. Some methods work only with unpaired datasets and show superior results, called unsupervised approaches. The present survey offers a comparative evaluation of different methods, emphasising their advantages, disadvantages, and clinical suitability beyond conventional benchmarks, with additional assessment metrics and practical concerns added to offer an in-depth comprehension of Image Super Resolution effectiveness to lead prospective studies in improving imaging for medical purposes workflows.



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45 Fostering Authentic Scholarship through Automated Scholastic Evaluation and AI-Driven Integrity Verification

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The possibilities surrounding generative AI's use in the classroom raise many issues concerning academic integrity and automated evaluation processes of assessment and the implications of these technologies. This paper provides one method of addressing these challenges through providing methods for validating authorship of assessment submissions and performing assessments of academic work through automated means. This paper presents one hybrid form of assessment, where semantic similarity and keywords-based assess-ments are employed to create a more scalable and unsophisticated assess-ment method than previous methods employed by educational institutions. To alleviate the challenges related to the enormity of the grading key that would need to be developed, consideration is given to a retrieval-augmented generation model to create more responsive and contextually-aware answers to questions by collecting and synthesizing the needed information from course material (such as textbooks and PDF files) that has been ingested into the system. Finally, aside from evaluating assessments, there is developing work utilizing AI in evaluating integrity by detecting instances of student ac-ademic misconduct (including, but not limited to, AI-assisted plagiarizing) through employing complex algorithms and analyses that have been and con-tinue to save time for evaluators, reduce manual effort by evaluators, and eliminate the potential of cheating within academia through the utilization of an expansive, automated, and unbiased approach to academic integrity.

52 Hybrid MedSeg Approach for Multi-Class Chest X-Ray Lung Pathology Detection with Quantitative Activation Analysis

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The accurate detection of multi-class lung disease based on the chest X-ray images has not yet been clinically solved because of the overlapping radiographic features, imbalance in classes, and lack of interpretability of the deep learning models. It is especially challenging to distinguish between Bacterial Pneumonia and Viral Pneumonia, Corona Virus Disease (COVID-19), Tuberculosis, and Normal lungs since subtypes of pneumonia have similar features of consolidation and opacity in most cases. The current methods often use single CNN models which have high accuracy, but lack explainability and class-wise discrimination. To cover these gaps, the current study suggests Hybrid MedSeg Framework, an explainable deep learning framework that combines transfer learning, discriminative feature extraction, and localization by Grad-CAM in the context of multi-class classification of lung pathology. The images were downsized to normalized input sizes and were subjected to deep convolutional layers to learn hierarchical features and then optimized classification layers. The model reached a total accuracy of 87.97% with high performance in COVID-19 (recall 98.9%), Normal (recall 98.9%) and Tuberculosis (precision 100.0%) and



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relatively low and stable performance in subclasses of pneumonia. Strong class separability and interpretability were confirmed using deep feature visualization (t-SNE), ROC, Precision-Recall analysis and ROI histogram profiling. The originality of the work is in the fact that it integrates classification, explainability, and analysis of the intensity of ROI in a single framework. The results show that it is a reliable, interpretable, and scalable automated lung disease screening solution.

57 Advancing Clinical Decision Support: SVM-Ensemble Models for Reliable Breast Cancer Detection

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The early detection of breast cancer is very important in ensuring better treatment outcomes. This study examines the performance of various machine learning algorithms in the diagnosis of breast cancer based on the University of California, Irvine (UCI) Wisconsin Diagnostic Dataset. The study compared the performance of algorithms such as K-nearest neighbors (KNN), Naive Bayes, random forest (RF), support vector machine (SVM), and logistic regression. Besides the performance of these algorithms, the study also examined the performance of some of the ensemble algorithms that combined SVM with RF in classification. Consequences showed that the linear SVM model achieved an accuracy of 98.24%. Meanwhile, the combination of SVM and RF reached a maximum accuracy of 98.83%. These findings suggest that ensemble models, especially those based on SVM, have great potential to greatly improve the accuracy of diagnosing breast cancer and pro-vide valuable support to clinical decision-making.

73 Decision Support Framework for Voltage Deviation Prediction in VPP Modelled Power Networks using ElasticNet

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Ensuring voltage stability is critical in modern cyber-physical power systems, particularly with the expanding integration of Virtual Power Plants (VPPs) and distributed energy resources integration. The presented paper pro-poses a data-driven model to support decision-making on the prediction of volt-age deviations in a VPP-modelled IEEE 9-bus power network. Based on a rich dataset covering a large portion of operating conditions, including differences in load demand and generation curves, it is formalised as formulated as a supervised regression problem with the goal of predicting continuous indices of voltage de-viation. It uses five regression models which are ElasticNet, Random Forest, Sup-port Vector machine, Extreme Gradient Boosting and Artificial Neural networks. The model performance is measured using cross-validation that is rigorous and a set of statistical



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measures, the coefficient of determination (R2), mean absolute error (MAE), root-mean-square error (RMSE), and explained variance. The re-viewed models have shown that an improved version of ElasticNet formulation provides better predictive performance with higher accuracy and better generali-zation across unseen operating conditions. Further validation is carried out through the residual analysis and comparisons of the actual and predicted values that support the robustness and readability of the framework. The suggested so-lution can be a good decision support tool used in proactive assessment of volt-ages in VPP-integrated power systems, which will result in more stable operation under dynamic grids.

79 Multi-Class Crop Disease Identification Using Transfer Learning and ResNet50 Deep Neural Network

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Plant diseases have a great impact on agricultural productivity in that they destroy crops and decrease the quality of the yield. This requires the early and correct diagnoses of plant diseases in order to have good management of crops and sustainable agriculture. Nevertheless, manual inspection methods of disease diagnosis are usually time-consuming, subjective, and need expert knowledge, which is not applicable in large-scale agricultural monitoring. Though artificial intelligence has been recently used to detect plant diseases, most of the current methods are based on small datasets, or they do not provide detailed feature interpretation and sound evaluation, which leaves a gap in building effective and interpretable automated systems of disease detection. To solve this problem, the current study suggests a deep learning-based plant disease classification model with the use of the APID dataset that consists of 1000 leaf images belonging to 10 categories, such as Maize Brown Spot, Maize Healthy, Maize Rust, Potato Early Blight, Potato Healthy, Potato Late Blight, Soybean Mosaic Virus, Soybean Pod Mottle, and Soybean SBS. The data was separated into 700 training samples, 150 validation samples, and 150 testing samples so that the model training and evaluation results are reliable. The visual features that are identified automatically by the proposed model are the hierarchical elements which include lesion patterns, color variations as well as texture structures extracted on the leaf images. The performance of the experiment is high with the overall classification accuracy of 99.33% being achieved over the test dataset. Practical implications of this study show that the suggested framework is capable of being applied to provide the cases of automatic diagnosis of plant diseases, helping farmers and agricultural specialists with the initial diagnosis of the disease as well as with the management strategies in precision agriculture

80 Healthcare IoT Honeypot System: A Multi-Protocol Deception Framework for Medical Device Cybersecurity

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The increasing adoption of Internet of Things (IoT) technologies in healthcare has improved patient monitoring, diagnostics, and hospital automation. However, the growing number of connected medical devices has also introduced significant cybersecurity risks. Many healthcare IoT systems operate on legacy infrastructure with limited security mechanisms, making them vulnerable to cyberattacks that can lead to data breaches, service disruption,



and potential risks to patient safety. This research proposes a Healthcare IoT Honeypot System, a multi-protocol deception framework designed to emulate medical devices and capture malicious activities targeting healthcare infrastructure. The system creates an isolated environment that attracts attackers while preventing damage to real medical systems. It supports multiple healthcare communication protocols including HTTP, HL7, FHIR, MQTT, and DICOM, enabling the monitoring of attacks across different medical communication standards. The honeypot records attacker interactions, logs network activities, and captures protocol-specific payloads for analysis. The collected data is used to study attack patterns and vulnerabilities in healthcare systems. The proposed framework provides a safe platform for cybersecurity research and helps improve the understanding of emerging threats targeting healthcare IoT environments.

85 Real-Time Multi-Hazard Risk Assessment for Safe Evacuation Routing Using Geospatial Intelligence

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Natural disasters like floods, earthquakes, fires, along with man-made incidents like industrial accidents, significantly disrupt transportation networks and change the risk landscape in a big way. Standard navigation tools usually focus on minimizing distance or travel time, but disaster alert systems tend to send out separate warnings about hazards, lacking any kind of evacuation advice. In this paper, we introduce a framework for evacuation routing that takes into account multiple hazards in real-time, utilizing geo-spatial intelligence. The framework combines organized disaster alerts, satellite data, and informal textual information to create localized hazard insights. Using a geo-keyword extraction system, we can pinpoint localized danger signals, while a multihazard risk model assesses the risk scores for different regions by evaluating how severe the hazards are and how close they are. The risk scores we calculate are used in a revamped routing algorithm where edges are weighted by their risk, putting safety first instead of just focusing on the shortest distance. Experimental results show that the proposed approach reduces hazard exposure by up to 60%. The results support effective real-time decision support for evacuation planning in dynamic disaster environments.

115 Multi-Stage Classification of Parkinson's Disease Using Hybrid CNN-BiLSTM, Transformer, and Graph Neural Networks

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The automated staging of Parkinson's disease (PD) continues to be a challenging issue in clinical AI, mainly due to the disease's progressive nature, which unfolds along a spectrum instead of transitioning suddenly from health to illness, and because the biomedical signals employed as indicators—such as voice recordings, gait patterns, and hand-drawn spirals—exhibit significant individual variability and overall inconsistency. Most published work sidesteps these difficulties by reducing the problem to a binary yes/no decision; this paper does not. We treat PD assessment as a four-class ordinal task (Healthy / Early PD / Moderate PD / Advanced PD) and pit three structurally distinct deep learning architectures against each other under identical training conditions for 100 epochs on a



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merged, multi-modal dataset of 6,070 records and 30 harmonised features. The three models are: a 1D-CNN stacked with Bidirectional LSTM units (CNNBiLSTM), a Transformer encoder built around multi-head self-attention, and a GraphSAGE-flavoured Graph Neural Network (GNN). Using five-fold stratified cross-validation with strict data-leakage prevention at every preprocessing step, we find that CNN-BiLSTM reaches 97.24% accuracy, a macro F1-score of 97.27%, and a specificity of 98.01%, and a mean one-vs-rest AUC of 0.9943. The Transformer lands at 94.12% and the GNN at 92.87%. Both secondary models already beat or match the best binary classifiers published between 2022 and 2025 — making the CNN-BiLSTM result on a strictly harder task all the more notable.

122 RAMD-Net: Enhancing Robustness of Malware Image Classification Against Adversarial Attacks

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Malware visualization combined with convolutional neural networks (CNNs) has shown promising results for automated malware family classification. However, recent studies reveal that deep learning models remain highly vulnerable to adversarial perturbations, raising serious concerns for their deployment in security-critical environments. In this work, we conduct a systematic robustness evaluation of a CNN-based malware image classifier trained on the Malimg dataset containing 25 malware families. We analyze the impact of gradient-based adversarial attacks under a white-box threat model using the Fast Gradient Sign Method (FGSM) and Projected Gradient Descent (PGD). Experimental results show that while the baseline model achieves 94.19% accuracy on clean samples, performance degrades drastically to 16.25% under FGSM and 10.06% under PGD attacks. To mitigate this vulnerability, we incorporate PGD-based adversarial training during model optimization. The resulting model significantly improves robustness, achieving 79.76% accuracy under FGSM attacks and 71.37% under PGD attacks while maintaining a clean accuracy of 95.48%. These findings demonstrate that adversarial training can substantially enhance the resilience of malware image classifiers without sacrificing classification performance. The study highlights the importance of robust optimization techniques for developing reliable AI-driven malware detection systems.

127 XDFT-Based Time–Frequency Representation and Modified GoogleNet Framework for Motor Imagery BCI Classification

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Brain Computer Interface (BCI) systems enable communication between the human brain and external devices using electroencephalogram (EEG) signals. Among various BCI paradigms, Motor Imagery (MI)-based EEG classification remains a challenging task due to the non-stationary and low signal-to-noise characteristics of brain signals. This paper proposes an efficient EEG-MI classification framework based on an Extended Discrete Fourier Transform (XDFT)-based scalogram combined with a modified GoogleNet architecture. The XDFT convert EEG time signal into scalograms mean transforming signal into time frequeny representation so that 2 different feature



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amplitude and phase are obtained. The generated scalogram are used as input to a modified googleNet for automatic feature learning and classification. The proposed model is evaluated on Dataset I of BCI Competition IV, consisting of 59-channel EEG recordings from 4 subjects performing motor imagery tasks. Performance is assessed using multiple metrics including accuracy of 96.19%, specificity of 96.22%, precision of 96.18%, F1-score of 96.16% and recall of 96.15%. Experimental results demonstrate that the proposed XDFT-modified GoogleNet framework outperforms conventional architectures. The results confirm the effectiveness of the proposed approach for robust and high-accuracy MI-BCI classification.

130 Multidomain Acoustic Feature Analysis of Nyishi and Adi: Evidence of Cross-Linguistic Overlap

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Nyishi and Adi are the two closely related languages of the Tani branch of Tibeto-Burman family spoken in Arunachal Pradesh, Northeast India. Although they are closely related genealogically, their acoustic relationship has not been studied without a structured approach of quantitative multidomain analysis. This study addressed that whether the utterance-level acoustic mean descriptors can be separated between the two languages in the context of prosodic, energy, articulatory, and spectral aspects. About 4.6 hours of the speech that contained 1,646 utterances by 52 speakers were analysed. The acoustic parameters extracted for this analysis are fundamental frequency, RMS energy, formant frequencies (F1, F2), and spectral shape parameters centroid, bandwidth, roll off, and spectral slope. Statistical analysis and multidimensional structure have been performed by five-fold cross-validated logistic regression. Univariate analyses did not show significant differences among features with small effect sizes occurring constantly. Multivariate classification achieved accuracy of 61% and ROC-AUC value of 0.503, which shows a distributional overlap across domains. These results indicate lack of acoustic separability between Nyishi and Adi with the examined feature combination and offer a quantitative account of the acoustic similarity between the two Tani Languages.

135 AI-Based Screening Kidney Abnormalities Using CT Images

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The kidney cysts, stones, and tumors are some of the most common kidney problems in the world. These kidney conditions if left untreated it may lead to CKD (Chronic kidney diseases), severe renal dysfunction or life threatening complications. For effective treatment planning, it is important to find problems early and accurately using Computed Tomography (CT) imaging. But interpreting CT images by manually takes a lot of time and can vary from person to person. This paper presents a deep learning framework that compares transfer learning-based classification ResNet50 and ResNet101 as well as pixel-wise lesion segmentation employing UNet and UNet++. There are 12,446 CT images in the dataset, and they are divided into four class consisting Normal, Cyst, Stone, and Tumor. We divided the images into three groups: training (70\%), validation (15\%), and testing (15\%). Experimental results show that ResNet50 had a classification accuracy of 99.79\% and ResNet101 had a classification accuracy of



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99.63\%. UNet++ had a pixel accuracy of 99.56\% and a mean IoU of 0.9851 for segmentation, while UNet had a pixel accuracy of 97.72\% and a mean IoU of 0.9241 for segmentation.

136 Classification of Brain Tumor from MRI Using Modified ResNet-50 Architecture

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The detection of a brain tumor is a critical function in medical image analysis because incorrect or delayed diagnosis can greatly affect patient survival. In medical image analysis, Magnetic Resonance Imaging (MRI) is normally used in the detection of abnormalities in the brain because it can create detailed pictures of the brain tissues. The manual investigation of MRI images by a medical expert can be a tedious process and can lead to incorrect diagnoses. In this regard, deep learning (DL) techniques have been instrumental in developing efficient systems for automated medical image analysis. In this work, a framework for brain tumor classification using DL techniques is presented. In this regard, a model based on the ResNet-50 architecture for feature extraction as well as classification of MRI images is used in this approach. In addition, a modified version of the ResNet-50 model is presented by adjusting the classification layers in this model for efficient learning in brain tumor recognition. The Deep learning architectures enables a model to learn from MRI images without requiring feature engineering. As shown in the experimental evaluation, the modified ResNet-50 model has shown promising results in brain tumor classification, with an accuracy of 96.90%, specificity of 97.09%, sensitivity of 96.69%, and an F1-score of 96.51%.

138 CNN-Based Detection and Cross-Linguistic Acoustic Analysis of the Palatal Nasal/ɲ/ in Nyishi

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This work was conducted on the automatic recognition and acoustic analysis of the palatal nasal phoneme /ɲ/ of Nyishi, a language of low resources and spoken in Arunachal Pradesh in India. Having said that, there is little information on the acoustic properties of the /ɲ/ sound in the understudied languages, yet the /ɲ/ sound is present in most languages. In order to address this gap, the convolutional neural network (CNN) model was created to identify the presence of /ɲ/ in speech recordings. The system applies Mel-frequency variants of Cepstral Coefficients (MFCCs) of speech samples to perform binary recognition of /ɲ/ versus non- /ɲ/ audio samples. Its performance was measured based on the conventional measurements, including accuracy, precision, F1-score and confusion matrix analysis. The acoustic characteristics of /ɲ/ in other languages other than phoneme detection are discussed in the paper. Auto-extraction of such features as MFCCs, formant frequencies (F1-F3), and pitch in voice records was done using computational techniques. Differences between the Nyishi and other languages were analyzed by Mahalanobis distance with repeated sampling and the statistical significance was determined by permutation-based testing. Silhouette scores and cross-validated logistic regression were also used to evaluate the



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separability at the language-level using a global comparison. The graphical interface provided the ability to extract features, operate in batch with audio, and visualize waveforms and MFCC representations, which made the process of experimentation and analysis easier. The proposed solution indicates how automated acoustic analysis and machine learning can facilitate phonetic studies in low-resource languages. The findings contribute to phoneme detection and cross-linguistic speech sound comparison, which provides a highly efficient and scalable approach to computational phonology.

156 Machine Learning Framework for Medical Health Prediction Based on Symptoms and Doctor's Appointment

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The Disease Prediction Model supports probabilistic method to incur a patient's health condition rely on the health indicators they intimate to the medium. Health premises need important enhancement to improvise decision-making with respect to patient cure and diagnosis options. At the core of machine learning, healthcare improvises the study of advance and aggregate health related metadata in the medium, enabling for understanding and the elicitation of nursing predictions. The machine examines the patient's health indicators and gives the prediction of the which illness as a feedback. The coding of Decision Tree, K-Nearest Neighbour algorithm, Naïve Bayes, and Random Forest improvise illness probability. The purpose of this paper is to create a special tool by combining machine learning applications from the medical field. Despite relying solely on treatment, the medical field can progress with the use of machine learning predictive algorithms for sickness prediction. Many cases may occur when an illness cannot be treated in a timely manner. Illness prediction can therefore be put into practice quickly. The main goal of this research is to develop a quick health care protocol, or medium, that incorporates health indicators obtained from multimeter machines into a medical dataset together with other health history data. A machine learning terminology with an accuracy of more than 90% will be used to analyze this dataset.

164 A Significant Investigation on Hybrid Algorithms with Different Variants for Problem Solving in Waste Management Optimization

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Increased urbanization makes it more difficult to manage municipal solid waste from an operational logistics perspective due to the constraints of controllable resources and monetary resources. The objective of this study is to develop a new approach to solve an allocation of waste problem and a vehicle routing problem using two hybrid metaheuristics, genetic algorithms (GA's) and particle swarm optimization (PSO's). A mathematical model was developed in this study in order minimize costs associated with transportation and processing to operate facilities while searching for a balance between total cost while maintaining the facility's capacity through a penalty-based procedure. Hybrid architectures take advantage of the global search capabilities of GA and the rapid convergence characteristics of PSO to facilitate the exploration of solutions differently and refine them afterwards. All computational experiments conducted were based on completing multiple independent simulation runs and subsequently comparing the results from each run against the results of the individual implementations of GA and PSO. Performance was evaluated based on cost per solution, mean cost, standard deviation and the amount of



time taken to complete computation. The results from the performance evaluation demonstrate that the GA + PSO hybrid framework achieves a 3–5% reduction in total operational costs, along with substantially lower variability, than either individual algorithm, which suggests that using a hybrid approach results in greater robustness and convergence stability. Furthermore, the proposed hybrid approach retains the computational efficiency of either algorithm, while producing equally balanced allocations and feasible routing structures. The findings from this study indicate that hybrid metaheuristics can be applied to manage urban waste logistics in a sustainable manner as part of the development of smart cities.

165 A Unified CNN-GRU-Attention Framework for Electricity Theft Detection in Smart Grids

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Electricity theft is a serious problem for utility operators of smart grids in developing countries, which results into incurring huge economic losses, grid instability, and a reduction of reliable service to the customers. As smart meters and sophisticated metering infrastructure take place on a large scale in developing countries, data-driven deep learning detection methods have become critical to detecting fraudulent consumption behaviors. Nevertheless, current approaches tend to have critical issues of class imbalance, long-term temporal dynamics, and a lack of interpretability. To overcome these weaknesses, this paper proposes a Unified CNN-GRU-Attention (UCGA) model for electricity theft detection. The proposed model combines a 1D-Convolutional Neural Network(CNN) used to detect local anomalies in raw load profiles, a Gated Recurrent Units(GRU) used to recognize sequential dependencies on a time basis, and a soft attention mechanism that emphasizes the period of time in consumption data that likely indicate theft, and lowers attention to irrelevant data points. Trained on the State Grid Corporation of China (SGCC) dataset, with class balancing via Adaptive Synthetic Sampling(ADASYN), the UCGA model attains a 94.80% accuracy, 98.20% precision, 91.25% recall, 94.60% F1-score, 97.45% ROC-AUC, and 98.23% PR-AUC. Not only does the model outperform other existing baseline models, but it has the ability to balance the detection accuracy and robustness, minimize false alarms, and identify those who are legitimate consumers. The proposed model is scalable, interpretable, and a highly performance-based solution to electricity theft detection, which is a good fit to be deployed in smart grids.

167 Channel Estimation in IRS-Assisted Uplink Communication Systems: A Comprehensive Analysis

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The model-driven deep unfolding approach for channel estimate in Intelligent Reflecting Surface (IRS)-assisted uplink wireless communication systems is examined in this work. We create a five-layer deep unfolding net-work using an MMSE-like iterative method with learnable regularisation parameters (β) and step size (α). The performance of the model is assessed in both ideal (high SNR, single user) and challenging condition (lower SNR, multi-user) Rayleigh fading scenarios. The model delivers near-perfect chan-nel estimation under ideal



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circumstances. The model exhibits adaptive be-haviour by modifying its learning parameters to maintain high accuracy un-der challenging condition.Compared to traditional LS and MMSE estimators, the proposed deep unfolding model shows competitive results. Although MMSE yields slightly better performance under the assumption of perfect channel state information (CSI), this study highlights the robustness and scalability of deep unfolding in dynamic, complex wireless channels.

178 A Dual-Agent Architecture for Autonomous Cloud Provisioning and OS-Level Operations with Integrated Secure DevSecOps CI/CD

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The delivery of cloud-native software involves automated provisioning of infrastructure, secure configuration of systems and continuous validation in CI/CD pipelines. Existing solutions generally consider cloud orchestration, OS configuration and security automation as independent entities. The architecture involves dual agent design that allows for autonomous provisioning of AWS resources and orchestrating OS level automation with integrated secure DevSecOps CI/CD support. The infrastructure agent is able to support multiservice cloud orchestration across compute, network and storage resources. EC2 and VPC deployment is evaluated as a representative case. The OS-level agent is a guided Linux helper that generates and executes the system commands for updates, package installation, and service configuration to guide users who are not experts in the server environment. Jenkins runs on dedicated EC2 instances while container-based demonstrations validate agent capabilities. The pipeline includes multiple security assessments, all happening with integrated static analysis, dependency and container vulnerability scanning, dynamic one and deploying into Kubernetes. The experimental results confirm that provisioning is automatic, security gates are enforced, and execution is controlled with minimal overheads.

192 Assessment of Land Cover Changes Using Multi-Temporal Remote Sensing Data in East Sikkim, India

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The growth of urbanization and the growing urban population, particularly in emerging nations, have been the main concerns of environmental experts and urban planners in recent years. This has been proven and is widely accepted. In order to determine the rate of natural vegetation depletion and urban sprawl expansion, as well as to identify underlying patterns and related causes, this research project, motivated by the identified relevant issue, aims to perform a temporal analysis of Landsat satellite datasets from East Sikkim over a ten-year period. This study employs statistical models and multi-temporal satellite data to identify and track trends of land use and land cover change in East Sikkim. Using Landsat satellite data from 2013 to 2023, ERDAS Imagine was used to predict long-term land use and land cover (LULC) and urban spatial change. The analysis of the data showed that between 2013 and 2023, there was a notable decrease in the areas of dense forest and barren land due to the growth of urban built-up regions. Supervised image classification has been used to detect various land cover classes, such



as urban areas, woods, flora, and barren terrain, in order to accomplish the research goals. According to the classification results, urban areas and barren land have grown by about 0.26 km² and 16.48 km², respectively, whereas dense forest and vegetation have decreased by about 9.27 km² and 3.27 km². The result was a Kappa value of 0.8529 and an average classification accuracy of 93.5%.

198 Exploring OPC-UA Architecture and Digital Twins in Critical Infrastructures

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This research seeks to demonstrate an initial exploration of the industry-standard open platform communication architecture for real-time data visualization of sen-sors and PLCs in critical infrastructures. The model critical infrastructures men-tioned in this article are the WaterLAB, with its smart water-focused infrastruc-ture, and the Lucas-Nuelle Savonia Smart Factory. We have examined different methodologies for configuring client-server architecture in data flow systems within selected critical infrastructures. According to our investigations, we have developed an architecture in which the WaterLAB's WaterLOOP distribution system simulator OPCUA server is initialized using the TwinCAT OPC-UA configurator. For the client side, we conducted experiments to demonstrate real-time data on three distinct terminals: UaExpert, Prosys OPC-UA Historian, and Prosys OPC-UA Monitor. Furthermore, a prototype of a digital twin of an indus-trial control system has been developed, which incorporates programmable logic controllers (PLCs), sensors, and a communication network. This prototype has been implemented using the ignition platform. Additionally, we conducted an analysis of various OPC-UA clients concerning their data security and data rate capabilities.

202 Attention-Based Parallel Network for Gallbladder Cancer Classification

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Gallbladder cancer remains highly lethal due to late-stage diagnosis. While ultrasound (USG) imaging offers non-invasive, affordable, and accessible evaluation, accurate tumor classification from USG images faces challenges including low contrast, noise, and imaging instability. This paper presents a hybrid deep learning architecture combining ResNet50V2 and VGG19 networks, enhanced with Convolutional Block Attention Module (CBAM) and Multi-Head Attention (MHA) mechanisms. The architecture exploits residual and fine-grained features while attention mechanisms direct focus toward discriminative regions. Comprehensive experiments on the GBCU dataset employed 3-fold cross-validation for both binary and multiclass classification tasks, achieving accuracies of 95% and 91%, respectively. Results demonstrate the attention-augmented hybrid framework's effectiveness in



differentiating normal, benign, and malignant cases. The proposed approach offers a promising foundation for developing reliable computer-aided diagnostic systems for gallbladder cancer classification from ultrasound images, while delivering performance comparable to state-of-the-art (SOTA) image classification methodologies, potentially improving early detection and clinical decision-making in cancer diagnosis.

203 Class Aware Federated Learning for Highly Imbalanced Dataset with Hellinger Distance Based Non-IID Data Distribution

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Federated learning (FL) [6] enables collaborative model training across decentralized clients without sharing raw data, making it suitable for privacy-sensitive distributed learning environments. However, real-world federated systems often contain non-identical data distributions (non-ID) [3,7] and highly imbalanced data, where client datasets differ in both class proportions and dataset sizes, resulting in label skew and quantity skew [14]. Such heterogeneity can reduce the effectiveness of standard aggregation methods such as Federated Averaging (FedAvg) [6]. In this work, heterogeneous client datasets are constructed using the Hellinger Distance (HD) metric [4] to control the degree of non-IDness. To address the limitations of FedAvg under imbalanced dataset conditions, a Class-Aware Federated Averaging strategy with bounded class aware amplification parameter is proposed to increase the influence of minority-rich clients during aggregation. Model behaviour is initially an alyzed using local evaluation; however, due to heterogeneous client distributions it may produce poor performance estimates. Therefore, centralized evaluation [10] is adopted to provide a consistent global performance assessment. Experimental results under increasing heterogeneity demonstrate that the proposed work significantly improves minority-class detection, achieving up to 63% improvement in recall and 33% improvement in F1-score compared to standard FedAvg at higher Hellinger Distance levels.

206 A Comparative Study of CNN and Transformer-Based Architectures for Skin Lesion Segmentation on the HAM10000 Dataset

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Early and accurate detection of skin cancer, particularly malignant melanoma is critical for improving patient survival rates. Automated skin lesion segmentation using deep learning has become an important component of computer-aided diagnosis systems for dermoscopic image analysis. In this study, we perform a comparative evaluation of six deep learning architectures for skin lesion segmentation including U-Net, Attention U-Net, SegNet, Fully



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Convolutional Network (FCN), Trans UNet and Swin U-Net. The models are trained and evaluated on the HAM10000 dermoscopic image dataset using standard segmentation metrics such as Dice Similarity Coefficient, Intersection over Union (IoU), Accuracy, Precision and Recall. In addition, the influence of key hyperparameters including optimizer selection and learning rate is analyzed to examine their impact on model performance. Experimental results show that the Transformer-based Swin U-Net achieves the best segmentation performance scoring a Dice score of 0.9483 and an IoU of 0.9067 outperforming both hybrid and traditional CNN-based architectures. The findings demonstrate that hierarchical Transformer architectures are highly effective in capturing both global contextual information and fine-grained lesion boundaries, making them promising candidates for accurate skin lesion segmentation in computer-aided diagnostic systems.

207 Machine Learning enabled Thermal Management for Photovoltaic Panels using Variable Cooling Water Flow Rate

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Standard photovoltaic (PV) efficiency, typically ranging from 15 % to 20 %, is notably impeded by thermal degradation, with a decline of approximately 0.5 % for each 1◦C rise in temperature. Conventional constant-flow water cooling systems often fail to enhance net energy yield due to substantial parasitic pumping power. This study introduces a novel innovative variable flow rate control strategy that employs machine learning (ML) to proactively predict panel temperatures and calculate the required flow rate of water for PV cooling. By applying Newton's Law of Cooling, the system dynamically determines the minimum flow rate necessary to sustain the target temperature. Validation through simulations and physical experiments indicates good agreement with the ML models. Two machine learning models, random forest regressor and XGBoost regressor, were trained, which demonstrated notable accuracy of around 0.95 R2 score, 0.15 RMSE, and 0.11 MAE each. The efficiency of the photovoltaic system reaches a maximum of 18.2% using the variable mass flow rate approach, in the TRNSYS simulation, while average power consumption is reduced by 75.97% from 0.811 kWh with constant flow cooling to 0.195 kWh with the proposed framework. The results demonstrate a scalable solution for maximizing the net energy yield of solar infrastructure through proactive cooling.

212 Lightweight Efficient Multiclass IoT Malware Classification based on Grayscale using MobileNetV3

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The IoT malware proliferation poses severe threats to constrained devices through DDoS botnets like Gafgyt and Mirai variants. This study proposes an efficient image-based deep learning framework for multiclass classification with input grayscale images converted from ELF IoT malware binaries. The dataset comprises of 7,449 samples collected from two different time frames 2017-2016 and 2024-2025 covering different types of malwares with various purposes such as DDOS attacks, crypto mining. We propose a novel architectures of image based malware analysis using MobileNetV3 through transfer learning with frozen ImageNet backbone. The input images are of standard 224X224 and variable image size which is the average size of images in the dataset. The model MobileNetV3 with



fixed input size achieves 98.86% in training accuracy with 100 epochs of training and 98.51% in validation accuracy. With a compact footprint of 11.44 MB on-disk will enable the model to perform efficiently for resource-starved IoT gateways. Results demonstrate image-based static analysis best suited for IoT malware analysis considering the computational constraints of the devices. The experimental result shows the model is efficiently lightweight with superior IoT scalability and comparable to various complex high resource consuming models.

214 A Systematization of Cryptanalysis Techniques for Reduced-Round Keccak

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Cryptographic hash functions form the core of information security today, providing the foundation for various security requirements. In response to the structural flaws found in previous hash functions, MD5 and SHA-1, the SHA-3 competition resulted in the standardization of the Keccak hash function, which is a permutation-based hash function utilizing the sponge construction. This paper aims to provide a systematization of knowledge (SoK), which presents a taxonomy of the cryptanalysis of the Keccak hash function. By conducting a systematic review of 41 primary sources, it provides a taxonomy of various cryptanalysis attacks on the Keccak hash function, including differential cryptanalysis, cube attacks, algebraic attacks, zero-sum attacks, rotational cryptanalysis, distinguishing attacks, and automated cryptanalysis. In addition, providing a comparison of the attacks according to the number of rounds covered by the attacks, computational complexity, and the use of automated tools such as Mixed-Integer Linear Programming (MILP) and Boolean Satisfiability (SAT). The security margin of the 24-round Keccak hash function is shown to be wide, and the use of machine-based cryptanalysis is a promising direction for future work.

215 A ROI-Guided Preprocessing and ResNext-50 Framework for Enhanced Breast Tumor Classification in MRI

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Breast MRI inspection in the detection of tumors is characterized by low contrast, image noise, and heterogeneous tissue architecture. The objective of this study is to propose a computational framework that includes region of interest(ROI) guided preprocessing, adaptive contrast enhancement, and the application of the ResNeXt-50 convolutional neural network in the classification of tumors. The enhancement method improves saliency and separability of features with help of textural characteristics, enabling the learning of hierarchical representations. The evaluation of the framework using the stratified five fold cross-validation method shows the reliability of the classification process,where we got an accuracy of 97.59% and an AUC of 0.997.



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216 Transformer based Multi Disease Classification in Retinal Images

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Retinal diseases cause a large number of vision impairments across the globe. Hence, early and precise detection is essential for appropriate treatment and prevention of permanent vision impairment. Fundus images provide a non-invasive technique for studying retinal diseases. However, precise disease classification is not easy due to various reasons. Hence, this paper proposes a framework for automatic classification of various retinal diseases using a Vision Transformer architecture. The proposed method is tested using the RFMiD dataset and results for three classification tasks, including the classification of myopia, distinguishing normal and combined abnormal conditions such as diabetic retinopathy, macular hole, and optic cupping, and multi-class classification among these four classes. The results show excellent classification capability for all three classification tasks. The binary classification for detecting myopia results in 95.45% accuracy, distinguishing normal and combined abnormal conditions results in 86.0% accuracy and 92.36% AUC-ROC, and multi-class classification results in 85.87% weighted accuracy and 96.6% AUC-ROC. Hence, this paper proves that transformer architecture is capable of learning unique features from retinal images for various disease conditions. Hence, this proposed framework provides a firm foundation for developing computer-aided diagnostic tools for eye screening and diagnosing diseases.

217 Long-Horizon Dengue Forecasting Using Machine Learning and Climatological Weather Inputs

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Dengue fever is known to be one of the fastest-growing vector-borne diseases worldwide, especially in tropical and subtropical regions of the world, characterized by favorable environmental conditions for mosquito-borne transmission. Dengue forecasting is critical for better epidemic preparedness and resource allocation in public health services. However, dengue forecasting is difficult because of seasonal characteristics, environmental influences, and significant inter-annual differences in outbreak sizes. This research aims to develop a machine learning-based framework for dengue forecasting for long-term prediction intervals. A dataset is constructed using hospital admissions, WHO SEARO dengue surveillance reports, and environmental variables including rainfall, temperature, humidity, soil moisture, surface runoff, and wind speed. A regression model based on gradient boosting is trained using features including climate lags, seasonal indicators, and epidemiological memory. To enable forecasting for long prediction intervals when future environmental variables are not known, environmental variables are approximated using averages of historical weather records. The system is designed for dengue forecasting for three different prediction intervals of 3, 6, and 12 months. The performance of the system is evaluated using year-based cross-validation, showing the model's capability for seasonal outbreak forecasting and long-term



prediction. The system is expected to demonstrate the feasibility of machine learning-based dengue forecasting systems for climate-sensitive epidemic preparedness.

218 Generative Adversarial Network-Based Integration of Functional and Structural MRI Scans for Alzheimer's Disease Diagnosis

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This study's main goal is to use multimodal neuroimaging data to create a trustworthy framework for early Alzheimer's disease (AD) detection. In order to improve clinical intervention outcomes and slow the progression of AD, early diagnosis is crucial. However, the intricate structural and functional changes that take place in the brain during the early stages of the disease are frequently missed by traditional single-modality approaches. This work addresses this limitation by combining resting-state functional magnetic resonance imaging (rs-fMRI), which uses blood-oxygen-level-dependent (BOLD) signals to reflect spontaneous neural activity, with structural magnetic resonance imaging (sMRI), which records anatomical brain structures. Both modalities undergo a comprehensive preprocessing pipeline including spatial registration, skull stripping, and functional connectivity analysis using the Automated Anatomical Labeling (AAL) atlas to extract meaningful regions of interest (ROIs). Generative Adversarial Network (GAN) is then employed to learn a shared latent feature space that effectively fuses structural and functional biomarkers derived from sMRI and fMRI data. The fused representations are subsequently provided to a dedicated convolutional neural network (CNN) classifier to predict diagnostic categories, namely Alzheimer's disease (AD), Mild Cognitive Impairment (MCI), and Cognitively Normal (CN). Experimental evaluation on multimodal data from the ADNI dataset demonstrates that the proposed multimodal adversarial learning framework can capture complementary neuroimaging features and improve diagnostic reliability, offering a promising approach for automated early-stage Alzheimer's disease detection.

223 A Comparative Study of Deep Learning and Machine Learning Models for Surface Roughness Prediction in EDM Machining

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In this study, the effects of three different process parameters (current, pulse on time and time interval) in electrical discharge machining (EDM) were experimentally investigated on AISI 1050 steel surface roughness. In the experimental study, two different current values (8A,16A), three different pulse on time and time interval values (200,300 and 400µs) were examined and surface roughness values were measured. Experimental results were interpreted as average roughness (Ra) and mean roughness depth (Rz). Obtained experimental data was organized and utilized in several machine learning algorithms including Linear Regression, Random Forest and XGBoost in order to evaluate the success of the machine learning approaches in predicting the surface roughness value. The same data was also used to train an Artificial Neural Network (ANN) to properly evaluate the performance of the



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modern deep learning approach in predicting the average roughness value (Ra). Metrics which are Mean Square Error (MSE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Coefficient of Determination (R2) were considered and provided. Findings were presented as a comparison between Deep Learning and Machine Learning Methods.

224 Deep Learning with Attention Mechanisms for Handwritten Compound Odia Character Recognition

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Odia language is spoken by over 50 million citizens and has a rich literary history documented in handwritten texts and centuries of history. Computerization of these materials is still not an easy task because of the complicated forms of Odia characters and a vast difference in handwriting among authors. In this paper, compound Odia handwritten character recognition is explored with deep learning. Our custom data comprise 5,760 handwritten samples in 64 classes of character compounds, which were collected in a systematic way using standardized grid-based sheets. An extensive preprocessing pipeline was adopted, which involved subsequently; geometric correction, skew correction, perspective transformation, and adaptive thresholding in extracting clean character images. CNN architectures, VGG-16, ResNet-18, DenseNet121, EfficientNet-B0 and MobileNet-V2 were compared, and the top model was found to be DenseNet-121 with an accuracy of 95.52 percent and was chosen as a backbone to implement the attention mechanism. DenseNet- 121 had five attention mechanisms applying squeezeand-excitation (SE), Efficient Channel Attention (ECA), Convolutional Block Attention Module (CBAM), Bottleneck Attention Module (BAM) and Non- Local Attention (NL) as independent mechanisms, with each attention mechanism trained under the same conditions. DenseNet-121 + ECA demonstrated the highest level of 96.88 percent accuracy and 96.89 percent F1-score, which is 1.36 percentage points higher than the baseline, and no extra parameters were added (7.019M). These findings indicate that lightweight channel attention is an effective model that boosts the recognition of compound Odia characters without adding complexity to the model, thus suitable in the implementation of model in government document processing, educational institutions, and archival preservation programs.

227 Smart IoT-Driven Solution for Real-Time Household Food Waste Monitoring and Reporting

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Domestic food waste disposal is significantly affected by delayed detection of food spoilage and the lack of an affordable real-time monitoring system in household storage facilities. We present a smart Internet-of-Things (IoT) enabled monitoring platform which combines multi-parameter sensing with deterministic and event-driven decision-making to provide early warning and allow hygienic operation. The prototype includes a gas sensing MQ3 sensor, a temperature-humidity DHT11 sensor, an ultrasonic sensor to estimate the bin fill level, and an infrared proximity sensor for contactless opening of the lid through a servo system. The classifier is a rule-based device that takes the shape of local alerts, such as an audible buzzer, a red LED, and an LCD, when the concentration of gasses



reaches a pre-configured level or when the bin occupancy reaches a threshold limit. Periodically, a ThingSpeak cloud dashboard is connected to the ESP8266 Wi-Fi module to receive telemetry information, remotely visualize it, and store it in history. The experimental validation performed with the use of archived sensor data and cloud-based trend plots has been proven to be reliable in terms of threshold event activation related to spoilage conditions and bin-full conditions under controlled indoor conditions. The proposed system is a light-weight architecture that allows it to be deployed in resource-constrained domestic environments. The proposed method also forms a platform on which future extensions to community-level data collection, predictive waste sorting, and redistribution of leftover food with opportunities to generate revenue for all stakeholders are possible in future studies.

228 Solana Powered Peer-to-Peer Energy Trading System

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The increasing use of distributed renewable energy sources reveals inefficiency, high cost and absence of transparency in the traditional central form of energy trading. To provide secure, real-time, and automated transactions between prosumers and consumers, this paper suggests a new peer-to-peer (P2P) energy trading platform that utilizes the Solana blockchain and Internet of Things (IoT) hardware to support transactions in a secure, real-time, and automated manner. The architecture makes use of the high throughput and low latency of Solana along with the minimal transaction costs. The IoT layer is built out of ESP32 microcontrollers with the INA219 sensors, and it provides real-time monitoring of the energy and automated load control by using relay modules. The average transaction confirmation times of 230s and energy-transfer accuracy of over 90\% were found through experimental measurements, with network fees costing less than 0.0001 SOL, which is the native cryptocurrency of the Solana network. These findings support the possibility of combining blockchain with IoT in order to build a scalable, transparent, and cost-effective framework of decentralized energy markets in microgrids and sustainable energy communities.

235 Performance Analysis of ResNet-18 Under Varying Image Resolutions and Training Epochs

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Now in modern days, there are lot of image data available from the internet. There is a need for automated image analysis and image classification. Deep Learning Models like Convolutional Neural Networks (CNN) had became more popular as they can automatic extract the useful features from the image. This study focus on how image resolution and training time (epochs) will affect on the performance of the model. For experimental analysis, we use ResNet-18 Model and CIFAR-10 dataset. For image resolutions, we took 16x16 and 32x32, and 10, 20 and 30 were the epochs. From the experimental analysis we found that higher resolution 32x32 outperforms 16x16. Higher the image resolutions more visual details. Also training lower image resolutions with more training time, will also perform better. The study shows that when choosing training configurations, there is a trade-off between success and the cost of computing.



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236 Explainable Machine Learning-Based Prediction of 30-Day All-Cause Hospital Readmissions in Geriatric Patients

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Thirty-day hospital readmissions among elderly patients are a major quality concern. This study leverages the publicly available MIMIC-IV EHR dataset to develop and compare machine learning models for predicting 30-day all-cause readmission in patients aged ≥75. Assessed Logistic Regression, Random Forest, and XGBoost classifiers using structured clinical features (demographics, vitals, labs, medications). Model performance was evaluated on a hold-out test set: the optimised XGBoost model achieved the highest discrimination (AUC = 0.595), compared to Random Forest (AUC ≈ 0.583) and Logistic Regression (AUC ≈ 0.573). SHAP explainability analysis identified ICU admission during the index stay, high medication count, and longer hospital stay as the strongest predictors of readmission risk. These findings highlight the limited predictive power of structured data alone and suggest incorporating unstructured clinical notes in future models. The developed methodology provides a framework for geriatric readmission risk stratification using EHR data.

238 Credit Card Fraud Detection Using Explainable AI

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Credit card fraud detection is a significant challenge in the financial system due to the huge class imbalance and the need for accurate yet interpretable decision-making mechanisms. The paper presents an explainable hybrid machine learning framework for credit-card fraud detection merging multiple models such as Artificial Neural Networks (ANN), Random forest (RF), and Extreme Gradient Boosting (XGBoost). The proposed system evaluates individual and ensemble - based models to increase the robustness against always evolving fraudulent patterns. The performance of our system is assessed using precision, recall, F1-Score, Receiver operating characteristic (ROC), and precision-recall metrics to address the imbalance inherent in real world transaction datasets. The Results from our experiment demonstrate that the XGBoost model achieves a superior performance with a fraud class precision of 0.87, recall of 0.84, F1-score of 0.85, ROC-AUC of 0.9803, and PR-AUC of 0.8805. The 0.88 recall with the hybrid ensemble, improving the ability to identify fraud without reducing overall accuracy. To ensure transparency in decision-making, SHapley Additive exPlanations (SHAP) were incorporated for both global and transaction- level interpretation, enabling identification of risk-driving features influencing model predictions. The proposed framework provides a high robust and explainable solution suitable for real-world application in banking and financial risk assessment systems, optimizing detection accuracy with model explainability.



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247 UNet-Based Semantic Segmentation of Remote Sensing Imagery: A Comparative Study of Diverse Deep Learning Backbones

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Semantic segmentation of high resolution remote sensing imagery is a key factor in the successful implementation of various geospatial, related fields, such as urban development, land cover classification, and natural disaster management. In this context, UNet, based models stand out as a very effective solution for the pixel level classification task. The present article reports an in-depth comparative analysis of the UNet architecture combined with different encoder backbones, such as various versions of ResNet, SE-ResNet, SE-ResNeXt, SENet, VGG, DenseNet, Inception, MobileNet and EfficientNet families. For the case of binary segmentation, the WHU-II dataset, which is a standard dataset in the field of building extraction, has been employed. Besides, for multiclass land cover segmentation, a newly created dataset named Cartosat-2E has been chosen to test the models ability to generalize to a number of classes. The experimental results confirm that EfficientNetB5 undoubtedly stands a chance to be the overall champion, with mean IoU of 85.27% and an F1-score of 91.51% measured on the WHU-II dataset, while InceptionResNetV2 dominates with mean IoU of 95.51% and an F1, score of 97.69% on the Cartosat-2E dataset. On the whole, this paper sheds light on the crucial impact of backbones choice on UNet results and stands as a sound reference for those willing to take the level of semantic segmentation in remote sensing to the next stage.

252 A Comprehensive Review of Hybrid CNN–Transformer Models for Multi-Class Lung Disease Classification Using Chest X-Ray Images

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Automated interpretation of chest X-ray images has become an important research area due to the increase in respiratory illnesses worldwide. Because of convolutional architectures like VGG16, ResNet50, and DenseNet121, deep learning has significantly advanced computer-aided diagnosis. Global feature capture was expanded when self-attention mechanisms were introduced into transformer-based systems. Our study identifies unresolved research topics and assesses the current state of the area; we produced twenty carefully chosen papers.



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255 A Unified Predictive-Prescriptive-Explainable AI Pipeline for Automated Web Performance Engineering

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Diagnosing poor web performance is only half the battle; practitioners also need clear, trustworthy guidance on exactly what to fix. This paper introduces a unified three-phase pipeline that covers the full remediation cycle: a leak-proof predictive classifier, a direction-aware prescriptive optimizer, and a multi-method explainability layer. An XG-Boost model trained on 885 real-world webpages enriched with Core Web Vitals from the Google PageSpeed Insights API achieves 90.60% test accuracy within a scikit-learn Pipeline that prevents data leakage across cross-validation folds. The model transfers to an independent corpus of 8,000 HTTP Archive URLs at 97.54% accuracy, establishing strong cross-dataset generalizability. A Differential Evolution engine translates predictions into domain-compliant feature prescriptions with a 100% batch success rate. Beyond routine SHAP and LIME reporting, the explainability layer contributes a fidelity-weighted consensus ranking, quantitative stability analysis, category-stratified feature importance, and hybrid counterfactual explanations that reveal an actionability gap: timing features such as TTI and TBT appear far more frequently in counterfactuals than their SHAP importance ranks suggest. A controlled real-world experiment independently confirms the pipeline, reducing Largest Contentful Paint by 97.3% and raising the Google PageSpeed score from 55 to 100.

257 Hidden Markov Model-Based Keyword Spotting for Manipuri Speech Recognition

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Keyword spotting (KWS) is a fundamental component of modern voice-activated systems; however, developing KWS systems for low-resource languages remains challenging due to the scarcity of annotated speech data. This paper presents a Hidden Markov Model (HMM)–based keyword spotting system for Manipuri, an under-resourced, phonetically rich language spoken in Northeast India. The system is trained on a custom speech corpus comprising 1,040 isolated keyword utterances collected across multiple speakers. Mel-Frequency Cepstral Coefficients (MFCCs) augmented with first- and second-order temporal derivatives are employed to capture both spectral and dynamic speech characteristics, followed by cepstral mean and variance normalization (CMVN). The HMM parameters are carefully optimized to handle variations in speaker characteristics, speaking rate, and natural prosody. Experimental evaluation demonstrates that, by integrating Δ and ΔΔ temporal features with Cepstral Mean and Variance Normalization, the proposed MFCC-based representation improved keyword spotting accuracy from 35% to 90%, demonstrating robust performance of HMM-based modeling for Manipuri speech in low-resource conditions. The proposed HMM-based KWS system achieves 90\% accuracy with balanced precision (92%) and recall (90%), confirming robust keyword detection performance on low-resource Manipuri speech. These results indicate that classical HMM-based approaches remain competitive for keyword spotting in resource-constrained settings and provide a strong baseline for future development of Manipuri automatic speech recognition KWS systems.



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258 Modelling Lockdown-induced Air Quality Changes in Urban India using Bidirectional LSTM Network

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In India, the COVID-19 pandemic, which started in late 2019, resulted in widespread lockdowns that drastically reduced human activity and changed the dynamics of air quality. This study looks at how lockdowns affect three major air pollutants—PM_2, NO_2, and O_3—in Delhi, Kolkata, and Guwahati, three of India's most polluted cities. Kolkata continues to surpass national particulate matter standards despite recent improvements, Guwahati is known for having exceptionally high black carbon concentrations, and Delhi recorded extreme $PM_{2.5}$ levels exceeding 20 times WHO guidelines in 2024. Prior research has connected air pollution to higher rates of COVID-19 infection and death; lockdowns have been shown to significantly lower PM_2 levels while raising O_3 levels. We use a bidirectional Long Short-Term Memory network to model the intricate, nonlinear relationships between pollutants and environmental variables, which performs better when handling multivariate temporal data than conventional statistical and simulation-based approaches. The analysis covers pre-lockdown, lockdown, and post-lockdown phases using datasets from 2019 to 2021. It also includes a thorough trend analysis of pollutant variations during these times. The results show the promise of cutting-edge deep learning techniques for precise air pollution forecasting and policy development in urban India, as well as the behavior of pollutants under conditions of limited activity.

261 Smart Fertilizer Recommendation Using Soil Properties for Rice Crops

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This research develops a computer system for smart fertilization rec-ommendations for the efficient fertilization of rice crops through deep learning and analysis of soil properties. The correct application of fertilizer is an important operation in agriculture today, and be-cause of the general nature of many fertilizer recommendations given to farmers and because of their response to the variability of soil properties on fields, the use of fertilizer is being wasted, therefore causing an increase in the cost of growing crops and deteriorating the natural environment. By using the model as a database-driven system to calculate the amount of fertilizer needed based on soil properties, this model will achieve the listed objectives. The inputs into the model used to determine the effect of soil and environmental proper-ties on soil fertility and crop yield include: Nitrogen (N), Phosphorus (P), Potassium (K), Soil pH, Atmospheric temperature, Atmospheric humidity, and Rainfall, etc. The determination of how much fertilizer is required to produce a good yield of rice using a DNN will then de-rive a complex non-linear function to link these inputs to the amount of fertilizer to be applied. The input data into the DNN will be normalised, and the hyperparameters will be optimally tuned for maxi-mum DNN performance when trained. We'll measure how well the model performs by calculating performance metrics (e.g., accuracy, MSE). The experimental results indicate that the proposed DNN out-performs traditional machine learning techniques, both in terms of prediction accuracy and reliability of predictions. The DNN also encourages sustainable agriculture by facilitating precise nutrient management, reducing excessive fertilizer applications, and maximizing crop yield.



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264 EfficientNetV2 and Adaptive Fusion Strategies for Gallbladder Cancer Classification

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Gallbladder cancer (GBC) remains one of the most lethal gastrointestinal malignancies. This is largely due to late diagnosis and the inherent limitations present in ultrasound imaging. These include speckle noise, shadowing artefacts, and operator-dependent variability. Therefore, this work proposes a deep learning based model for the classification of gallbladder into normal, benign, and malignant using ultrasound images. The dataset used in this work is the Gallbladder cancer Ultrasound dataset (GBCU). The proposed framework uses image enhancement, noise reduction technique and contrast boosting following a multiscale feature extraction via EfficientNetV2 framework. The anatomical features and hierarchical texture are fused together using an adaptive fusion strategy. Also, the framework uses attention mechanisms for the identification of the region of interest. The framework is evaluated using 10-fold cross-validation where the proposed approach achieves a mean classification accuracy of 0.9188 with an AUC of 0.9738, precision of 0.9201, recall of 0.9155, and specificity of 0.9561 across folds. Comparative assessment shows that the proposed architecture outperforms the existing methods while maintaining computational efficiency. The results suggest its potential as a reliable and computationally efficient tool to support early GBC classification in routine ultrasound clinical workflow.

267 An Ensemble Learning Approach for Electric Vehicle Battery Health and Lifespan Prediction

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Accurate estimate of lithium-ion batteries' state of health is vital to ensure electric vehicle reliability. This paper presents a high-precision intelligent framework for SOH estimation and RUL prediction of electric vehicle batteries. The key features extracted from NASA battery data with multi-cycle charge–discharge profiles include cycle number, temperature-related parameters, discharge features, and capacity degradation rates. Different machine learning models, such as LightGBM, XGBoost, and Random Forest, are individually trained to estimate battery capacity and SOH. Further, a stacking ensemble with a Linear Regression meta-learner is proposed to enhance the prediction accuracy and robustness. Therefore, the RUL can be calculated from the predicted capacity and SOH using a threshold value of end-of-life failure. The experimental result clearly indicates the efficiency of the combined ensemble approach with respect to the other models.



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268 VISION: Video Intelligent Sampling using Integrated Semantic, motion, and Structural information

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Keyframe sampling is a critical technique for enhancing efficiency in video indexing, retrieval and summarizing the long video sequences into semantically diverse frames. Traditional sampling methods rely on the similarity comparison with query video frames to remove the high redundant frames, in contrast deep learning approaches capture complex frame using scene variation. Sometime in hybrid approaches, it combines both traditional and deep learning model to balance redundancy reduction and temporary continuity. However, those techniques are very sensitive to noise, varying illumination conditions and camera motion, which result in unstable keyframes detection or redundant frame selection. To overcome this problem, we proposed Video Intelligent Sampling using Integrated, Semantic, Motion and Structural information (VISION), a traditional based mathematically driven framework for action-focused keyframe discovery and compact clip generation. This method demonstrates two level of stage: First level of stage involves in mathematical increment innovation of keyframe sampling introducing a new multi-indicator fusion mechanism to detect salient event frames, that jointly models of Scene variation, Motion dynamics and Structural changes incorporates region of interest semantic tracking, multi-scale temporal saliency modeling, residual motion estimation to capture the semantically meaning of video events while supressing background noise and camera motion. Second level of stage involves the process of removing redundancy frames in the detected salient event with temporal coherence and visual diversity. Unlike conventional keyframe extraction, VISION framework uses a training-free, multi-indicator approach that combine two level of stage to index a large number of videos at scale in real time with limited computational resources.

269 Hybrid Quantum–Classical Framework for Smartphone-Based Multi-Class Vehicular Accident Detection

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Road accidents have been a safety issue of public concern, highlighting the importance of the development of automatic detection systems capable of detecting accidents and facilitating quick response from emergency services. In the present study, a hybrid quantum-classical approach is proposed for the detection of different classes of vehicular accidents based on smartphone sensor data. In the proposed method, the sensor data is represented by six different features: acceleration magnitude, angular velocity, vehicle speed, barometric pressure, microphone intensity, and jerk. These features have been represented as a six-qubit variational quantum circuit through the data re-uploading method. Expectation values of Pauli-Z and Pauli-X operators have been used in conjunction with additional features based on probabilities to form the hybrid feature vector. This feature vector has been used to classi-fy the different types of driving events through a combination of three differ-ent classifiers—logistic regression, random forest, and gradient boosting—based on the soft voting method. In the present study, the proposed approach has been implemented on a balanced dataset consisting of 10,003 data points for seven different types of driving events: normal driving, airbag deploy-ment, rollover, rear-end collision, barrier impact, pothole, and sudden brak-ing. In the experiment, the proposed approach recorded a test accuracy of 90.6% and a macro F1-score of 0.907 compared to the baseline approach that has recorded a test accuracy of 85%. In addition,



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the experiment has been performed to show the effectiveness of the proposed approach in the detection of different types of accidents.

270 Data-Driven Prognostic of Li-Ion Battery Life with Quantile Uncertainty Modeling

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This work presents a novel method for predicting the Remaining Useful Life (RUL) of lithium-ion batteries using a combination of uncertainty handling techniques and machine learning (ML) models. By including data smoothing and neural representation learning into the prediction pipeline, the work presents a novel three-stage approach that goes beyond traditional regression-based methods. The work starts with meticulous data preprocessing, which includes feature extraction, outlier treatment, and normalisation, using a publically accessible dataset that includes over a thousand charge-discharge cycles from lithium-ion cells. The suggested technique investigates three layers of modelling: a hybrid strategy that uses Gaussian smoothing to maintain long-term degradation patterns, neural network-based feature modification, and direct usage of raw data in regression. The third approach, which included encoded characteristics and smoothed time-series data, turned out to be the most accurate of all the models examined. Specifically, the XGBoost model produced extremely accurate results with an almost perfect correlation with real values R^2 of 0.9996 and an exceptionally low prediction error RMSE of 6.20. Furthermore, the implementation of ensemble models offered a useful method for estimating prediction uncertainty, providing confidence intervals that facilitate safer decision-making in crucial applications. Cycle indices and voltage-related traits were identified by feature analysis as the main markers of battery wear. This study's main innovation is the combination of robust regression, advanced feature learning, and temporal data processing to create a dependable real-time battery health monitoring system. This strategy is ideal for use in contemporary battery management systems across energy storage and electric transportation platforms.

271 Leveraging Hybrid Stacking Ensembles for High-Accuracy Stroke Risk Classification

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Stroke is one of the major causes of death and long-term disability globally. Predictive models are the first step in identifying high-risk patients. Personalized treatment can help reduce mortality rates. In this paper, we present an automated stroke prediction. It derives important information using machine learning algorithms in a healthcare dataset. The data set includes patient data, such as age, gender, hypertension, and heart disease values. The presence of potentially confounding variables was identified as the number of births, BMI, smoking status, type of work, housing, and marital status. To address the problem of class imbalance, we used oversampling, and compared the efficacy of a few classification models with Random Forest, XGBoost, Logistic Regression, Support Vector Machines and Extra Trees. To reduce predictive performance, Recursive Feature Elimination (RFE) with a Random Forest classifier was used to find the most relevant risk factors, namely age, overall glucose level and BMI Hyperparameter optimization using GridSearchCV is also incorporated into the methodology to ensure model



optimality and limit potential overfitting. The proposed method is built around a hybrid stacking ensemble that includes bagging, boosting, and LightGBM. Experimental results show that the stacking model outperforms individual classifiers and other ensemble approaches, with a peak accuracy of 99%, F1-score of 99%, and AUROC of 0.989. The findings highlight the importance of rigorous preprocessing and ensemble techniques in building credible clinical decision support tools for early stroke risk diagnosis.

276 AI-Enabled Predictive Maintenance for Turbofan Engines**

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Predictive maintenance has emerged [1][6][16] as a critical approach for improving reliability and reducing operational costs in industrial systems. Traditional maintenance strategies, such as reactive and scheduled maintenance, fail to effectively utilize real-time sensor data, leading to unexpected failures and increased downtime. This paper presents an AI-enabled predictive maintenance framework that uses a Multi-Task Transformer model to simultaneously predict Remaining Useful Life (RUL) and Degradation Rate (DR) of industrial components. The proposed model is trained and evaluated using benchmark datasets [3][5], including NASA C-MAPSS turbofan engine data and the IEEE PHM 2012 bearing dataset. The framework incorporates data preprocessing, feature normalization, sliding window segmentation, and multi-task learning to capture degradation patterns across varying operating conditions. Experimental results show significant performance improvement, achieving up to 27–30% reduction in RMSE compared to baseline models such as LSTM. The proposed system also integrates a Digital Twin-based monitoring framework for real-time visualization and decision-making. The results indicate strong cross-domain generalization and highlight the effectiveness of transformer-based architectures for industrial prognostics.

280 Computer-Vision Based Sun Tracking System for Solar Panels

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Photovoltaic systems (PV) in the modern world are one of the best approach to solve the maximum energy expectation in a solar panel by directing the position of the panel towards the sun. Existing systems like light-dependent resistor systems (LDR) lacks or has limitation in cloudy conditions. This pa-per presents a dual-axis solar tracking system using Computer Vision using deep learning to correctly and accurately point the solar panel toward the sun for maximum energy gain. The proposed framework works by obtaining im-ages of the sky through a camera module and then processes the images on a Raspberry Pi using an object detection model called YOLOv8n to accurate locate the sun. After detecting the sun, its position is used for calculate the alignment error with respect to the center of the frame of the sky image, and then control signals are used to drive the dual-axis servo mechanism which adjusts the direction of the solar panel. Additional validation features like brightness based validation, chromatic validation and temporal consistency checks help to correctly identify the sun and not other bright light sources. Results show accurate sun detection with metrics like precision, recall, F1 and mean Average Precision. This proposed approach shows improve accu-racy over tradition LDR systems.



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282 AgroChain: A Multi-Modal Agricultural Intelligence Framework Integrating Machine Learning, Computer Vision, and Blockchain-based Verification

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This paper presents AgroChain, a multi-modal agricultural intelligence frame-work integrating machine learning-based yield prediction, computer vision for disease and soil classification, and a hybrid blockchain-based verification layer. The system is trained on a harmonized multi-source dataset constructed by the authors, covering 662 administratively harmonized districts across India, 61 crops, and 255,442 records spanning 2001–2023. To the best of our knowledge, this is one of the largest harmonized district-level agricultural datasets for India. A hybrid ensemble routing framework dynamically selects between unified and crop-specific models using eight algorithms (XGBoost, LightGBM, CatBoost, Random Forest, ExtraTrees, HistGradientBoosting, ElasticNet, MLP) with two-stage hyperparameter tuning. Rigorous spatial evaluation with strict temporal separation (training: 2001–2018, validation: 2019–2021, test: 2022–2023) demonstrates strong generalization: district-level cross-validation achieves mean R^2 of 0.8903 (std: 0.0035), while state-level holdout evaluation yields R^2 of 0.8654 (MAE: 0.4328). Cold-start analysis reveals performance degradation (R^2 = 0.2097, MAE=0.5032) for districts with <10 years of historical data, highlighting the critical role of temporal memory. Prediction stability, measured as variance across stochastic runs (used as a proxy for model consistency rather than calibrated uncertainty), is 0.0172. Computer vision models achieve 96.1% accuracy for soil texture classification and 97.5% for plant disease detection on curated validation sets. The harmonized dataset will be released publicly to support reproducible agricultural machine learning research.

283 KA-ResUNet++ for Polyp Segmentation

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Automated polyp segmentation in colonoscopy images is a safety-critical challenge in gastroenterology. Flat sessile polyps carry among the highest malignancy risk yet remain the most difficult subtype to detect, with clinical miss rates exceeding 40% in routine examinations. A fundamental limitation shared by most existing architectures is that their bottleneck layers apply fixed nonlinear activations identically across all feature channels, regardless of semantic content. We propose KA-ResUNet++, which replaces this rigid bottleneck with two stacked Kolmogorov-Arnold Network (KAN) blocks, where every inter-neuron connection learns its own B-spline activation curve from data. The full architecture combines this learnable bottleneck with a corrected ASPP module (independent BatchNorm per branch), dual spatial-and-channel attention gates on all four skip connections, and a boundary supervision head driven by GPU-native Hausdorff distance and Active Contour losses. Under a strict zero-shot cross-dataset evaluation (ZS-CDE) protocol in which Kvasir-Sessile was withheld entirely from training, validation, and model selection, the epoch-59 best-checkpoint model achieves Dice 0.9362 and HD95 10.98 px—the first reported ZS-CDE sessile result from any KAN-based segmentation architecture, to the best of our knowledge. On the source benchmarks it scores Dice 0.9192 on Kvasir-SEG and 0.9438 on CVC-ClinicDB. A rigorously controlled



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three-configuration ablation (80 epochs, seed 42) shows that while the KAN bottleneck independently drives small-lesion detection (+1.02% Dice), the boundary-aware losses are essential as a mandatory topological regularizer to stabilize the spatial instability inherent in unconstrained splines.

292 Intelligent Reflecting Surfaces and 6G: A Survey of AI Enhanced Channel Estimation and Operational Trade offs

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Intelligent Reflecting Surfaces (IRS) represent a transformative physical-layer enabler for sixth-generation (6G) wireless networks, reconfiguring the radio propagation environment into a software-programmable scattering medium. Practical IRS deployment depends critically on accurate cascaded Channel State Information (CSI) acquisition. Conventional linear estimators impose a training overhead governed by T ≥ N, where T is the number of pilot training slots and N is the number of IRS elements a constraint that becomes intractable for large-scale 6G deployments where N regularly exceeds 1024. This survey addresses that bottleneck through three contributions. First, a methodological taxonomy of AI architectures for cascaded channel estimation is established, encompassing convolutional networks, generative diffusion models, graph transformers, deep unfolding, hybrid Deep Learning Compressive Sensing (DL-CS) frameworks, and Deep Reinforcement Learning (DRL). Second, a systematic qualitative trade-off analysis benchmarks these paradigms across pilot compression, inference speed, out-of-distribution generalization, and training label dependency. Third, each paradigm is critically evaluated against realistic 6G hardware impairments phase quantization noise, near-field spherical wavefront propagation in Extremely Large-Scale IRS (XL-IRS), high-mobility Doppler distortion, and wideband frequency selectivity using a formal four-category taxonomy. Five specific future research directions are identified: joint ISAC estimation, digital twin pre-training, neuromorphic spiking inference, score-based near-field channel imputation, and personalized federated learning.

297 SMITLe: A Robust Transfer Learning Algorithm for Multi-Class Classification with LS-SVM

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This paper, named SMITLe, is a new transfer learning method designed to weaken negative transfer in multi-class classification problems with LS-SVM. A method is needed that is capable of transferring knowledge from a source to a target task. The method developed here gives equal emphasis to both positive and negative transfer. This is achieved by optimizing the transfer parameters through a leave-one-out (LOO) error function. SMITLe's convergence is shown theoretically. This means its own risk can never be greater than non-transfer. Through rigorous experiments on the AwA and Caltech-256 datasets in positive, negative, and mixed transfer scenarios, we find that SMITLe outperforms several transfer learning baselines with significantly higher classification accuracy. Index Terms—Transfer learning, LS-SVM, multi-class classification, negative transfer, leave-one-out error, knowledge transfer.



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299 Trust as a Strategic Multiplier: Signed Edges and Fast Consensus in Evolutionary Networks

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This paper offers recommendations for trustworthy updates in the Iterated Prisoner's Dilemma through social net-works. In the sparse signed-trust Epinions network, classical imitation and Fermi rules induce low cooperation. The introduction of two new trust-sensitive mechanisms: pairwise trusted imitation and aggregate signed-neighbor payoff aggregation, dramatically enhances cooperation to above 90% and speeds up convergence from diverse initial conditions. With the addition of signed trust edges to the strategy update rules, the cooperation and consensus speed can significantly improve in a networked multi-agent system. Index Terms—Prisoner's Dilemma, social networks, trust, co-operation, evolutionary game theory, signed networks, consensus.

300 Subtraction-Guided Temporal Deep Learning for Automated Detection of New Multiple Sclerosis Lesions in Longitudinal MRI

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Multiple sclerosis (MS) progresses rapidly, which makes it crucial to effectively identify newly developed lesions in subsequent magnetic resonance imaging (MRI) scans. In addition, the slight variations in intensity over time, the very small size of the lesion, and the significant imbalance between the lesion and normal brain tissue make it challenging to detect new lesions automatically. To facilitate the automatic detection of new MS lesions from longitudinal MRI data, this study proposes the Subtraction-Guided Temporal Residual Attention U-Net (SGTRA) framework. The proposed approach explicitly captures the changes occurring between two time points by integrating baseline MRI, follow-up MRI, and a temporal subtraction image. By incorporating subtraction-guided temporal information into an attention-enhanced encoder–decoder model, the network can focus on regions indicative of potential lesion progression.A patch-based learning method is employed to efficiently detect the localized lesion features and address the class imbalance found in longitudinal datasets. The proposed method was examined on the MSSEG-2 longitudinal Multiple Sclerosis dataset, which includes paired MRI images from 100 patients. The results of the experiments prove that the model effectively identifies patterns of lesion evolution over time and provides strong detection performance. This approach achieved a patch-level Dice score of 0.73, showing reliable identification of lesion features. When evaluated against patients with lesions, the suggested method achieved a Dice score of 0.603, indicating precise localization of newly emerging lesions. Competitive performance is shown by comparison with current MSSEG-2 techniques, and efficient automated tracking of MS lesion growth is made possible by the subtraction-guided temporal learning approach.



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302 Metaheuristic Optimization of Electric Vehicle Charging Under Grid Capacity Constraints

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Uncoordinated charging of electric vehicles (EVs) places significant strain on the grid and can disrupt the power supply, leading to a complete blackout. Thus, this paper proposes a metaheuristic-based optimization technique for around 100 EVs in a coordinated charging scenario, thereby minimizing peak load, energy costs, and grid overload in the distribution system. The EV charging time is formulated as a multi-objective problem, with different grid capacities serving as feeder constraints. Different scenarios are considered, including grid capacity levels, tariff structures (e.g., time-of-use), and EV time of usage rates, which are optimized using Simulated Annealing (SA) and Genetic Algorithm (GA). In the simulation environment, the grid capacity scenario shows medium and comfortable conditions, as coordinated charging reduces peak demand by 30-40% compared to uncoordinated charging. While significantly more than 70% of the overload in a stressed grid scenario is reduced. In the comparative analysis, GA achieves lower objective values, resulting in approximately a 3% improvement and a faster convergence rate in the simulation environment. Whereas GA demonstrates robust global search capabilities, it comes at a high computational cost.

304 Design of an FPGA-Based CNN Accelerator for Defect Detection in Photovoltaic Panels Using UAV Imagery using Constrained Resources

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The increasing rate of solar power installation has led to the need to maintain and check the performance of the photovoltaic panels to obtain the best performance from them. Conventional techniques for inspection are mainly manual and not efficient for large-scale solar power plants. In this paper, we propose a system for automatic detection of defects in photovoltaic panels using Unmanned Aerial Vehicles (UAVs) for acquiring images. The method is based on the detection of various defects like cracks, hotspots, and dust accumulation on the surface of the panels. A wide variety of images is obtained from various sources, and then pre-processing is performed to standardize the data. A lightweight MobileNetV3 model is employed to classify the images, and the accuracy obtained is approximately 97%. The model is efficient and lightweight, and it is employed for the classification task. The model is then implemented on the Field-Programmable Gate Array (FPGA) platform, and the CNN accelerators are employed to obtain real-time and efficient results. The experimental results show that the proposed system is efficient in providing accurate results and improving the processing speed, and it is applicable for real-time monitoring in large-scale solar power systems.



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306 Gender Identification Using Orthopantomographic Images with Deep Transfer Learning Models

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Gender identification is the initial step in the human body identification in forensic sciences and it becomes crucial as well as challenging when the body is severely mutilated and is beyond recognition. In juvenile crimes, anthropological area, unaccompanied documents and massive disasters, gender identification is the primary phase to move forward the investigation. Since human teeth are the strongest and are least susceptible to changes over time. So, forensic odontology serves as a primary tool to solve this situation. This paper comprises the machine learning segmentation techniques for gender identification be developing a novel cascaded YOLO segmentation and CNN deep transfer learning model 'Gen-Net' and a comparison study is also shown with the existing pre-trained models for the same dataset training. Our dataset contains 1521 images, male-737 and female-784 provided by RIMS, Ranchi. Data is augmented and pre-processed and post augmentation images are 6084. The classification is done by Gen-Net model which performed far better than the pretrained transfer learning models. The primary differences between male and female characteristics in the shape of features (male: larger canines and pronounced wear, female: smaller teeth and less wear) are fed into the machine to generate identification results. This proposed solution can solve the precious efforts of the experts and increase the accuracy of the results. Withholding the accuracy of 99.54% this study demonstrates the effectiveness of integrating forensic odontology with medical imaging using deep transfer learning techniques for robust and scalable gender identification.

311 Efficiency of phytoremediation of Centella asiatica in household pig wastewater: A Pilot Approach to Sustainable Rural Development

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Rural pig farming wastewater poses significant environmental challenges because of its high nutrient load and the limited availability of affordable treatment technologies in small-scale agricultural systems. This study inves-tigated the influence of light availability on the phytoremediation performance of Centella asiatica cultivated in household livestock wastewater under laboratory conditions to assess its potential as a low-cost biological treatment option for sustainable rural wastewater management. Centella asiatica is a fast growing species characterized by strong flood tolerance, rapid regeneration after harvesting, and a conservation status classified as Least Concern in IUCN. A 30-day pilot scale experiment was conducted under two light regimes: supplemental LED illumination and ambient indoor light at 25°C. Each treatment included 30 glass containers containing 0.5 kg of gravel, 1.8 L of pig wastewater, and cultivated plants. Water quality parameters were monitored on days 0, 5, 10, 15, 20, 25, and 30 to evaluate nutrient removal efficiency and plant biomass response. Nitrogen removal was significantly enhanced under supplemental light. $NO3^{-}$-N concentrations decreased from 51.5 ± 2.1 mg/L to 17.5 ± 6.3 mg/L under LED treatment, compared with 20.5 ± 4.9 mg/L under ambient light. NH4+-N declined from 70.25 ± 0.3 mg/L to 5.7 ± 0.2 mg/L under supplemental light, whereas ambient light reached 16.3 ± 0.5 mg/L. Phosphate removal remained limited, with PO_4^{3-}-P decreasing from 103.5 ± 0.7 mg/L to 99.2 ± 3.9 mg/L under supplemental light and to 65.8 ± 0.2 mg/L under ambient conditions.



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315 Spectral–Spatial Mamba for Unsupervised Representation Learning on ENMAP Hyperspectral Data

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This work explores whether state-space models, specifically the Mamba architecture, can serve as a robust backbone for learning meaningful representations from hyperspectral satellite data without any labeled annotations, addressing the gap between the fragility of CNNs under spectral noise and the heavy data demands of Transformer-based approaches. We designed a Spectral–Spatial Mamba backbone with two dedicated branches — one modeling long-range dependencies across all 224 spectral bands and the other capturing global spatial structure within image patches — trained using a SimCLR-inspired self-supervised contrastive learning framework entirely without labels on a real ENMAP satellite scene acquired over the Meghalaya region of India. Representations were evaluated across four independent clustering algorithms and tested under realistic spectral perturbations. The most striking finding was spectral noise robustness — our Mamba backbone achieved a cluster flip rate of just 6.74% under spectral perturbation compared to 85.23% for the CNN baseline, representing a 12.6× improvement in representation stability held consistently across all four clustering methods. UMAP visualizations further confirmed that Mamba embeddings produce smoother and more globally organized embedding spaces that better reflect the gradual spectral transitions of real hyperspectral scenes. These results establish state-space models as a genuinely practical and robust alternative for unsupervised hyperspectral representation learning, particularly where labeled data is unavailable and spectral noise is unavoidable. This study is currently limited to a single ENMAP scene over one geographic region and future work should validate these findings across additional scenes, sensors, and downstream tasks such as land-cover classification.

319 A Enhancing and Securing Audio Decision Transparency Using TrustFusionNet

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Nonetheless, audio intelligence systems are beginning to assist in healthcare diagnosis, environmental detection, and affective computing, but due to inadequate interpretability, people are not yet able to trust deep learning forecasts. The current explainability frameworks do not consider attribution methods in isotope of the model training procedure, leading to unsteady explanations and unreliable performance across diverse audio fields. TrustFusionNet is a hybrid architecture of the predictive learning and explanation stability to single-mode analysis of English audio introduced. The architecture combines Attention based Convolutional Neural Network acoustic encoder, Temporal Transformer context module and gated demographic fusion mechanism. Attribution consistency regularizer imposes fidelity and stability restrictions on the training objective. Experimental results on several standard audio datasets show that it produces better predictions and is more resilient to explaining than traditional



explainability pipelines. The framework enhances reliable audio intelligence through tying the classification performance to reliable, fairness-conscious attribution conduct.

322 A Deep Learning Approach to Meitei Mayek OCR and TTS for Low-Resource Language Accessibility

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Visually impaired people face many challenges in daily life, one of which is the difficulty of reading text present in natural scene images (NSI). This problem extends even to native speakers who are not familiar with the script when a different script was used for reading and writing in earlier times, despite speaking the language fluently. To address these accessibility gaps, the proposed system converts NSI into audio using an integrated OCR and TTS system. The system utilized YOLOv8 to detect and segment words from the NSI, followed by a character segmentation algorithm to extract individual characters. A CNN-based classifier is then used to recognize the segmented characters, and the recognized text is converted into audio using a VITS-based TTS system. The YOLOv8 model achieved a mAP50 of 89.5% for text detection in NSI. The CNN-based recognition model achieved 94.1% validation accuracy. The VITS-based TTS system produced high-quality speech with natural prosody, successfully generating syllables not encountered during training. This system has the potential to improve accessibility for individuals with visual impairments by producing audio output of the text present in NSI.

325 SPOT-Based Active Learning for Efficient Deep Neural Network Training in Cybersecurity Threat Detection

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Detection of cybersecurity threats requires large amounts of annotated data for training deep neural networks (DNNs), which, however, cannot be collected via crowdsourcing due to the high cost of expert labeling. Existing active learning (AL) approaches become ineffective in cases with significant class imbalance (ratio of benign-to-attacks larger than 27) and non-uniform distributions of features, resulting in biased sampling that ignores critical yet rare attacks. We propose SPOT-Cyber, a novel AL approach using Space-Filling Optimal Transport (SPOT) for cybersecurity in three ways: (i) an optimal transport map T*, which maps the imbalanced distribution of features to a uniform one on the hypercube; (ii) Maximum Projection (MaxPro) space-filling, which guarantees coverage of all possible projections of the feature space; and (iii) a down-weighting procedure to direct the labeling effort towards under-represented classes. With a 590,540 transaction dataset, SPOT-Cyber reaches 43.9% F1 and 89.5% ROC-AUC at r = 500 samples, outperforming the best baselines by 34.0 pp F1 when r = 200. Our analysis shows that both OT alignment and space-filling are crucial parts of SPOT.



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326 MSTAN: Multi-Task Spatio-Temporal Attention Network for Student Engagement Behaviour Detection in Online Learning

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Detecting student engagement in online learning is a critical challenge. Existing methods often treat engagement detection as an isolated classification problem and struggle to capture the temporal dynamics of video-based behavioral cues. To address this, we propose MSTAN (Multi-Task Spatio-Temporal Attention Network), a novel deep learning framework that jointly predicts four affective states—Boredom, Engagement, Confusion, and Frustration—from student video clips. MSTAN integrates a ConvNeXt-Tiny spatial backbone for per-frame facial feature extraction with a Transformer-based temporal encoder to model behavioral dynamics. Our key contribution is the Cross-Task Attention module, which captures inter-dependencies between affective states (such as the inverse correlation between engagement and boredom). We employ Focal Loss with label smoothing to overcome severe class imbalance, alongside a dual aggregation strategy refined by Squeeze-and-Excitation attention for robust feature representation. Evaluated on the DAiSEE benchmark (9,068 clips, 112 students), MSTAN achieves a strong mean accuracy across all states: Boredom, Engagement, Confusion, and Frustration. Ablation studies validate our novel cross-task attention, face detection, and Focal Loss, while learned attention weights confirm the model captures psychologically meaningful correlations consistent with affect theory.

328 Synergizing Blockchain and Public Key Cryptography for Secure Cloud Authentication: A Comprehensive Review

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This review examines the integration of blockchain technology and public key cryptography (PKC) to enhance security in Cloud–Edge–End and Internet of Things (IoT) systems. It surveys decentralized authentication and access-control architectures based on permissioned blockchains, public platforms, and Directed Acyclic Graph (DAG)-based ledgers, emphasizing tamper-resistant auditability and smart-contractdriven policy enforcement. The review further analyzes lightweight cryptographic techniques, including optimized Merkle trees and zero-knowledge proofs, designed for resource-constrained devices. It also evaluates emerging post-quantum cryptographic approaches, particularly lattice-based schemes and Module Learning With Errors (M-LWE), to improve resilience against quantum adversaries. Finally, the paper identifies key research challenges related to scalability, interoperability, and the performance overhead of privacy-preserving mechanisms, and outlines directions for developing adaptive security frameworks for next-generation distributed systems.



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332 Design and Analysis of Intelligent Fractional Order PID Controller in Speed Control of DC Motor Using Metaheuristic Algorithm

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Fractional-order proportional-integral-derivative (FOPID) controller is a special kind of PID controller which has fractional integral and derivative order instead of integer along with five tunable parameters. The tuning can be achieved by various methods including classical as well as intelligent methods. This paper presents one of these intelligent methods to deter-mine five degrees of freedom (DOF) parameters, namely Kp, Ki, Kd, λ and μ of a FOPID controller via a recent population-based metaheuristic algorithm known as weIghted meaN oF vectOrs (INFO) algorithm, to achieve speed control of a Direct Current (DC) motor. The integral of time multiplied absolute error (ITAE) is considered as the objective function to be minimized in order to obtain the parameters of FOPID controller by INFO algorithm. A comparative analysis of the proposed INFO-FOPID controller has been performed with other existing controllers from literature such as Grey Wolf Optimization based FOPID (GWO-FOPID), Atom Search Optimization based FOPID (ASO-FOPID) and Manta Ray Foraging Optimization based FOPID (MRFO-FOPID) controllers in MATLAB/Simulink platform. In comparison to the pre-existing controllers that were taken into consideration, it has been noted that the closed loop system with the proposed INFO-FOPID controller has better response and performance, including shorter rise and settling times and comparable overshoot. Robustness analysis is also carried out with parameter variations of DC motor and the final simulation results validate the superiority of the proposed approach.

337 Deep Machine Learning-Driven Intrusion Detection with a Statistically-Robust Three-Stage Feature Selection

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Recent threat reports indicate the financial, political, and reputational damage caused by Distributed Denial of Service (DDoS) attacks. While the existing intrusion detection system (IDS) using conventional feature selection methods achieved satisfactory accuracies, these approaches often face key limitations: filter methods can overlook multicollinearity and retain redundant features; wrapper methods are computationally expensive and scale poorly with high-dimensional traffic data; and embedded methods may bias selection toward a specific model and yield unstable feature subsets across datasets collectively increasing over-head, hindering real-time deployment, and risking overfitting. To address these issues, this paper proposes a statistically grounded three-stage feature selection method which integrates Welch's t-test (to identify discriminative features under unequal variances), Variance Inflation Factor (to remove multicollinearity), and chi-square (to capture class dependence) that reduces computation while preserving discriminative power. Evaluated on the CICDDoS2019 dataset, the proposed method identified fifteen significant features. Eight machine-learning (ML) classifiers were then trained on this compact dataset; the Quadratic Discriminant Analysis (QDA) classifier achieved 99.43 ± 0.1410% average accuracy across four distinct test datasets. Beyond high accuracy, the significance of the proposed method lies in its efficiency (smaller, non-redundant feature set suited for real-time IDS), robustness (stable performance across multiple test



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splits), and interpretability (statistically justified selection), and it showed superior performance to existing works in a state-of-the-art comparison.

338 Local Interpretable Model-Agnostic Explanation Based Feature Selection for Detection of High-rate and Low-rate Network Attacks

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Distributed Denial-of-Service (DDoS) attacks continue to pose a substantial risk to network services, thereby creating significant challenges for cybersecurity systems. This research presents a machine learning-based approach to DDoS attack detection, with a focus on both detection performance and model interpretability. The methodology was evaluated using the CICDDoS2019 dataset, a comprehensive and current benchmark that encompasses diverse attack scenarios and typical network traffic patterns. To improve model transparency, we identified important features in the dataset using the Local Interpretable Model-agnostic Explanations (LIME) method. A dense Multi-Layer Perceptron (MLP) model has been trained using selected features, which can detect complex patterns associated with anomaly traffic. The experiment results indicate that the proposed approach achieves high accuracy precision and recall while also retaining the descriptiveness required for practical cybersecurity applications. In summary, this research successfully balances strong detection capabilities with a model that is easy to understand. This helps improve network monitoring and allows for a quicker response to DDoS attacks.

339 Safety Assistance and Guidance Engine

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The Safety Assistance and Guidance Engine (SAGE) is an online routing engine that enhances urban mobility by maximizing user safety while on the move. The engine combines real-time crime analytics information with geospatial routing algorithms to estimate safety changes throughout space and recommend the safest route available. The engine captures and considers the volume and type of crime data (e.g., crime type or severity, geographic and time aspects) to estimate risk in complex urban areas. Real-time crime information is also enabled through live RSS feeds from the National Crime Database, allowing real-time updates on crime data and automatic adjustment of routing based on changing safety conditions during a trip. Geospatial algorithms (e.g., hexagonal spatial indexing) have also been employed with the assistance of Uber's open-source H3 library, and accompanied with heatmap map visualization facilitates analysis while providing a simple user interface. The backend processing



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stack includes a Python Flask server with a PostgreSQL/PostGIS database for spatial queries; a Docker container deployment of the Valhalla routing engine that provides efficient use of routing from the geo-spatial cost estimates and allows route optimization based on travel risk for crime. Each roadway section incurs a penalty according to the distance to more recent and severe crime, effectively detouring the user away from higher risk areas. There is a frontend built in React, with Mapbox, to provide users with an interactive map interface to input their intended destination and origin and visualize safe routes in real-time. The SAGE system was quality tested with data from Delhi, India and shown to have a realistic tradeoff between distance and safety. In the experimentation, SAGE is able to reduce users' exposure to crime prone areas significantly with little change in travel distance or time such that it enables data driven safety focused routing in urban cities.

343 Deep Learning-Based Deep fake Image Detection using Transfer Learning and Hybrid Architecture

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Deepfake images become a serious concern due to their misuse in digital frauds. Identifying such manipulated images accurately is an important challenge in com-puter vision. This paper presents a relative study of deep learning models: CNN, Xception, and a hybrid CNN–Xception models. The models are trained and eval-uated on the real and fake Faces dataset, which contains identical distribution of real and AI-generated facial images. Results show that the CNN model achieves 95% accuracy, while Xception and the hybrid model achieve improved performance with 97% accuracy, higher precision, F1-score, recall and AUC values. Xception effectively captures fine visual features using transfer learning, while the hybrid model combines local and deep feature extraction to provide balanced performance. The results demonstrate that hybrid deep learning architectures improve reliability and robustness of deepfake image detection systems.

344 Mutation Analysis of Human Deoxyhaemoglobin (PDB: 4HHB) with Machine Learning and Structural Biology

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Proteins are central players in sequence dependent and 3D structure dependent biological function, and so such is disrupted by mutation leading to disease, e.g. sickle cell anaemia. This is structural biology and machine learning-based mutation analysis of human deoxyhaemoglobin (pdb4hhb), a central oxygen transport protein. We



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investigate the effect of missense mutations on the predicted secondary structures (α- helices, βsheets, coils) with the DSSP library by predicting 97% accurate secondary structure classes (H: helix, E: sheet, C: coil) using a TensorFlow Keras model. Metrics including mutation position, BLOSUM62 scores, hydrophobicity, weight molecular, and charge contrast were created to train Random Forest classifiers to attain 90% accuracy for clinical significance (benign/pathogenic), 78% for annotation of phenotype, and 86% for mutation origin (germline/somatic). Visual examination shows germline mutations are the most common (over 60% of variants), with the highest number of variants on chromosomes 1 and 2, and genes TTN and BRCA2 being hit the hardest. These phenotypes are cancer inherited and anemia and ""uncertain significance"" the clinical annotation most frequently used. Tools such as UCSF Chimera and PyRosetta assisted with 3D visualization and modeling of the mutations and for clinical annotation provided ClinVar. The approach to predicting effects from mutations described herein is a scalable one which can be used in precision medicine as well as in diagnosing genetic disease.

349 Multimodal Stress Detection and Adaptive Music Recommendation via Hybrid Audio-Visual Signal Fusion

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This paper aims to tackle the long-standing issue of collecting accurate affective information in a noisy environment in the context of multimedia signal processing. In this paper, a multimodal audio-visual framework for emotion recognition in a real-time environment is proposed. The visual modality is processed using a ResNet50 CNN model to extract spatial features. At the same time, the acoustic modality is denoised using Kalman filtering and MFCC feature extraction, followed by temporal feature extraction using a CNN-BiLSTM model. The fusion model uses a weighted late fusion method with confidence weights of 0.6 and 0.4 for the visual and acoustic modalities, respectively, to attain a classification accuracy of 95.4% for eight emotion classes. The experimental outcome reveals that the fusion model significantly outperforms the unimodal models. The extracted features are successfully interfaced with an external API.

350 Performance Analysis of Repairable Water Purification System

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In generally, water is a fundamental energy fluid that regulates temperature, and used for food preparation. Urbanization leads to an increase in the use of water resources. So, supplying clean drinking water is major concern



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in today's society. There are many reasons for water pollution such as industrial waste, domestic waste, agricultural waste, global warming, radioactive waste, etc. The water purification is the process of removing impurities from the water, and satisfies the government standards. Its performance depends on layout, design, operation, and maintenance. It ensures safe drinking water supply in rural and urban areas. There are different techniques for purification of water resources under limitations such as sand filtration, disinfection, solar purification, and iodization. Here, artificial intelligence is used to analyze the reliability measures of a multi-stage water purification system. The whole system has five main components such as pre-sediment filter, sand filters, activated carbon units, ceramic membranes, and UV disinfectors. All these components have two modes such as active mode and failure mode. If any component fails then whole system fails. So, AI informs about the working stability of the components and utilizes the strategy for their improvement. The regenerative point graphical technique is employed to analyze the system behavior under general distribution for failure and repair rates. The table and figure provide insight into optimizing maintenance strategies for sustainable operation.

353 Deepfake Detection in Multilingual Indian Videos

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With the rapid advancement of generative model development, generative models have become much closer to perceptual realism rendering conventional frame level deepfake detectors increasingly ineffective. Current state pipelines maximize spatial accuracy on an individual frame basis, whereas more subtle temporal anomalies (inconsistent micro-expressions, blink effects and motion edges) are still unexplored forensic evidence. In complex and multilingual and demographically diversified contexts like that in India, articulation, facial dynamics, compression on mobile standards, and variability of environment are also much different which further poses a greater challenge. This paper proposes a video-only factorized spatio-temporal deep fake detector that clearly divides spatial representation learning with temporal reasoning. Frame level embeddings are obtained with a ResNet-50 backbone followed by serial modelization of the embeddings using a Long Short-Term Memory (LSTM) network to demonstrate temporal coherence between the 16 uniformly sampled frames. Decoupling spatial and temporal modeling the proposed model improves interpretability reduces parameter redundancy compared to monolithic 3D CNN's and enhances generalization across heterogenous recording scenarios. The model is evaluated using the InDeepFake database comprising 20,000 multilingual Indian video samples. The achieved experimental performance is 94.3% accuracy, 0.962 AUC, 0.94 precision and 0.93 recall, 0.93 F1-score, and 0.89 MCC, which outperformed both powerful video-only baselines, MesoNet and RealForensics. The cross-validation (five out of five) ascertains robustness and low variance. The results confirm that explicit recurrent temporal modeling can help greatly in identifying deepfakes in the linguistically diverse and real-life conditions.

354 An Interpretable Ensemble Learning Framework for Cardiovascular Risk Prediction Using Explainable AI

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Cardiovascular disease has been one of the major causes of mortality across the globe. Therefore, a number of approaches has been proposed in the literature for its accurate prediction. However, the existing approaches are complex and time-consuming, which requires the development of a simple and accurate risk forecasting mechanism. The current work presents an ensemble-learning model in which Extreme Gradient Boosting and Random Forest classifiers are coupled to estimate the cardiovascular risks based on the a soft-voting hybrid system. High dimensionality was reduced by use of a hybrid feature-selection method that combined principal component analysis with recursive feature elimination, which reduced the number of features to 16 from 76. Simulations reveal the AUC score of 0.70, which highlight the effectiveness of the proposed model for cardiovascular disease predictions. SHAP-based interpretations are also performed for insights about important features and their significance.

364 Self-Supervised Contrastive Multimodal Graph Transformer for Financial Time-Series Prediction

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Stock price prediction is still a tough problem because of the nonlinear behaviors, noise and volatility of the financial markets. Traditional machine learning (ML) and deep learning (DL) models have difficulty in capturing both the temporal dependencies and structural information of financial time-series data. To overcome these problems, we introduce a Self-Supervised Multimodal Fusion Network for stock price trend prediction. Muti-scale Gramian Angular Field (GAF) time-series imaging based on Transformer fusion is constructed in the proposed framework to capture the spatial and temporal features of the financial data. Meanwhile, a Chunked Masked Time-Series Modeling (CMTM) approach is proposed as a self-supervised learning method for enhancing feature representation by means of reconstructing masked chunks of time-series sequences in pretraining. The multi-scale GAF representation can help the model learn the both local price movements and global market trends. Experimental results verify that the proposed method can improve the prediction accuracy, stability, prognosis capability in contrast with traditional single deep model, which offers an effective and reliable solution for financial prediction.

367 A Comparative Study of Machine Learning Models for Cardiovascular Disease Prediction with Feature Engineering

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Cardiovascular diseases are one of the main causes of death globally. Therefore, it is vital to have accurate and early prediction methods. There has been a lot of research into using machine learning (ML) techniques to predict heart disease. However, many of these studies use only a small number of features with limited comparative analysis and ablation study. This study develops a framework using ML that includes feature engineering (FE) and thoroughly evaluates the performance of popular ML models, such as Logistic Regression, Random Forest, Support Vector Machine (SVM), XGBoost, CatBoost, Gradient Boosting, and an Ensemble Voting. An ablation study is performed to observe the impact FE on the model's prediction capability. The results from the experiments show that the SVM model has the highest overall accuracy (86.96%). The results suggest that FE has a significant effect



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on the overall performance of the model and the improvement goes upto 8.11%. The proposed framework can be used as a robust and effective method for predicting the likelihood of heart disease.

368 A Multi-Class Parasite Detection Framework in Blood Smears Using EfficientNet-B3 and Multi-Phase Fine-Tuning

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Rapid and accurate detection of blood borne parasites is essential for the treatment of parasitic diseases such as malaria, babesiosis, and leishmaniasis. Traditional microscopic examination of blood smear is con considered as gold standard but can be laborious and time-consuminging, and vulnerable to errors. In this paper, we present a robust deep learning-based framework for multiclass parasite detection through fine-tuning with EfficientNet-B3 architecture true. The proposed framework applies multi-phase fine tuning on pre-trained weights with the consideration of para site-specific morphology. Furthermore, data augmentation and label smoothing techniques are applied to compensate for the class imbalance in training dataset. Experiment results show that our method obtained an overall macro F1 score of 0.982 and accuracy of 98.5terms of parasites and their various morphologies as well as leukocytes.

370 Analysis of IoT-based Smart Fire Detection System

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Fire remains to be one of the concern things that can occur to a house or a company. Every year, billions of rupees are ruined, yet the tragedy of it all is the loss of lives. Many of which might have been spared did our detection systems only prove a little quicker or wiser. The thing is that the majority of the typical smoke detectors are relatively weak as well as are inactive devices, which do nothing but make a racket. When no one is around to hear the alarm, it is not of much use. The devices are unable to ping your phone, also do not adapt to varying conditions, and it is difficult to actually learn or prevent future incidents. The paper dismantles the development and testing of an IoT fire detection system that we have developed. It purposely created to rectify those retro flaws. Rather than using a



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single simple sensor, we have four specialized ones combined: an MQ-2 gas, a DHT22 temperature and a humidity, an infrared flame sensor, and an optical smoke sensor. All this information streams to a NodeMCU ESP8266 microcontroller. We use a ""weighted fusion model"" which considers the combination of all the data and generates a fire risk score in real-time. A simple (0 to 1) scale provides a far better idea of the extent to which the situation is dangerous. To test the system as to its actual performance, we put it through half a dozen practical tests, ranging between simulated kitchen fires and gas leaks all the way to the ordinary cooking steam. The outcome was amazing that the system was able to detect all the actual fire events hitting a 100% recall with an overall accuracy of 95%.

371 A Lightweight Drone-Bird Detection Framework Using YOLOv11n with Enhanced Loss Optimization

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The exponential rise of UAVs in modern warfare, as witnessed in recent conflicts such as Iran-Israel-U.S. and Russia-Ukraine, has significantly trans-formed airspace security in the intelligent digital era. Small drones such as DJI Mavic 3, Ababil UAV, Shahed-136, and Black Hornet Nano have posed substantial threats due to their accessibility, high maneuverability, and use in suicide and precision-strike missions. These developments have highlighted the challenge of accurately distinguishing drones from visually similar objects, such as birds, in complex and dynamic environments while ensuring real-time response. Therefore, in order to classify them, a lightweight drone-bird detection framework based on YOLOv11n has been proposed integrating loss function optimization to improve localization accuracy. For this purpose, the baseline CIoU loss has been replaced with Shape-IoU to better capture object geometry through explicit modeling of width and height discrepancies. Further, a novel Class-Aware Shape Sensitivity Scaling (CA-SSS) loss has also been introduced. In CASSS loss, a shape-based penalties have been adaptively scaled according to class-specific characteristics which enable the differentiated optimization for deformable objects such as birds and rigid objects such as drones. Experimental results have demonstrated that the pro-posed approach enhances model performance. The baseline framework achieves a precision, recall and mAP@50 of 0.578, 0.656, and 0.612 respectively, while CA-SSS improves precision to 0.599 with balanced mAP@50. Conclusively, the propose drone detection precision improves, indicating reduced false positives and more reliable predictions in complex environments.

372 AI-Driven Multi-Band Hyperspectral Framework for Non-Ferrous Metal Classification in E-Waste Recycling

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With millions of tons of electronic waste (e-waste) generated annually, accurate identification and classification of discarded materials have become critical challenges for sustainable recycling. Among these materials, non-ferrous metals, particularly, copper, gold, silver, and palladium account for over 95% of the total metal value in e-waste,



making their efficient recovery highly crucial. However, conventional recycling techniques relying on RGB im-aging fail to accurately classify these metals due to their visual similarity, resulting in low practical efficiency. Therefore, hyperspectral imaging offers a promising solution by capturing detailed spectral signatures across a wide range of wavelengths, enabling improved discrimination between visually similar materials. This work presents a comparative analysis of classical machine learning and deep learning architectures across three spectral dimensionalities: RGB-equivalent (3 bands), multispectral (7 bands), and full hyperspectral (76 bands). Five classification models are implemented, including 1D, 2D, and 3D CNNs, along with Random Forest and Support Vector Ma-chine (SVM). Experiments conducted on the Tecnalia WEEE dataset demonstrate that classification performance consistently improves with an increase in spectral bands across all models. Traditional machine learning approaches, such as Random Forest, achieve an accuracy of 67.87%, whereas deep learning-based models, particularly the 3D-CNN, attain a significantly higher accuracy of 89.77% using full hyperspectral data. These results highlight the effectiveness of hyperspectral imaging combined with deep learning for accurate and efficient e-waste material classification. Keywords: Hyperspectral Imaging, Non-Ferrous Metal, Classification, CNN, E-waste.

374 A Hybrid Deep Learning Framework for Real-Time Network Intrusion Detection: Integrating CNN-LSTM, and Multi-head Self-Attention Mechanisms

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Modern network environments face a rapidly escalating volume and variety of cyber threats that conventional signature-based and rule-driven intrusion detection systems are no longer equipped to handle effectively. This paper introduces a unified hybrid deep learning architecture that combines three complementary mechanisms: a Convolutional Neural Network (CNN) for extracting local spatial correlations among traffic features, a Long Short-Term Memory (LSTM) network for capturing temporal dependencies across sequential connection flows, and a multi-head self-attention layer that focuses the model on the most discriminative portions of each traffic window. The system is tested on two popular benchmark da-tasets such as NSL-KDD and CICIDS2017 using organized preprocessing pipe-line-which includes Min-Max normalization, SMOTE-based minority class over-sampling, and Principal Component Analysis (PCA) to reduce features. On NSL-KDD, the proposed model is best with an accuracy of 99.1 percent, an F1-score of 98.8 percent, and a false-positive rate of 0.8 percent, surpassing standalone CNN, LSTM, SVM and Random Forest baselines on all reported metrics. An ablation study proves that every architectural



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element can bring real additive value, with the attention mechanism offering the most significant value to the rare and high-consequence types of attacks, like User-to-Root (U2R) and Remote-to-Local (R2L) intrusions.

378 SMS Spam Detection in Bangla and Assamese Using Handcrafted Feature Engineering

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Spammers cheat the public in a variety of ways, causing financial loss and mental health issues. They share sensitive information like bank details, OTPs, and other details that help spammers steal money. We aim to mitigate this problem by identifying spam messages earlier, before they reach the user's mailbox. We used Bengali and Assamese SMS to develop machine learning models in this paper. Patterns in spam messages have been studied, and 14 features were extracted to support effective spam classification. Experimental results showed that these hand-crafted features play a vital role in the spam classification process, yielding an accuracy of 99% with the RandomForest classifier.

379 Intelligent Career Guidance Systems: Integrating Generative AI, Skill Gap Analysis, and Hybrid Job Recommendations

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Most job sites in the modern world are nothing more than online bulletin boards; they find the relevant keywords in a resume and the relevant job description and leave it at that. They do not provide any practical advice, career development tips, or reasons why a specific job was suggested or how a prospective employee can increase their chances of getting the job. This paper proposes an AI-based career guidance system that goes far beyond job listing search. The system is based on Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG), as well as a two-part methodology that is a combination of two text analysis techniques that are complementary to each other. TF-IDF and Sentence-BERT (SBERT) to examine the resumes in a more detailed semantic scope, compare the skills of the candidates with the current needs of the market, and suggest specific courses or training to address the gaps in the identified skills. The platform also combines an AI Career Coach that is powered by GPT and can simulate role-specific interviews to practice and provides structured career mentoring based on the GROW model (Goal, Reality, Options, Way Forward). This is to ensure that the system does not



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appear like a search engine but more like a knowledgeable and ever-present guide. The results of experimental analysis of the dataset of 4,200 job postings and 1,500 anonymized resumes show that the accuracy of job matching is 86.5, and the search time of candidates is reduced significantly. These findings support the assumption that the integration of generative AI into job search services can address the mismatch between the current and the desired capabilities provided by job seekers and the current labor market requirements in a meaningful way.

380 Fixed-Size Chunking Outperforms Tuned Semantic Methods in QA Retrieval: A SQuAD Benchmark Study

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While Retrieval-Augmented Generation (RAG) proves to be a good way to ground Large Language Models through external knowledge, the factual accuracy of RAG depends on document segmentation during indexing. In this paper, we analyze how different chunking techniques affect retrieval efficiency. Specifically, we compared four different techniques of Fixed Size, Recursive, Sentence and Semantic chunking based on a randomly sampled 300 samples from the SQuAD dataset indexed on a vector-based FAISS database. In our findings, it was noted that the baseline Fixed Size sliding window technique performed better than any of the sophisticated semantic chunking methods, with the best average MRR@3 score being 0.7739. Our findings indicate that default semantic chunking suffers from 'Context Dilution', in which paragraphs not closely related to one another are combined to create context confusion.

381 Latency-Aware RAG: Characterizing the Tradeoff Between Retrieval Depth and Effectiveness

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The fixed-retrieval parameter (k) in traditional Retrieval-Augmented Generation (RAG), now moving into production quality; is becoming an obstacle to meeting Service-Level Agreements (SLA's) as RAG is moved into real-time applications. Therefore, this paper presents a novel-latency aware retrieval framework that dynamically adjusts document count based on time-budgets of each retrieval. We demonstrate the effectiveness of our method by testing it using the Sci-Fact data set. We show there exists no monotonic relationship between retrieval-depth and effectiveness. Findings in the research find that while increase in the latency budget increase the recall, the precision drops due to the excessive semantic noise. Experimental results show that the F1 Score peaks at a



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specific temporal inflection point (T = 0.05s in our setup) before degrading by over 90% at higher latency allocations. To mitigate this, we introduce a Tier-Based Throttling mechanism that optimizes the latency–quality tradeoff. This work proves that more computation does not linearly translate to better RAG performance and provides a blueprint for designing robust, time-constrained AI systems.

*** Only Abstract*



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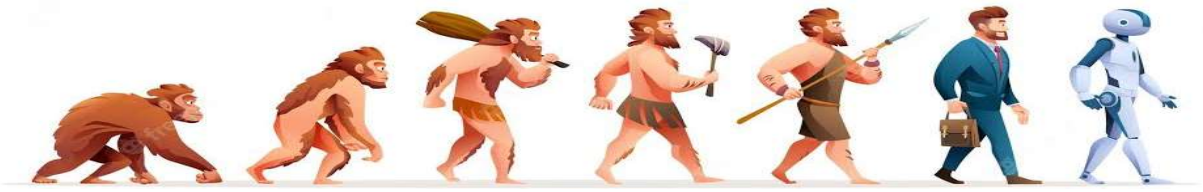
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