

3rd International Conference on

Hybrid Intelligence

Theories and Applications



October 30 - 31, 2026

School of Technology Management & Engineering (STME)
NMIMS Navi Mumbai, INDIA

SVKM'S NMIMS Deemed to be UNIVERSITY | NAVI MUMBAI

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Hybrid Intelligence: Theories and Applications (2026)

October 30 – 31, 2026

School of Technology Management & Engineering (STME), NMIMS Navi Mumbai, INDIA

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Dear Participants and Researchers,

Welcome to the book of abstracts for HITA2026! In this compilation, we embark on a journey through the diverse realms of soft computing, exploring its profound importance in addressing real-life challenges.

Hybrid Intelligence is a cooperative collaboration between Human and Artificial Intelligence in solving intelligence tasks. It is one of the leading international conferences for presenting novel and fundamental advances in hybrid Intelligence and their applications. It serves to foster communication among researchers and practitioners working in a wide variety of scientific areas with a common interest in improving environment using hybrid intelligent algorithms. Further it will help in exploring the broader concept of a smarter future, where intelligent algorithms are leveraged to enhance various aspects of society.

The scope of HITA2026 comprehends both theoretical aspects and practical applications of Hybrid Intelligent algorithms in all the spheres.

HITA 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 Hybrid Intelligence for Research & Innovations.

As you peruse these abstracts, envision the tangible impact of Hybrid Intelligence 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



Hybrid Intelligence: Theories and Applications (HITA2026) is now **Three years** International conference.

HITA serves to foster communication among researchers and practitioners working in a wide variety of scientific areas with a common interest in improving environment using hybrid intelligent algorithms.

Previous HITA conference was successfully organized at the following venue

HITA2024:	Shobhit University Gangoh, India	(October 18 - 19, 2024)

First International Conference on Hybrid Intelligence: Theories and Applications (HITA2024) was organized by Shobhit University Gangoh, INDIA in technical support of Instruments Research and Development Establishment (IRDE), Defence Research & Development Organization (DRDO), Dehradun, Dr B R Ambedkar NIT Jalandhar, National Institute of Technology Srinagar and Coal City University, Enugu, Nigeria, in collaboration of Baba Farid University of Health Sciences, Faridkot and supported by STEM-Research Society during October 18 - 19, 2024

HITA2025:	Sri Sri University, Cuttack, Odisha	(November 20 - 21, 2025)

2nd International Conference on Hybrid Intelligence: Theories and Applications (HITA2025) will be organized by Faculty of Engineering and Technology, Sri Sri University, Cuttack, Odisha, INDIA in technical support of Dr B R Ambedkar NIT Jalandhar, National Institute of Technology Srinagar and Coal City University, Enugu, Nigeria, INTI International University, Malaysia and Hasanuddin University, Indonesia supported by STEM-Research Society during November 20-21, 2025.

HITA2026:	STME, NMIMS Navi Mumbia	(October 30 - 31, 2026)

3rd in the series, HITA2026 held at School of Technology Management & Engineering (STME), NMIMS Navi Mumbai, INDIA in technical support of Dr B R Ambedkar NIT Jalandhar, National Institute of Technology Srinagar and Shobhit University Gangoh supported by STEM-Research Society in hybrid mode during October 30 - 31, 2026.

The conference had 5 keynote lectures presented by eminent academicians and practitioners from different parts of the world. Totally, 90 technical papers under 6 different themes of the conference were presented during the conference in 14 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 HITA2026 had undergone a peer-review process and subsequently revised before being finally accepted.

The credit of the success of the HITA 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 HITA Series as well.

Looking forward to have your significant contribution in HITA Series.



Message from the Conveners

Dear Colleagues and Distinguished Participants,

It is with great pleasure and enthusiasm that we welcome you to the Third International Conference on Hybrid Intelligence: Theories and Applications (HITA2026), to be held at School of Technology Management & Engineering (STME), NMIMS Navi Mumbai from October 30 – 31, 2026.

Following the success of the first two conferences in the series, 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 hybrid 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.

HITA2026 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 honoured to host this prestigious event in the vibrant city of Mumbai, renowned for its rich cultural heritage, cosmopolitan spirit, and dynamic blend of tradition and modernity. We hope that you will benefit from the enriching academic and professional interactions and take the opportunity to experience Mumbai's unique charm, iconic landmarks, and warm hospitality.

We extend our heartfelt gratitude to the organizing committee, sponsors, and all participants for their contributions and support in making HITA2026 a successful and memorable event. We look forward to your active participation and to a stimulating and enriching conference experience.

Warm regards,
Conveners, HITA2026



Invited Talks



Dr. Sankar Kumar Pal
ANRF Prime Minister Professor, Govt. of India
Emeritus Professor, Indian Statistical Institute(ISI)
Distinguished Scientist and Former Director & President, ISI

Prof. Sankar Kumar Pal, an eminent Indian computer scientist and distinguished Padma Shri awardee, is internationally renowned for his pioneering contributions to machine intelligence and soft computing. In recognition of his outstanding contributions to Science and Engineering, he was conferred the Padma Shri by the President of India in 2013. He is also a recipient of the prestigious Shanti Swarup Bhatnagar Prize (1990) and serves as an ANRF Prime Minister Professor of the Government of India, currently hosted at IIIT Bhubaneswar. He has served as the Director and President of the Indian Statistical Institute (ISI), Kolkata. His research spans pattern recognition, image processing, fuzzy neural networks, rough-fuzzy hybridization, granular mining, and machine intelligence. His pioneering vision also led to the establishment of the Machine Intelligence Unit at ISI in 1993 and the Centre for Soft Computing Research in 2004, reflecting his enduring impact on the advancement of computational intelligence. To mention about his educational background, Prof. Pal received a Ph.D. in Radio Physics and Electronics from the University of Calcutta in 1979, and another Ph.D. in Electrical Engineering along with DIC from Imperial College, University of London in 1982. He joined his Institute ISI in 1975 as a CSIR Senior Research Fellow where he became a Full Professor in 1987, Distinguished Scientist in 1998, the Director for the term 2005-2010, and the President for the term 2022-2024. He worked at the University of California, Berkeley and the University of Maryland, College Park in 1986-87; the NASA Johnson Space Center, Houston, Texas in 1990-92 & 1994; and in US Naval Research Laboratory, Washington DC in 2004. Since 1997 he has served as a Distinguished Visitor of IEEE Computer Society (USA) for the Asia-Pacific Region, and held several visiting positions in Italy, Poland, Hong Kong and Australian universities. Prof. Pal is a Fellow of the IEEE, the Academy of Sciences for the Developing World (TWAS), International Association for Pattern recognition, International Association of Fuzzy Systems, Asia-Pacific Artificial Intelligence Association, and all the four National Academies for Science/Engineering in India. He is a Foreign Member of the European Academy of Sciences and Arts. He has coauthored 21 books, about 500 research papers and 2 US patents in the areas of pattern recognition and machine learning, image/video processing, data mining, web intelligence, soft computing, bioinformatics, and cognitive machines.





Dr. Yash Chawla
Founder & CEO of SustematiQ,
Wroclaw University of Science & Technology, Poland

Dr. Yash Chawla is a multidisciplinary academic and researcher at Wrocław University of Science and Technology, Poland, with five academic degrees spanning engineering, renewable energy, business, and management. He holds a Ph.D. with distinction in Management and Quality Sciences from Wrocław University of Science and Technology and was recognised in 2020 as the university's best young scientist under 40 in this discipline. He leads the MoSAic research project, funded by Poland's National Science Centre, and coordinates the EU co-funded STEM for Humanities initiative. His research features in leading international journals, including the Journal of Business Research and Energy Policy, International Journal of Consumer Studies, Information Processing and Management. He is also the Founder of CRAFT (Collaboratory for Responsible and Future Technologies), promoting responsible technological innovation.



Mr. Aninda Bose
Executive Editor, Research Publishing – Books, Interdisciplinary Applied Sciences, Springer Nature Limited London, United Kingdon

Mr. Aninda 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.





Dr. Ramkumar Rajendran
Associate Professor, Centre for ET, IIT Bombay, India

Dr. Ramkumar Rajendran is an Associate Professor at the Centre for Educational Technology at IITB. Previously, he worked as a research scholar at Vanderbilt University in the USA and as a researcher at NEC Central Research Laboratory in Japan. His research interests include Learning Analytics, AI in Education, Affective Computing, Educational Data Mining, Personalised and Adaptive Learning Environments, Self-regulated learning, and MOOC Data Analytics. Ramkumar received a Ph.D. from IITB-Monash Research Academy, IITB, India, and Monash University, Melbourne. He served as Program Chair and Track Chair for several International conferences, including T4E, ICALT, LAK, and ICCE. He serves on the Board of Directors of the International Educational Data Mining Society (IEDMS), is a member of the Executive Committee of the EdTech Society, India, and the Asia-Pacific Society for Computers in Education (APSCE).



Dr. N K Harale
IT Governance and Cybersecurity Expert

Dr. Naresh Kumar Dharale is an accomplished information security professional and technology leader with extensive experience in cybersecurity, information systems auditing, data privacy, and IT infrastructure. He has served in senior leadership roles, including Senior Vice President and Head of Information Security at State Bank of India. His professional credentials include CISM, CISA, and DCPLA-DSCI, reflecting his expertise in information security governance, risk management, and data protection. He is also actively engaged in academic collaboration, technical advisory roles, and professional mentoring in cybersecurity and information technology.





Message
Hon'ble Chancellor, SVKM's NMIMS University

The world is witnessing an unprecedented convergence of human ingenuity and technological advancement. As Artificial Intelligence continues to transform industries and societies, Hybrid Intelligence offers immense potential by combining the strengths of human and machine intelligence to address complex challenges and create meaningful, sustainable solutions. Realising this potential requires not only technological innovation but also ethical responsibility, critical thinking, and interdisciplinary collaboration.

At NMIMS, we remain committed to promoting academic excellence, research, and innovation. We believe that higher education must empower individuals to embrace emerging technologies responsibly while developing the knowledge and capabilities needed to shape the future.

In this context, the 3rd International Conference on Hybrid Intelligence: Theories and Applications (HITA2026), organised by the School of Technology Management and Engineering (STME), SVKM's NMIMS, Navi Mumbai on 30-31st October 2026, provides a valuable platform for researchers, academicians, and industry professionals to exchange ideas, share research findings, and explore emerging applications of Hybrid Intelligence. Such engagements foster innovation and strengthen the connection between theoretical advancements and real-world challenges.

I extend my best wishes to the organisers, distinguished speakers, authors, and participants for a successful and intellectually rewarding conference. I wish HITA2026 every success in its endeavour to advance knowledge, foster collaboration, and contribute to a future in which human intelligence and artificial intelligence work together for the greater good of society.

With Best Wishes,

Shri Amrishbhai Patel
Chancellor
SVKM's NMIMS University





Message
Vice Chancellor, SVKM's NMIMS University

It gives me immense pleasure to extend my warm greetings to all participants, distinguished speakers, researchers, academicians, and industry professionals attending the 3rd International Conference on Hybrid Intelligence: Theories & Applications (HITA 2026).

I am particularly delighted to see the growing adoption of Artificial Intelligence (AI) and Machine Learning (ML) across diverse domains, including agriculture, healthcare, communication systems, and smart infrastructure. It is encouraging to see that HITA2026 revolves around these transformative technologies, bringing together researchers and practitioners to explore their potential in addressing real-world challenges, fostering innovation, and contributing to sustainable development.

This focus on emerging technologies and innovation resonates strongly with the vision of the School of Technology Management & Engineering (STME), Navi Mumbai, a constituent school of SVKM's NMIMS. Established in 2017, STME is committed to advancing technical education and fostering a culture of research, innovation, and excellence. As a vibrant academic and innovation hub, the school plays a significant role in empowering young minds through quality education and opportunities for meaningful research and technological exploration.

I commend the School of Technology Management & Engineering (STME), Navi Mumbai and the organizing committee for their dedicated efforts in organizing this international conference. Such initiatives greatly enrich the academic environment and strengthen collaborative research endeavors. I am confident that HITA2026 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. (Dr). Saugata Ray
Vice Chancellor
SVKM's NMIMS Deemed to-be University





Message
Campus Director, SVKM's NMIMS Navi Mumbai

It gives me immense pleasure to extend my warm greetings to all participants of the 3rd International Conference on Hybrid Intelligence: Theories and Applications (HITA 2026), being organised by the School of Technology Management & Engineering (STME), SVKM's NMIMS, Navi Mumbai, on 30–31 October 2026.

NMIMS Navi Mumbai has evolved into a multidisciplinary campus, bringing together diverse fields of knowledge and perspectives. We believe that education must extend beyond the boundaries of individual disciplines and the classroom, enabling students and researchers to connect ideas, apply knowledge to real-world challenges, and develop solutions with practical relevance. The School of Technology Management & Engineering (STME) at NMIMS Navi Mumbai campus plays an important role in advancing this vision by integrating technological learning, innovation and industry-oriented problem-solving.

The theme of HITA 2026 resonates strongly with this vision. As artificial intelligence advances, an important question is how we can combine the capabilities of intelligent technologies with human creativity, critical thinking and judgement. Hybrid intelligence offers a valuable framework for exploring this relationship and understanding how human and artificial intelligence can complement one another in addressing complex challenges. The conference provides an important platform for researchers and practitioners to examine these possibilities, exchange ideas and advance the application of hybrid intelligence across domains.

The Book of Abstracts reflects the range of research questions and applications being explored by the participating researchers. I hope the conference discussions will generate new insights, encourage interdisciplinary collaboration and contribute to the further development of this emerging field.

I commend STME and the organising committee for their efforts in bringing this conference together. I also thank the collaborating institutions, distinguished speakers, reviewers, delegates and authors for their valuable contributions. I wish HITA 2026 a successful and stimulating exchange of ideas, with outcomes that advance research and inform practice.

Best Regards,
Dr. Arun Sharma
Campus Director, SVKM's NMIMS Navi Mumbai





Message
Dean, Mukesh Patel School of Technology & Management (MPSTME) , NMIMS

It is a matter of great pleasure to note that the School of Technology Management & Engineering (STME), SVKM's NMIMS, Navi Mumbai, is hosting the 3rd International Conference on Hybrid Intelligence: Theories and Applications (HITA2026) on 30–31 October 2026. I extend my warm greetings and best wishes to all the participants, researchers, academicians, and industry professionals attending the conference.

In an era of rapid technological transformation, Hybrid Intelligence, which brings together the complementary strengths of human and artificial intelligence, is emerging as an important area of research and innovation. Its applications across healthcare, agriculture, industry, management, smart cities, sustainable infrastructure, and several other domains hold significant potential for addressing complex real-world challenges.

HITA2026 provides a valuable platform for researchers, academicians, industry professionals, and practitioners to exchange knowledge, present emerging research, and foster interdisciplinary collaborations. The conference reflects our commitment to advancing research and innovation in emerging areas of technology.

I extend my heartfelt congratulations to the organizing committee and the entire STME team for successfully bringing together the conference. I wish HITA2026 great success and hope that the conference leads to meaningful academic and research collaborations.

With Warm Wishes,
Prof. (Dr.) Koteswararao Anne
Dean, MPSTME



Message

Springer



It is heartening to see that **International Conference on Hybrid Intelligence: Theories and Applications** (HITA 2026) is growing every year and already reached third consecutive year of its organization. I am looking forward to an interesting and successful conference which brings together people from all over the world to exchange and discuss ideas in this interesting field of *hybrid intelligence* which combines human power and artificial intelligence to expand human thinking and find innovative solutions to numerous global challenges.

I am taking this opportunity to congratulate the organizing committee of HITA 2026 and all those associated members who have worked hard in organizing this conference.

The conference is the perfect forum for researchers and scholars to network, collaborate and meet world renowned experts to learn, share and solve problems through discussion. I expect several high-quality deliberations from specialists which will help students and young researchers to learn.

I convey my warm greetings to all the participants and congratulate organizing members for grand success of the conference.

All the best,

Aninda Bose

Aninda Bose
Executive Editor – Interdisciplinary Applied Sciences
Research Publishing – Books

Springer Nature Limited
London, United Kingdon
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Message from Conference Convener

It gives me immense pleasure to welcome all participants to the 3rd International Conference on Hybrid Intelligence: Theories and Applications (HITA 2026), being organized by the School of Technology Management and Engineering (STME), SVKM's NMIMS, Navi Mumbai, in collaboration with Dr. B. R. Ambedkar National Institute of Technology, Jalandhar, and Shobhit University, Gangoh, with the support of the STEM-Research Society.

HITA 2026 seeks to provide a multidisciplinary platform for exploring the theoretical foundations, emerging methodologies, and practical applications of hybrid intelligent systems across diverse domains like healthcare, agriculture, communication systems, smart infrastructure, and other emerging areas.

Hosting HITA 2026 at STME NMIMS Navi Mumbai reflects our continued endeavour to nurture a vibrant research culture, strengthen academic and industry partnerships, and create opportunities for innovation and knowledge exchange. We hope that the conference will inspire new perspectives and foster collaborations that extend well beyond the event.

This Book of Abstracts brings together a diverse collection of research contributions reflecting the breadth of inquiry and innovation in the field of Hybrid Intelligence. Each contribution represents the efforts of researchers committed to advancing knowledge and exploring solutions with the potential to create meaningful impact. I extend my sincere appreciation to all the authors for sharing their work, the reviewers for their valuable insights and careful evaluation, and the organizing and technical committees for their dedicated efforts in bringing this conference to fruition. I also gratefully acknowledge the support of our University Leadership, collaborating institutions, partners, and all those who have contributed to the successful organization of HITA 2026.

I am confident that HITA 2026 will serve as a stimulating forum for intellectual engagement, meaningful deliberations, and the development of enduring research partnerships. I warmly welcome all participants to Mumbai and wish them an enriching, productive, and memorable conference experience.

With best wishes for a successful HITA 2026,

Dr. Preeti Gupta
Associate Dean, STME, NMIMS Navi Mumbai



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23 AI-Powered Legal Intelligence: Automating Judicial Workflows for Scalable Justice Delivery

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The fast-growing amount of digital legal case files and documents is causing an ever-increasing strain on administration, making judicial administration more efficient, trans- parent, and easier to access, has created major challenges. The solution proposed in this paper is an AI-based judicial administration support framework that is focused on non-decisional court workflows while maintaining total judicial authority. This is not an AI that has any judgment-making authority, prediction of case outcome, or suggestions on a verdict. The system will operate under a decision-bounded, human-in-the-loop structure. The framework has interpreted classical NLP models and generative AI for the purposes of document summary, language simplification, and explainable AI. Additionally, in order to man- age an administrative process consisting of document ingestion, document pre-processing, document review, information retrieval, and document review routing, a controlled agentic workflow is used. The proposed methodology incorporates ethical safeguards and mandatory human validation to ensure that all parties involved in the adjudicatory process comply with applicable laws, regulations, and policies. This new approach to collecting and organizing publicly available judicial documents, longitudinal case law and to retrieving historical case law through established workflows, provides a basis for evaluating the administrative effectiveness and transparency of case organization in a non- predictive, compliance-based manner.

98 Using Agentic AI to Find and Fix Software Vulnerabilities

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The race against time in the detection and fixing of software vulnerabilities is a race that cannot be met by conventional means of software inspection. In this paper, we introduce agentic AI, or autonomous systems that do more than simply match patterns for reasoning through software vulnerabilities. Instead of conventional means of utilizing constant prompting with regards to LLMs, agentic AI makes use of planning and the integration of tools for independent scanning and



patching of the codebases. In this paper, we will also be discussing how software security has moved from reactive to proactive and how these autonomous agents work, as well as how their performance has been measured.

117 Employing PCA and LSTM for Intrusion Detection: The KDD99 Evaluation, Deep Modeling, Mathematical Foundations, and System Architectures

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A Comprehensive synopsis on Intrusion Detection Utilizing LSTM with PCA, The KDD99 Assessment, Improved Modeling, Mathematical Principles, and System Architectures. This research provides a comprehensive analysis of a PCA enhanced Long Short-Term Memory (LSTM) architecture for intrusion detection systems (IDS), evaluated with the KDD99 dataset. This paper is far more complete than the ones that came before it. It goes into further detail on how LSTM and PCA work together, the math behind cybersecurity pipelines, the arrangement of the datasets, the threat models, and the architecture diagrams. The numerical results of this investigation are derived solely from the sanctioned reference. Some of the index terms are KDD99, PCA, deep learning, cybersecurity, and intrusion detection.

143 A Machine Learning-Based Framework for Schizophrenia Classification Using Behavioral Features

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Schizophrenia is a severe and persistent mental disorder that presents behavioral abnormalities, emotional instability, and cognitive impairment, making an early and accurate diagnosis challenging. The intervention process may be slowed significantly by the traditional diagnosis procedure, which is mostly dependent on subjective evaluation and clinical interviews. The paper proposes a machine learning-based classification strategy for schizophrenia based on structured behavioral and psychological variables extracted. The intended method looks for behavioral indicators that can be seen in daily life, such as mood swings, sleep issues, emotional exhaustion, socializing behaviors, thinking, and functioning manifestations, to distinguish between schizophrenia and typical behavior. It has a robust



preprocessing approach, which can include categorical encoding, standardization, feature engineering through interaction, and handling class imbalance using the Synthetic Minority Over sampling Technique (SMOTE). PCA and Linear Discriminant Analysis (LDA) have been carried out for dimensionality reduction to avoid noisy data and improve the separability of classes. Various machine learning classifiers such as Logistic Regression, SVM, RF, and XGBoost have been trained and validated. Furthermore, a stack ensemble approach has been proposed for utilizing the strength of individual classifiers. The experimental results verify that models, mainly Random Forest and XGBoost, performed better, with accuracy greater than 83.9%, and the macro-AUC value is 98%. The proposed model has demonstrated the effectiveness of behavioral feature analysis and ensemble learning to effectively classify schizophrenia and provides an explicit framework to aid decision-making mechanisms of mental health systems.

164 Adaptive Online Learning Framework for Personalized Eye-Gaze Controlled Assistive Wheelchair Navigation

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Individuals who have extreme motor disabilities (like ALS, quadriplegia, or high spinal injury) have their eye muscles under complete control, despite non-response in the rest of the body. Although eye-gaze controlled wheelchairs are widely researched, the current systems are based on pre-trained and fixed models, which cannot adjust after implementation. This is a rigidity which leads to the undermining of performance in reality such as fluctuating light, fatigue amongst the user, slow variation in gaze behavior and head position. This paper suggests an Adaptive Online Learning Framework dedicating eye-gaze controlled wheelchair navigation that continuously personalizes its classification boundary by using implicit behavioral feedback in the course of its normal operation. It consists of a common webcam and MediaPipe Face Mesh with face and eye landmark detection, a multi-dimensional gaze feature vector and utilizes a MobileNetV3-Small convolutional neural network as the underlying classifier. There is a safety layer based on confidence that blocks ambiguous commands to the wheelchair motor controller. A real time online adaptation module only updates the final layers of the classifier with pseudo labels based on the user behavior. It is assumed that the improvement of the accuracy will be on the order of 95-97 percent to 97-99 percent between the two conditions of a static baseline and adaptation, and the fatigue robustness and false-activation reduction will be measured in increasing sessions. The proposed system demonstrates strong potential for real-time assistive navigation in practical environments.



168 Performance analysis of Quantum AI algorithms for recommendation and prediction in healthcare

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In this paper, we provide a comprehensive study of quantum artificial intelligence (QAI) algorithms for the recommendation and prediction systems in the health domain by analyzing empirical and theoretical results from pa-pers published between 2020 and 2025. We distinguish three main methodological approaches: (i) all-quantum algorithms (quantum neural net-works (QNNs) and quantum annealing), (ii) hybrid quantum-classical algorithms (variational quantum circuits (VQCs) and quantum-enhanced recur-rent neural networks (QE-RNNs)), and (iii) quantum-inspired classical algorithms. Analyzed studies provide various performance metrics: QE-RNNs achieving 99% accuracy while reducing training time by 27% in the context of COVID-19 outbreak prediction; quantum kernel methods achieving 2-4% accuracy gain over support vector machines (SVMs) for heart disease classification with a mean squared error (MSE) of 0.0017; and theoretical exponential speed-ups for large-scale recommendation problems using quantum collaborative filtering (CF). We identify seven future research areas: standard benchmarks, feasibility of quantum random access memory (QRAM), lack of interpretability, lack of longitudinal clinical trials, characterization of noise effects, solution for cold-start problems, and EHR interoperability challenges. Finally, we list six key open research challenges: the barren plateau phenomena, overcoming data loading bottleneck, quantum ad-vantage not guaranteed, resource estimations in fault-tolerant quantum computing (FTQC) era, complexities of hybrid quantum-classical co-design, and quantum regulatory and ethical issues.

171 Parameter-Efficient Fine-Tuning for Tabular Deep Learning: A Leakage-Controlled Empirical Analysis

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Parameter-Efficient Fine-Tuning (PEFT) has transformed model adaptation in natural language processing and computer vision, yet its viability for tabular deep learning under rigorous evaluation



conditions remains unexamined. We present the first controlled empirical study of Low-Rank Adaptation (LoRA) applied to a tabular multilayer perceptron under a domain-grouped, leakage-controlled evaluation protocol on the PhiUSIIL Phishing URL dataset (235,795 samples, 220,086 unique domains). Three contributions are made. First, we introduce a domain-grouped stratified splitting procedure combined with a univariate AUC leakage audit that removes seven high-discriminativity features (univariate AUC > 0.95), enforcing zero domain overlap across all data partitions. Second, an Enhanced PEFT variant employing semantic feature grouping achieves 97.98% parameter reduction (195,073 → 3,940 trainable parameters) with only 0.037% accuracy loss relative to full fine-tuning (McNemar $\chi 2$ = 4.65, p = 0.031; SHAP Spearman ρ = 0.9432). Third, SCARF self-supervised pre-training yields a +6.21 percentage-point accuracy gain at extreme parameter reduction (99.97%, rank r = 65), validating pre-training as conditionally necessary only at extreme parameter budgets. Our results establish that architecture-aware LoRA is a deployment-efficient alternative to full fine-tuning for tabular classification when evaluation methodology is sound.

174 YouTube Sentiment Analysis with Real-time Monitoring: A Practical NLP System for Comment Analytics and Early-Warning Alerts

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YouTube comments reflect audience perception in real time, yet most sentiment tools remain batch-oriented and disconnected from channel monitoring. This paper presents an integrated framework for lexicon-based comment analysis, historical tracking, threshold alerts, and dashboard visualization. Comments are ingested via CSV batch files or YouTube Data API v3 polling. Evaluation on 691,407 U.S. comments and metadata from ten countries reports throughput of approximately 600 comments per second on commodity hardware and 68.5% three-class agreement between Text Blob and VADER on 2,000 sampled comments. Docker packaging supports reproducible deployment. The contribution is an end-to-end monitoring workflow rather than a new state-of-the-art classifier, enabling creators and researchers to translate raw feedback into actionable insight.



178 Adaptive RAG: An Optimized Framework to Improve LLM Responses

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By grounding language generation in knowledge from external sources, Retrieval-Augmented Generation (RAG) addresses the problem of hallucinations in large language models (LLMs). Nonetheless, static hyperparameter configurations employed in current designs do not adequately account for different levels of query complexity and document structure. In this work, we present an Adaptive RAG framework that leverages run-time parameter interpolation to adjust the search process. The proposed framework is built upon a Universal Query Complexity Scorer that estimates the continuous complexity score for each query, facilitating flexible reasoning paths and retrieval depth without enforcing explicit rules. Furthermore, a similarity-based semantic hunking technique is integrated into our design to ensure topical boundaries are considered.
Our approach demonstrates a state-of-the-art result of 96.4% Precision@1 with a 4.9x boost in signal-to-noise ratio when evaluated over 460 queries covering various topics. Using the proposed Adaptive RAG, we cut down the number of unrelated contexts by 85%, while only adding 21.0 ms of latency.

188 ADEGuard: Transformer-Based NLP System for Detection and Severity Classification of Adverse Drug Events

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Adverse Drug Events (ADEs) are harmful reactions caused by medicines and represent a major challenge in modern healthcare systems. This paper presents ADEGuard, a transformer-based healthcare assistance framework that detects Adverse Drug Events using BioBERT-based Natural Language Processing. The system allows users to enter symptoms and medication details in natural language form through a web interface. The entered medical text is analyzed using a fine-tuned BioBERT model to identify possible adverse drug reactions and classify severity levels into None, Moderate, and Severe categories. A hybrid rule-based validation mechanism is integrated to reduce false-positive predictions and improve reliability. For severe cases, the system provides emergency healthcare assistance by retrieving city-based hospital information including emergency contact numbers, departments, and on-call doctor details from a structured dataset. The framework is implemented using Python, Flask,



HTML/CSS, and BioBERT. Experimental analysis demonstrates that the proposed system can effectively process biomedical symptom descriptions and provide real-time healthcare guidance and emergency support.

191 Integrated Hybrid Particle Swarm Optimization with Machine Learning for Intelligent System Performance Enhancement

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PSO (particle swarm optimization) is one of the best-used methods for solving complex optimization problems with a metaheuristic approach; also, ML (machine learning) plays an integral role in developing an intelligent system. This study aims to integrate PSO with ML and improve model performance and optimization efficiency through the use of PSO in hyperparameter tuning; feature selection; and model optimization. The integrated method takes advantage of PSO's ability to search the global space, combined with the ability of ML algorithms to make predictions, resulting in faster convergence times and lower levels of computational complexity. The paper provides real-world examples from numerous fields (health care, smart cities, industrial systems, etc.) where the integrated method is being utilized to validate the effectiveness of this integrated approach. The paper concludes with a discussion on benefits, drawbacks, and future research opportunities concerning PSO-optimized ML models and provides evidence of their improved efficiency and reliability by using PSO-optimized ML models as viable options in developing intelligent systems.

192 Hybrid Metaheuristics for a Resilient and Sustainable Agro-Food Supply Chain in North India: A Quadri-Objective Location-Routing Approach

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The North Indian perishable agro-food supply chains face well documented structural problems, such as post-harvest losses of 15-30% on produce, fragmented cold-chain coverage, increased logistics cost, and



increased greenhouse gas emission from refrigerated transport. The challenges require an integrated optimization framework that considers economic, environmental and resilience goals across all at the same time rather than separately. In this paper, a quadri objective mixed-integer location-routing model is proposed, which minimizes total logistics cost, carbon dioxide emissions, post-harvest-loss (PHL) based resilience risk and total delivery lead time. The problem formed is NP-hard, so we propose an Enhanced Multi-Objective Genetic Algorithm (E-MOGA), which combines NSGA-II with local search using elite-targeted Or-Opt and 3-Opt. The hybrid design improves convergence, widens Pareto-front diversity and improves the quality of the routes in a cold-chain environment. Results from computational experiments conducted on a realistic district network of Punjab show that the proposed E-MOGA algorithm outperforms the traditional NSGA-II algorithm and the MOEA/D algorithm with regard to the five-evaluation metrics: hypervolume, inverted generational distance, spacing, convergence speed, and mean PHL reduction. The algorithm has achieved a reduction in post harvest losses of 11.2% compared to the baseline losses of 18%, and has also reduced emissions and delivery lead time compared to the baseline routes. The results have implications for investment decisions in the cold chain, for incorporating carbon considerations in fleet planning, and for science based agro-food policy in India.

197 A Deep Learning Framework for Automated Detection of Counterfeit Indian Currency Notes Using Convolutional Neural Networks

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The problem of Indian currency counterfeiting is a significant problem to the economy and mistrust in financial systems. To counter this, there is need to come up with very effective counterfeit detection models. The article is the first to recognize fake Indian money with the assistance of Convolutional Neural Networks (CNNs), a deep learning model that is reputed to be quite efficient in working with images. It begins with high resolution images of banknotes being taken and then pre-processing where important features such as watermarks, security threads and serial numbers are obtained. The CNN structure will be trained using a huge set of original and counterfeit notes. These odd features help the model to be able to differentiate between authentic and fake banknotes. The proposed system is very accurate and it is promising to the banks, financial institutions as well as law enforcement agencies as the results of the experiment show. This research is a move towards the right direction to make sure that the integrity of Indian money is kept and people can more trust financial operations are obtained. The CNN structure will be trained using a huge set of original and counterfeit notes. These odd features help the model to be able to differentiate between authentic and fake banknotes. The proposed system is very accurate and it is promising to the banks, financial institutions as well as law enforcement agencies as the results of the experiment show. This research is a move towards the right direction to make sure that the integrity of Indian money is kept and people can more trust financial operations Keywords: CNN,



MobileNet, ResNet, Counterfeit Detection, Indian Currency, Deep Learning, Image Processing. Index Terms—Counterfeit Currency Detection, Deep Learning, Convolutional Neural Networks, Indian Rupee, Computer Vision.

198 PrescriptAI: An End-to-End Machine Learning Framework for Intelligent Medical Prescription Digitization and Clinical Safety Validation

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Medical prescriptions are important documents that doctors use to tell patients what medicine to take. These documents have a lot of information and mistakes can be very bad for patients. A lot of the time this information is still written down by hand and then typed into a computer by someone else. This takes a lot of time. Can lead to errors. This paper is about a system called PrescriptAI. PrescriptAI is a system that uses computers to read and understand medical prescriptions. It has parts, including a special way of looking at images a way of reading text a way of finding important information and a way of checking for safety. We tested PrescriptAI on 5,000 prescription images from three hospitals. It was very good at reading printed prescriptions getting 92.5% of the characters correct. It was also good at reading prescriptions getting 77.3% of the characters correct. This is much better than systems that just use one type of reading software. We also tested PrescriptAI on 100,000 prescriptions. It was able to read and understand 77% of them without any help from people. This means that it can save a lot of time reducing the time it takes to enter the information into a computer by 84%. PrescriptAI also has a way of checking how sure it is about what it has read. It uses a scoring system that is very good at agreeing with what people think. It can also detect when two medicines might not be safe to take. It does this by looking at a list of medicine interactions. All of these results show that PrescriptAI is a good system, for reading and understanding medical prescriptions. It can help doctors and patients by reducing errors and saving time.

215 Early Detection of Health Emergencies Using Public IoMT Data and Predictive Modeling

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The Internet of Medical Things (IoMT) has evolved fast and changed the modern healthcare system by allowing patients to be constantly monitored with the help of wearable sensors and smart medical



devices. Nevertheless, the early identification of critical health emergencies is a significant problem (as a result of the high rate of heterogeneous physiological data produced by the IoMT devices). It is known that this research suggests an intelligent predictive framework called the Predictive Health Emergency Detection using IoMT Data (PHED-IoMT) to detect the possibility of developing health risks at early-stages. The proposed system incorporates the acquisition of data in the form of IoMT, its preprocessing, feature extraction, feature selection, and predictive modelling to process physiological parameters like the heart rate, the body temperature, the blood pressure, and the oxygen saturation. The data obtained are refined with normalization and feature optimization methods in order to increase the efficiency of prediction. The predictive model constantly keeps track of the health conditions and measures the differences between the normal physiological patterns to ascertain the status of the patients as normal, warn, or critical. The proposed PHED-IoMT model is evaluated experimentally and compared to the current healthcare prediction models such as RemoteCare and IGPLONN. The system effectiveness is determined by the performance evaluation metrics which include prediction accuracy, precision, recall, F1-score, detection latency and false alarm rate. The findings indicate that the proposed PHED-IoMT model has better prediction accuracy, quicker emergency detection and lower rates of false alarms as compared to the available methods. The suggested framework thus offers a dependable and effective remedy to real-time health tracking and prompt emergency identification within the healthcare setting of IoMT-based strategies.

217 DetectAI AI-Based Document Forgery Detection System Using Deep Learning

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The digital technologies have been developed rapidly and have changed the way we produce, store and distribute documents. While this migration has improved efficiency and availability, it has also increased the risk of file falsification across sectors, including banking, criminal investigation, cover-up, and identification management. With the provision of high-resolution images, distinguishing between fine print and coarse print using traditional handwriting techniques has become increasingly difficult. A hybrid machine named DetectAI is proposed to detect forged virtual files which combine deep mastering with digital forensic techniques to improve detection accuracy and reliability. Instead of drawing on a single technology, the machine combines three key elements: Convolutional Neural Networks (CNN) to identify visual patterns, Error Level Analysis (ELA) to assess stress mismatches, and metadata analysis to identify photo editing opportunities. The CNN output is studied on recorded statistics to understand the differences between real and fake models based entirely on features such as texture versions and signature styles. ELA is used to identify areas in a photograph that could have changed, meanwhile



metadata analysis provides additional facts related to the original image and editing records. The experimental results show that the mixed strategy performs better than the signal strategies and reduce the false positive payoff by 92%. The system has strong capabilities for real world applications, report authentication, fraud detection and authentication protection.

225 Intelligent Predictive Health Monitoring Using Large Language Models

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The number of nuclear families is increasing, which often leaves elderly relatives to live alone. This situation causes a range of problems in their daily lives, such as health conditions, falls, and reduced movement, because there is no one there to take care of them. So, this paper presents an Ambient Assisted Living system that helps to reduce such circumstances by integrating three components: a Multi-Layer Perceptron for human activity recognition, an autoencoder model for anomaly detection which detects any unusual pattern in the data and the Mistral-7B Large Language Model, which converts raw output to human-readable health reports for caregivers. Thus, the report contains four sections: an overview of activities, Health observation, Anomaly analysis, and suggestions for the next day. Our classifier achieves 94.2 percent, compared to an SVM at 79.3 percent, across six activities where the system is trained on the UCI HAR Dataset. This shows that this combination of models creates a strong, accurate, and practical solution for monitoring the elderly in real life.

226 AgriDUB+: A Retrieval-Augmented Generative AI Framework for Smart and Resilient Agricultural Advisory Systems

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The application of digital decision aid systems in agriculture has been steadily increasing, but many of the current systems have been inadequate in terms of coverage and accuracy. Initially, there were rule-



based expert systems that provided decision support, but they needed to be updated manually and were not very effective outside their geographical areas. Later, machine learning models improved the accuracy of specific tasks such as disease detection and yield estimation, but they were inadequate because they did not provide interaction, explanation, or flexibility. More recently, conversational systems based on large language models have made it easier to access the systems, but there are concerns about the consistency of the information provided and the transparency of the reasoning process. In our research, we introduce AgriDUB+, an agricultural recommendation system that combines casual and conversational dialogue with a robust data infrastructure. It learns sentence-level embeddings from agricultural knowledge extracted from publicly available Kaggle datasets via a Sentence Transformer. To facilitate efficient lookup, these embeddings are stored in an FAISS index. When a user submits a question, the system passes the looked-up information as context to an LLM via the Groq API. This ensures that the answers remain grounded in the original sources while still making the conversation seem natural. In addition to recommendations, AgriDUB+ also offers confidence and analytical summaries to enhance trust, AgriDUB+ develops into a comprehensive advisory system suited to the practical agricultural scenario.

237 Interpretable Machine Learning for Prioritization of Genomic Risk Markers In Major Depression and Substance Use Disorder

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Major depression (MDD) and substance use disorder (SUD) often occur together, but the genomic clues that may connect them are scattered across millions of markers. This study was guided by a practical question: can interpretable machine learning help organize these scattered signals into a clear, reproducible ranking of markers for further psychiatric-genomics research? To address this question, the MDD and SUD genetic data were converted into a small set of clear measures describing the evidence carried by each genetic marker, such as how strong the signal was, whether the two disorders showed similar patterns, and whether their association signals pointed in the same direction. Several machine learning methods were then compared with much simpler ways of ranking the markers. Nearby markers were kept together during testing to reduce overly optimistic performance caused by closely related genomic information being split across data groups. The simple methods already performed very well, while machine learning showed only a small improvement on the main measure used to compare the rankings. Its main added value was that it learned how much importance to give several types of genetic evidence while still allowing researchers to see what influenced the ranking. Overall, the framework narrowed millions of markers to a more manageable set for further study. Some highly ranked markers were consistent with previous genomic research, while others emerged as candidates for further exploratory and functional investigation.



238 A Reproducible Open-Source Framework for Black–Litterman Portfolio Optimization and Numba-Accelerated Monte Carlo Risk Analytics

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Portfolio management today increasingly relies on quantitative methods, which have so far been the domain of the back rooms of large investment institutions. Researchers and students are left to their own devices when it comes to high-end portfolio analytics currently used by professionals. This paper describes the architecture, the math, and the empirical results of an open-source portfolio management architecture that incorporates risk measurement into the portfolio construction process. The system is composed of three main modules: a mean variance optimizer which is enhanced by a Black–Litterman implementation and Ledoit–Wolf shrinkage of the sample covariance matrix which is formulated as a convex quadratic program and solved by the OSQP solver; a parametric as well as a Monte Carlo-based Value-at-Risk/Expected Shortfall (VaR/ES) module which is accelerated 15–20 times by Numba compilation; and a drift-based rebalancing module which is enhanced by a Marginal Sharpe Ratio Improvement (MSRI) opportunity detection module which is guarded by a bootstrap confidence interval. The results for a set of 50 large-cap U.S. equities, which are split into 10 GICS sectors, were provided for an out-of-sample time series from 2021 until 2023. The Black–Litterman-based tangency portfolio has a Sharpe ratio of 1.01, i.e., a ROI of 51% over that of an equal-weighted portfolio. The maximum drawdown of the Black–Litterman-based portfolio is 6.5% percentage points below that of the equal-weighted portfolio. The Monte Carlo VaR/ES satisfies both backtests by Kupiec as well as Christoffersen at a 5% significance level. In contrast, the normal-distribution-based parametric VaR/ES fails both backtests. The results clearly demonstrate that high-end quantitative-finance models, which are currently used by portfolio managers, are also computationally tractable and empirically verifiable for anyone who wants to implement them in an open-source architecture that can be replicated by anyone.



248 Anjaye-Flex: AI-Based Intelligent Defense System for Tactical Battlefield Operations

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The rapid development of large language models has increased the production of highly fluent AI-generated text, creating a need for reliable identification of machine-generated and manipulated content. Existing detection methods can be sensitive to the generating model, domain, decoding strategy, and textual transformation, while many approaches provide limited interpretability at the feature level. This study proposes two complementary frameworks for AI-generated text detection: the Custom Deepfake Text Model (CDFTM) and the Anomaly Deepfake Text Model (ADFTM). CDFTM formulates detection as supervised binary classification using interpretable stylometric features, including sentence length, unique-word ratio, average word length, and average character count. ADFTM formulates authorship verification as a profile-deviation problem by constructing a reference representation of an author's writing style and computing an anomaly score for a questioned document. This workflow includes the steps preprocessing, feature extraction, normalization and feature selection. model training, classification, and threshold-based anomaly decision. The primary dataset used for our experiments contains 1,300 records, including 650 human-authored samples and 650 AI-authored samples. The primary contribution of this paper is a unified.an interpretable framework to directly compare human-written content with AI-generated content and use author profiles for anomaly detection. Analysis. The revised manuscript further defines the data source, experimental protocol, comparative evaluation requirements, and limitations of the approach. The study positions the proposed models as compact, explainable detection frameworks and emphasizes that independent cross-generator and cross-domain validation is required before widespread adoption detection frameworks and emphasizes that independent cross-generator and cross-domain validation is required before broader deployment.

251 An Improved Yellow Saddle GoatFish Algorithm for Solving Speed Reducer Design Problem

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Yellow Saddle Goatfish Algorithm (YSGA) is a well-established metaheuristic optimization algorithm, but it lacks diversification, exploring-exploitation ratio, and a premature convergence. In order to resolve these problems, this study suggests a Improved Yellow Saddle Goatfish Algorithm (IYSGA) where adaptive chaotic maps and dynamic subpopulation sizing are implemented to enhance the global search capability and solution
quality. IYSGA is implemented on the Speed Reducer Design Problem and compared with Particle Swarm Optimization (PSO), Differential Evolution (DE), and Yellow Saddle goatfish Algorithm (YSGA) using the same conditions. Findings indicate that the IYSGA performs well concerning the best fitness values, efficiency, and stability of the solution as compared to the other algorithms.

274 Data-Driven Retail Price Optimization: A Hybrid Econometric and Machine Learning Framework for Demand and Profit Maximization

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This paper focuses on retail price determination for maintaining optimal profit margins and efficient sales in a cafe context, and taking transactional, sales, and calendar data and applying statistical modelling, EDA, and machine learning to estimate price elasticities for burgers, coffee, and lemonade. The actualisation of these prices involves considering sales volumes and profit-making margins while taking into consideration outside factors such as holidays. It also points out the efficiency of using data in pricing, as it not only holds potential for principles of revenue generation, inventory control, and customer satisfaction, but also as a solution that may be implemented on a large scale. Moreover, in this research, the various models have been implemented, but among them XGBoost achieved the lowest RMSE of 7.4 and MAE of 5.8 with an R2 of 0.85, outperforming Random Forest and OLS.



276 Comparative Evaluation of Machine Learning Models for Foot Biomechanics Analysis

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Accurate prediction of biomechanical variables, such as foot pressure and stride length, enables early injury prevention, personalized interventions, and rehabilitative solutions for individuals. This comparative study was designed to identify the best predictive method for pressure and morphological variables.
Methodology: Pressure distribution and foot morphology were evaluated in the forefoot, midfoot, and heel regions using five machine learning models: Random Forest, Naive Bayes, k-Nearest Neighbors (kNN), Neural Network, and Support Vector Machine (SVM) and model's performance was evaluated using quality metrics, including accuracy, prediction reliability, and the area under the receiver operating characteristic (ROC) curve (AUC). Results indicate Random Forest as the best performing model with better accuracy and AUC in fore, mid and heel regions of the foot. Overall, Random Forest and kNN can be used to select morphological and pressure analyses of the foot and to develop rehabilitative solutions. Future work may include deep learning model such as convolutional neural networks, to improve the prediction of joint kinematics and kinetics.

281 LLM-Based Threat Detection in Cybersecurity: A Review of Methods, Frameworks, and Challenges

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In light of ever-evolving nature of cyberattacks, there have been questions raised whether the existing techniques relying on signatures and machine learning algorithms prove to be adequate for mitigating threats related to malware and zero-day ransomware. The reason behind is that language models (LMs) can provide a unified framework for security problems owing to their semantic understanding and sequence modelling capability. Thus, taking into consideration the above-mentioned points, we deliver an in-depth overview of the current state of affairs concerning large language model-based cybersecurity solutions. Specifically, we focus on the problem domains of malware detection, vulnerability analysis, and cyber threat intelligence and discuss LLMs frameworks that are used to solve these kinds of problems. We examine features of representation and learning, consider implementation aspects,



conduct a multi-dimensional comparison of selected frameworks and represent our findings in tables. In addition to that, we identify some key challenges, including model ageing, explainability-accuracy-dilemma, and scalability.

309 Mental Health Signal Detection in Social Media with Multi-Model Classification and Explainable AI

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Mental health illnesses like depression and suicidal tendencies can be identified through their expressions on social media platforms through natural language processing. Unfortunately, current solution suffers from limitations like binary classification, poor interpretability, and inability to mitigate clinically critical errors. In this paper, we propose a mental health signal detection model (Normal, Depression, Suicidal Ideation) based on 12,000 Reddit post. The proposed method is based on a RoBERTa-based classifier augmented with class-wise focal loss to enhance detection accuracy on challenging classes. To avoid high-risk misclassification, the proposed method also includes a keyword-based safety override. A multiple explanation framework consisting of SHAP, LIME, integrated gradients, and attentionbased explanations, as well as the innovative Cross-Method Agreement Score (CMAS), has been used to ensure reliability of generated explanations. We observe that the proposed solution reaches an accuracy level of 93.4% on the macro-F1 score and surpasses other baselines significantly. The proposed methods are also clinically evaluated and found to align perfectly with well-established psycholinguistic characteristics of patients and significantly minimizes clinical risk.

321 A Hierarchical Failure Mode and Effects Analysis Framework for Failure Propagation Assessment in Automotive Mechatronic Systems

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Integration of mechanical parts, electrical hardware, electronic con-trollers, communication networks, and embedded software is be-coming increasingly important in automotive systems. In addition to



improving vehicle functionality, a close connection between these components opens the door for failure consequences to prop-agate beyond the point of origin. Conventional Failure Mode and Effects Analysis (FMEA) is still a popular reliability-assessment technique, although it frequently ignores overall system risk and failure interactions across several engineering domains. For auto-motive mechatronic systems, a Hierarchical Failure Mode and Effects Analysis (H-FMEA) architecture is introduced. System goals, functional behaviour, and physical components are all connected via function-motion-action decomposition within a single analytical framework. Relationships between the mechanical, electrical, and control domains are examined via failure-propagation assessment. Cumulative system-level risk is represented by a Risk Priority Index (RPI). A car backlight switching system was chosen for assessment. The main sources of risk were determined by analysis to be power-supply interruption, wiring-harness deterioration, BCM communication errors, and connection failures. Corrective measures were created based on subsystem dependencies and observable failure characteristics. Following the implementation of mitigating measures, system-level RPI dropped by 83.1%. Improved fault detectability and decreased incidence levels accompanied risk reduction across all indicated failure types. Results show that when ana-lysing complicated automotive mechatronic systems, integrating hierarchical decomposition with failure-propagation evaluation has useful advantages.

326 Robust Skin Disease Classification Using Enhanced Dermoscopic Imaging and Deep Learning Techniques

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Skin conditions are a problem for people all around the world. If we do not treat them away, they can become very serious skin problems. Usually, doctors look at the skin to figure out what is wrong. This can be wrong sometimes and it can take a long time to find out what is going on. Now that computers are getting smarter, they can help doctors look at pictures of the skin and find out what is wrong. This is because computers can look at lots of pictures and find things that doctors might miss. So we made a computer program that can look at pictures of the skin and find different kinds of skin diseases. The HAM10000 dataset is used for testing, training, and assessing the model. Results reveal that the technique significantly improves accuracy, allowing complete categorization and reliable forecasting compared to traditional methods. Three transfer learning models VGG-16 Xception and MobileNetV1 have been fine-tuned and a custom CNN model with simple architecture has been proposed for evaluation. The system achieves better stability and broader applicability with the help of pre-processing, data balancing, and CNN-based learning. Dermatologists receive faster results, which also



benefits online health camps where medical support is limited. The proposed CNN model has a accuracy of 73.28% whereas the fine-tuned Xception showed 74.43% accuracy performance.

347 Optimal Performance of Networked Control System under Attack with Disturbance Mitigation Approach

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The networked control system (NCS) are categorized to perform optimally and collectively with all elements of NCS tightly coupled through network. The robustness and transient performance of NCS is affected through attack and uncertain conditions. In this article to counteract the impact of attack a disturbance rejection control algorithm is implemented that provide the robustness and improved transient performance. To estimate the system states affected with attack a Luenberger observer method is used. The rise time is 6.181s and overshoot is approximately 19.89% at time 15s with proposed method and the error performance index is 11.4060 in case of only proportional integral derivative action and with disturbance rejection control algorithm the error performance index is 10.7828. To present the efficacy of pro-posed method a NCS is simulated using MATLAB Simulink/Control System Tool. Through analysis of simulation results it is inferred that proposed disturbance rejection control algorithm exhibits fast convergence and transient robustness with small tracking error and attack rejection.

348 Hybrid Intelligence Driven Behavior-Aware Blockchain Framework for Secure Healthcare IoT

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The rapid adoption of Healthcare Internet of Things (H-IoT) has significantly improved remote healthcare services; however, it has also introduced critical security and access control challenges due to dynamic user behaviour and heterogeneous connected devices. Conventional authentication mechanisms



primarily rely on static identity verification and often fail to adapt evolving security threats. This paper proposes a hybrid intelligence-driven behavior-aware blockchain framework for secure and adaptive authorization in H-IoT environments. The framework integrates behavioural analysis, contextual awareness, device trust, and blockchain trust to compute an Access Confidence Score (ACS), enabling dynamic access decisions based on the credibility of each re-quest. A permission blockchain securely records authorization decisions to en-sure integrity, transparency, and accountability while preserving healthcare da-ta privacy. Experimental evaluation demonstrates that the proposed framework achieves 98.3% authorization accuracy, 32 ms authorization latency, 1082 re-quests/s throughput, and 27 ms computational overhead, that outperforms existing H-IoT security approaches.

358 Spatial Association based Fusion model for Traffic Violation in Real Time

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Traffic violation detection plays a vital role in intelligent transportation systems by improving road safety through automated traffic monitoring and law enforcement. However, most existing approaches are limited to detecting individual violations and rely on sequential processing pipelines, which increase inference latency and hinder real-time deployment. This paper proposes a dual-model parallel-inference traffic violation detection framework that simultaneously performs traffic object detection and license plate recognition using independent YOLOv8-based models. The outputs of both models are integrated through a spatial vehicle-plate association module, while a rule-based reasoning engine identifies multiple traffic violations, including helmet violations, triple riding, red-light jumping, stop-line violations, illegal parking, and modified vehicles. The proposed architecture enables concurrent execution of object detection and OCR, reducing processing latency while maintaining reliable vehicle identification and comprehensive traffic scene analysis. Experimental evaluation demonstrates an overall precision of 84.2%, recall of 78.1%, F1-score of 81.0%, mAP50 of 81.2%, and real-time inference speed of 27.6 FPS. The integrated framework further achieves an overall traffic violation detection accuracy of 92.7%. These results demonstrate that the proposed framework provides an accurate, scalable, and computationally efficient solution for intelligent traffic surveillance and automated traffic law enforcement.



381 Selection of the Method of Transportation of Oil and Oil Products Through a Pipeline Network: An Approach Using the CROWM Method

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Pipeline transportation selection in large-scale infrastructure net-works involves multiple conflicting operational criteria and typically lacks publicly available granular performance data, making objective weighting methods essential. This study applies the CROWM method (Communalities on Ranking and Objective Weights) to the strategic selection among 40 pipeline archetypes in the Brazilian energy sector. CROWM integrates Principal Component Analy-sis (PCA) with the Method Based on the Removal Effects of Criteria (MEREC) to produce objective criterion weights that capture both the marginal performance impact of each criterion and the latent inter-criterion correlation structure, elimi-nating subjective pairwise comparisons. Performance scores were elicited from a validated expert panel (n = 25; S-CVI = 0.97) populating an 8-criterion decision matrix. PCA extracted two components explaining 67.9% of total variance: a technical-operational dimension (PC1, 36.0%) and a cost-environmental trade-off dimension (PC2, 32.0%). Integrated CROWM weights ranged from 9.3% (Energy Efficiency) to 15.5% (Transportation Cost). Pipeline AF, a large auto-mated pipeline with integrated real-time monitoring, ranked first (P = 0.969), fol-lowed by Pipeline AN, a high-pressure natural gas pipeline for high-density areas (P = 0.836). Rankings were robust across 32 weight-perturbation scenarios (Spearman rho >= 0.998) and significantly correlated with TOPSIS (rho = 0.573) and VIKOR (rho = 0.643), both p < 0.001; the moderate inter-method coefficients reflect CROWM's distinct aggregation via PCA factor scores and communalities, capturing structural relationships beyond distance- or compromise-based meth-ods. Contributions include a replicable objective-weighting MCDM framework for data-constrained contexts, a content-validity protocol for high-consensus ex-pert panels, and a robustness architecture for pipeline logistics.

382 Transpetro Easy Route: Development and Application of a Web-Based Logistics Decision Support System for Pipeline Spare Parts Management

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The maintenance of critical equipment in pipeline infrastructure requires spare parts to be stored at locations capable of meeting emergencies within predefined time windows. At Transpetro, Brazil's



largest pipeline and terminal operator, the operational criterion for mechanical pump seals establishes a maximum road travel time of 2 hours and 30 minutes between the storage terminal and the requesting terminal. However, no formal system existed to verify whether designated storage terminals met this criterion. This paper presents Transpetro Easy Route, a web-based system developed in Python/Streamlit that integrates two routing APIs, OpenRouteService and Google Maps Distance Matrix API, to calculate real road distances and travel times be-tween operational units. Developed according to the Design Science Research Methodology (DSRM), the artifact was applied to real Transpetro data: it analyzed approximately 30 route pairs, identified 2 non-compliant terminals, and resulted in the formal redirection of storage to compliant terminals, with documented managerial validation. The solution established a precedent for systematic logistical compliance verification of other critical materials. The software is registered with Brazil's National Institute of Industrial Property (INPI) and available as open source.

386 An Explainable End-to-End Multi-Modal QR Phishing Detection System Integrating Visual, URL, Behavioral, and Threat Intelligence for Real-Time Cybersecurity Decision Support

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Quick Response (QR) codes have been widely used in digital payments, online authentication, e-commerce, and information sharing, making QR code–based phishing attacks, known as "Quishing," more prevalent than ever. Malicious QR codes differ from traditional phishing attacks by hiding phishing URLs inside encoded images that are not immediately obvious to the user or conventional URL-based detection systems before they are used. Current detection methods are mostly based on a single modality (QR image analysis, URL lexical features or webpage content) and are not able to capture the characteristics of the modern phishing campaigns. In order to tackle these shortcomings, this paper introduces a Cross-Modal Attention Framework for Multi-Modal QR Phishing Detection which combines four complementary intelligence sources: visual representations of QR codes, URL intelligence, behavioral analysis of web pages, and threat intelligence. The framework uses EfficientNetB0 to extract visual embeddings from QR images, adds handcrafted and semantic URL features, adds behavioral indicators through safe static webpage analysis, and adds domain reputation and threat intelligence information to the detection. These are heterogeneous representations projected into a common latent space and fused through a cross-modal attention mechanism which is able to model inter-modal relationships while maintaining modality-specific properties. The proposed framework is tested on the CIC-Trap4Phish dataset with more than one million QR code samples, and multimodal fusion is



conducted on the aligned subset of 100,000 samples. The experimental results show that the proposed framework can achieve a validation AUC of 98.16% and an accuracy of 93.11%, which is better than the individual modality-based models, and also offers a scalable framework for explainable and robust QR phishing detection.

394 Chronic Kidney Disease Prediction Based on Machine Learning Algorithms: A Comprehensive Review

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The early stages of chronic kidney disease (CKD) have few symptoms, and therefore are often not diagnosed until much of the kidney function has been lost, which may be permanent. Therefore, early detection is very important as it will help to minimize the therapeutic expenses, prevent progression to end-stage renal disease and avoid dialysis. In recent years, machine learning (ML) has been identified as a potential early-stage screening tool for CKD and has matured from basic classifiers to ensemble classifiers, deep learning to hybrid ML and most recently explainable AI (XAI) systems. In this review, the literature on the subject from 2016 to 2026 is summarized and divided into 3 phases: the early classical-classifier studies (2016-2018); the growth phase (2019-2022) with ensembles and deep learning; the current maturity phase (2023-2026) with hybrid ensembles-deep learning and explainability techniques. Instead of summarizing individual studies, this work classifies the studies into four algorithmic families: traditional supervised models, ensemble approaches, deep architectures and hybrid/explainable systems, and compares across studies the datasets, pre-processing pipelines, feature-selection strategies, and performance metrics such as accuracy, precision, recall, and Area Under the Curve. Results indicate that ensemble and hybrid deep ensemble models are general-purpose models that always give the highest reported accuracy, at the cost of interpretability. Issues persist in the literature such as imbalanced classes, small and non-diverse data sets (many still using the 400-record UCI benchmark), little external validation and limited transparency in model. Based on these deficiencies, this review suggests that the most promising future directions to address these deficiencies are federated learning, explainable AI, and multimodal data fusion (which combines clinical, imaging, and genome data).



400 Perturb-Engine: A Semantically Validated Framework for Evaluating the Robustness of Large Language Models Under Input Perturbations

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Existing evaluations of Large Language Models (LLMs) generally report aggregate accuracy without assessing whether models remain consistent under meaning-preserving variations of the same question. This paper proposes Perturb-Engine, a controlled evaluation framework that generates lexical, syntactic, and pragmatic perturbations and validates them using semantic similarity and Natural Language Inference (NLI). Four open-weight instruction-tuned LLMs were evaluated on 500 MMLU questions. The results show that syntactic perturbations caused greater prediction instability than lexical and pragmatic perturbations, while aggregate accuracy alone failed to reveal these behavioural changes. One model maintained the same overall accuracy despite prediction changes for individual questions, demonstrating that aggregate accuracy alone is insufficient for robustness evaluation. The proposed framework evaluated 500 benchmark questions, generated 1,500 validated perturbations, and analysed 8,000 model predictions to provide a comprehensive assessment of LLM robustness.

401 Multi Stage Alzheimer Disease Detection through Patient Level Splitting using Explainable Neuroimaging Pattern Learning

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Early identification of Alzheimer's disease (AD) is essential as it is a progressive neurodegenerative disorder that affects memory, cognitive function, and daily living activities. Clinical intervention is quite time taking but the analyzing of brain Magnetic Resonance Imaging (MRI) scans is often challenging as there is a minute disorder which can be missed by the human eye while analyzing. Even though deep learning has shown promising results in automated Alzheimer's disease classification, many existing studies primarily emphasize overall accuracy while providing limited comparative analysis across different architectures and evaluation metrics



This study describes a transfer learning-based framework multi-class Alzheimer's disease classification using the ImagesOASIS MRI dataset. Combination of preprocessing and augmentation pipeline was developed to have a consistent training condition across selected models. Five different learning architectures were trained and evaluated using identical conditions namely ResNet-50, SE-ResNet-50, DenseNet-121, DenseNet-201, and EfficientNet-B2. Model performance was evaluated through multiple evaluation metrics Accuracy, Precision, Sensitivity, F1-Score, Balanced Accuracy, AUC-ROC, and Cohen's Kappa to obtain understanding of the classification.
The comparative analysis provides valuable insights into the robustness and generalization ability of each architecture under a common evaluation framework. The proposed solution highlights the importance of standardized benchmarking and comprehensive performance to develop a reliable system for Alzheimer's disease classification using brain MRI images.

405 An Integrated Machine Learning Model for Cognitive Attention Level Monitoring

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Humans cannot stay focused all the time. Their attention may decrease due to the factors like tiredness, stress, boredom, or distractions which influence their task performance, efficiency and decision-making. To understand these is important because attention affects how well a person performs a task. In this paper, we propose a multimodal deep learning approach to continuously predict human attention from Electroencephalography (EEG) signals and RGB video features from the face. EEG provides insight into cognitive engagement across frequency bands including delta, theta, alpha, beta, and gamma, but lacks behavioural and motion context. RGB facial video encodes facial expressions, eye-gaze, head pose, and micro-movements are externally observable correlations of internal cognitive states. Combining both modals enables a more complete and robust attentional representation. The proposed framework integrates neural activities recorded by EEG with behavioral cues such as facial expressions, eye-gaze and head pose from facial video to enhance the prediction accuracy. Deep learning models are used to encode EEG features and visual features separately, with a cross-modal attention mechanism to fuse the two to learn complementary representations. The regression model is used to estimate the continuous attention scores, allowing real-time attention monitoring. The proposed approach is tested on multimodal attention data sets, and compared to unimodal approaches on regression performance metrics showing better robustness and prediction accuracy. The framework provides a non-invasive and scalable method for intelligent attention which has potential for applications in online learning, productivity in workplaces, driver monitoring, and human–computer interaction.



408 Empirical Assessment of Short-Term Linear Dependencies in Blue-Chip Indian Technology Stocks Using Box–Jenkins Models

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The present work formulates an extremely rigorous univariate ARIMA model that has been optimised to predict the movement in multi-decade, large-cap equity prices, based on 6,531 data points representing daily trades on TCS between 2004 and 2026. In order to fix the problem of non-Gaussian innovations and frequency mismatches arising due to practical feeds, a cleansing process has been designed using linear interpolation on a rigid business calendar domain, natural log variance stabilisation, and statistical Winsorisation at a significance level of 1 %. The additive seasonal decomposition model with shows negligible annual seasonality wave amplitudes, thus justifying a simple ARIMA model over complicated seasonal methods. After testing for stationarity using the Dual tests consisting of the Augmented Dickey-Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test, a grid-based search minimizes the Bayesian Information Criterion (BIC) to select the optimum architecture. Without over-fitting on market noise. The post-estimation diagnostic tests for residual randomness include the Ljung-Box Q-test, which verifies convergence to Gaussian white noise. When tested on an unadulterated 20 %. validation period for its accuracy, the predictions made from the rescaled model are seen to be very accurate, with a mean absolute percentage error of less than the threshold acceptable within academia. Operational stability is assured through the 30-day rolling average window of MAPE that proves the prediction process to be totally free of bias. Demonstrating that predictive engine remains entirely unbiased and resilient across changing market regimes.

409 DeCNA-Net: Differential ConvNeXt Attention Network for Interpretable Multi-Class Skin Disease Classification

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Skin disease affects millions of people worldwide, making it a significant global health challenge. In remote locations, the availability of dermatologists is limited, which causes delays in diagnosis. To address these challenges, this paper proposes DeCNA-Net, a multi class skin disease classification based



on the ConvNeXtV2 backbone integrated with an enhanced Differential Context Channel Attention (DCCA) module. Conventional channel attention methods that mainly rely on global feature statistics, the proposed DCCA captures the difference between highly activated foreground (lesion) regions and weakly activated background regions within each channel, enabling the net work to focus more effectively on lesion specific features. The enhanced DCCA module further incorporates dual pooling, cross-stage context prior, intra block dense skip connections, top-k channel sparsification, and a learnable residual parameter for progressive multi scale feature refinement. Experimental results demonstrate that the proposed DeCNA-Net achieves 90.52% classification accuracy with a mean AUC of 0.9876, demonstrating its effectiveness as an accurate, robust and interpretable solution for automated skin disease classification.

410 Review of Brain–Computer Interfaces: Recent Advances, Emerging Trends, and Future Perspectives

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Brain-computer interfaces (BCIs) have advanced from lab prototypes to clinically proven devices that restore voice, movement, and digital access to people with severe paralysis. This study summarises the technological architecture, signal acquisition modalities, neurophysiological paradigms, signal processing pipelines, and recent advances that comprise the current BCI landscape. We investigate non-invasive (EEG, fNIRS, MEG), semi-invasive (ECoG), and invasive (Utah array, Neuralink, endovascular) acquisition strategies, as well as the computing machinery that converts neural activity into intent: artefact removal techniques (ICA, ASR), feature extraction (CSP, FBCSP, Riemannian geometry), and modern deep learning (EEGNet, convolutional transformers, EEG foundation models). The authors focus on intracortical speech neuroprostheses that decode attempted speech at 62 words per minute, streaming brain-to-voice synthesis with sub-second latency, multi-decade BrainGate consortium data indicating decoding stability, and the advent of massive pretrained EEG models. Signal non-stationarity, inter-subject variability, data scarcity, ethics, and the invasiveness-bandwidth trade-off are among the persistent issues. The paper concludes with future prospects, including closed-loop adaptive BCI, hybrid and multimodal integration, edge AI, foundation-model decoding, and bidirectional read-write neural interfaces.



411 Experimental Comparative Analysis of Energy Consumption and Performance Characteristics of Electric Two-Wheelers

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With the growing usage of electric vehicles in the current transportation scenario, there is a greater requirement to assess the performance and efficiency of these vehicles with reference to the usage of electricity. This project is based on the detailed energy audit of two different electric two-wheelers with the aim of analysing the performance and efficiency of these vehicles. It is important to note that the entire project is based on the observation of different parameters with reference to the usage of electricity, making sure both vehicles are tested under similar conditions. The data collected by performing experiments is further processed and analysed to find the energy losses and efficiencies of the vehicles. The project also examines the influence of different parameters such as riding patterns, road conditions, and driving behaviour on the energy consumption of the electric two-wheelers. Based on the analysis, practical suggestions are provided to improve energy utilization, enhance battery efficiency, and reduce unnecessary energy losses. This research not only helps to understand the techniques involved in the field of energy auditing with reference to electric vehicles, it also indicates the importance of optimizing the usage of energy for the development of sustainable transportation. The results of this project can be useful to the students, researchers, and users of EVs to understand the performance evaluation and improvement techniques of electric two-wheelers, which can contribute to the larger aim of energy conservation.

414 A Dual-Backbone Feature Fusion Network for Non-Invasive Early Detection of Hypertensive Retinopathy Using Retinal Fundus Images

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Hypertensive retinopathy (HR) is a retinal vascular disorder associated with chronic hypertension and is widely serves as a reliable non-invasive indicator of systemic cardiovascular disease. The problem of HR detection in retinal fundus images is still challenging due to the lack of diagnostic resources; therefore,



an automated diagnostic tool for HR detection can provide some assistance to the clinicians in the screening of early diagnosis. In this paper, a hybrid deep learning model is proposed, which is composed of DenseNet-121 and EfficientNet-B4 by a mid-layer feature fusion strategy. DenseNet-121 adds dense connectivity, and stable gradient propagation; EfficientNet-B4 adds compound scaling, which helps retain fine-grained spatial representations. Both backbones extract feature maps which are later spatially aligned and fused with a learnable channelwise gating mechanism to enhance discriminative power for lesion patterns related to hypertension like haemorrhage, cotton wool spots and arteriovenous nicking. The model was trained using the Retinal Fundus Multi-disease Image Dataset (RFMiD), and a weighted random sampler and class balanced loss optimisation were applied to tackle label imbalance. The model performed best on the held-out test set with an F1-score of 0.75, AUC of 0.935 and precision–recall AUC of 0.831 at the optimal decision threshold (T = 0.24) when compared with single-backbone CNN baselines (VGG16, ResNet50, DenseNet121, EfficientNet-B4). These findings suggest that the proposed fusion approach is able to fuse complementary information from both backbones to achieve satisfactory accuracy in HR classification, providing a promising basis for developing clinical decision support for early, non-invasive diagnosis of hypertensive eye disease and cardiovascular risk.

418 A Novel Hybrid Stacking Ensemble Framework with Explainable AI (SHAP) for Early-Stage Heart Disease Risk Prediction

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Despite numerous advancements in the field, CVD continues to be the major cause of early deaths across the world, contributing to the deaths of an estimated 17.9 million people each year. Even though conventional computational methods have been applied in non-invasive screening and proved to be useful, they face various problems such as high variance, being sensitive to noise, and being prone to overfitting to the specific problem domain. The following sections propose a Hybrid Stacking Ensemble Framework along with Explainable AI (SHAP) to overcome these basic constraints and predict early-stage heart disease risk. The novel framework uses heterogeneous base models including Random Forest (RF), Extreme Gradient Boosting (XGBoost), and Support Vector Machine (SVM) at Level-0 to learn diverse non-linear decision boundaries and high-dimensional linear decision boundaries. These continuous probabilities predicted by the base models are combined by using a Level-1 Logistic Regression model to



obtain refined risk scores. In order to avoid any biased predictions due to class imbalance, SMOTE technique is applied systematically along with the standardization of features. A detailed empirical investigation on the standard UCI Cleve land heart disease dataset proves that our framework is more accurate in its diagnoses. Our framework an outstanding Area Under the Receiver Operating Characteristic Curve (ROC-AUC) of 94.53%. Apart from quantitative measures, the game-theoretic SHapley Additive explanations (SHAP) through Tree Explainer approach is used to provide local and global feature attributions. Empirical analysis revealed that chest pain type (cp), thalassemia condition (thal), and the number of major vessels (ca) are the three most significant clinical risk factors. This framework manages to overcome the persistent problem of the gap between prediction performance and required clinical interpretability.

426 Learning-Based Sinogram Completion for Low-Dose Chest CT Reconstruction: A Comparative Study of FBP, GAN, and Conditional GAN

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Low-dose computed tomography (LDCT) reduces patient radiation burden but introduces sinogram undersampling and quantum noise that degrade diagnostic image quality. This paper presents a systematic comparative study of three reconstruction paradigms for LDCT chest imaging: (i) classical sinogram-domain linear interpolation combined with filtered back-projection (FBP), (ii) image-domain reconstruction using a Generative Adversarial Network (GAN), and (iii) a Conditional GAN (cGAN) that conditions the generator and discriminator on the low-dose input to enforce anatomical consistency. In addition, a GAN-based sinogram-completion model is proposed to recover a full 180° sinogram from a limited 90° acquisition, directly addressing sparse-view acquisition protocols. All methods are evaluated on a paired dataset of 1900 chest CT slices under four dose-reduction factors (80%, 75%, 70%, 50%) and four limited acquisition angles (5°, 4°, 3°, 2°), using Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) as quantitative criteria. Experimental results show that FBP alone is inadequate under aggressive dose reduction (SSIM ≤ 0.71), whereas the GAN and cGAN models raise PSNR beyond 35 dB and SSIM above 0.77, with the cGAN achieving the best conventional-pipeline performance (PSNR = 38.10 dB, SSIM = 0.7984 at 2° acquisition). The proposed limited-angle sinogram-completion network achieves the strongest overall reconstruction fidelity (PSNR = 41.97 dB, SSIM = 0.9193), indicating that operating directly on the sinogram to recover missing angular information is more effective than post



hoc image-domain refinement alone. The findings support a hybrid sinogram-completion-plus-GAN strategy as a practical route toward ALARA-compliant, diagnostically reliable low-dose CT imaging.

431 Analytical Properties of Degenerate Hermite--Genocchi Polynomials of the Second Kind and Some of Their Applications

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The main aim of this study is to introduce and investigate a new class of two-variable polynomials, called the \emph{degenerate Hermite--Genocchi polynomials of the second kind}, by combining the Gould--Hopper exponential generating structure with the degenerate Genocchi generating kernel of the second kind via logarithmic functions. We derive numerous formulas and relations for these polynomials, including convolution representations, implicit summation formulas, Stirling-number expansions, differentiation rules, recurrence relations, a heat-type partial differential equation, a multiplication formula, and correlations with earlier polynomial families. As a higher-order generalisation, we define the r-th order degenerate Hermite--Genocchi polynomials of the second kind and establish their basic properties. Additionally, we introduce degenerate Hermite--Genocchi polynomials of the second kind attached to Dirichlet character χ and derive some of their properties. As applications, numerical values and zero-distribution plots of these polynomials are presented in tables, and multifarious graphical representations for these zero values, including stacking plots, are shown together with a discussion of their significance.

432 Fully Degenerate Gould-Hopper--Genocchi Polynomials and Some of Their Applications in Computer modeling

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second kind via logarithmic functions. We derive numerous formulas and relations for these polynomials, including convolution representations, implicit summation formulas,Stirling-number expansions, differentiation rules with λ-falling factorial convolutions, recurrence relations, a multiplication formula, and correlations with earlier polynomial families. As a higher-order generalisation, we define the r-th order degenerate Hermite--Genocchi polynomials of the second kind and establish their basic properties. Additionally, we introduce degenerate Hermite--Genocchi polynomials of the second kind attached to Dirichlet character χ and derive some of their properties. As applications, numerical values and zero-distribution plots of these polynomials are presented in tables, and multifarious graphical representations for these zero values, including stacking plots and λ-migration diagrams, are shown together with a discussion of their significance.

439 Compact Single-Layer Tri-band MIMO Patch Antenna for Various Wireless Applications

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This paper presents a single-layer compact tri-band antenna for multiple-input-multiple-output (MIMO) communication systems. The MIMO element is formed by capacitively fed four-square patches, which are embedded with additional slots to realize tri-band operation. For mutual coupling reduction, the shorting vias are inserted at the corners of the adjacent patches. The antenna has a compact size of 1.02λ×0.60λ× 0.02λ at the lowest operating frequency of 4.5 GHz. The simulated data indicates that the proposed antenna operates at 4.5, 5.5, and 7.3 GHz, with bandwidths of 140, 150, and 210 MHz. Across these bands, the isolations are always better than 18 dB and the peak broadside gains are 5.8, 7.4, and 8.4 dBi, respectively. Besides, the antenna also shows good diversity performance in terms of envelope correlation coefficient, diversity gain, and mean effective gain.



440. Tri-band Dual-pattern Microstrip Patch Antenna for Sub-6 GHz 5G and WiFi Applications

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This paper presents a single-layer, single-feed tri-band microstrip patch antenna with frequency-dependent radiation patterns for sub-6-GHz 5G and 5-GHz Wi-Fi systems. A coaxially fed rectangular patch excites the fundamental TM10 mode at 3.4 GHz, while two edgecoupled parasitic patches perturb and tune the higher-order TM02 and TM03 modes at 4.0 and 5.2 GHz, respectively. The odd-order TM10 and TM03 modes produce broadside beams, whereas the even-order TM02 mode generates a dual-beam pattern. With an overall size of 0.68λ × 0.68λ×0.04λ at 3.4 GHz, the antenna provides simulated −10-dB impedance bandwidths of 3.30–3.51, 3.92–4.07, and 5.13–5.30 GHz, corresponding to fractional bandwidths of 6.2%, 3.8%, and 3.3%. The peak realized gains are 6.0, 5.4, and 4.8 dBi, respectively. The first two bands support 5G NR operation, while the upper band accommodates multiple lower-5-GHz Wi-Fi channels. Parametric results further demonstrate quasi-independent control of the middle and upper resonances through the parasitic-patch lengths. The proposed antenna therefore combines tri-band operation, pattern diversity, and independent frequency tuning in a simple single-layer configuration.

442 Human–AI Hybrid Intelligence for Smart Traffic Management

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The human-AI hybrid intelligence provides a practical path towards moving away from the single-stock traffic-prediction models and black-box signal controllers and towards accountable and multimodal traffic management that is ready for use in the field. This review critically summarizes empirical research conducted in the period 2016–2026 in the following areas: Traffic Forecasting, Adaptive Signal Control, and Human role in automated decisions. The review is organized by similar benchmark evidence, study-reported control outcomes, mechanisms of the model, data realism and deployment safeguards.



Compared with a pre-trained transformer model which achieved 3.31, representative METR-LA 60-min MAE decreased to 3.34 using STAE former and to 3.31 using DCRNN, although the gains were minor compared to the differences induced by the datasets, the preprocessing and evaluation methods. Signal-control studies reported larger operational gains but under heterogeneous settings: person-based HMD control reduced waiting time per capita by 19.2% relative to fixed timing; HumanLight reported 15–55% improvements in person delay and queues relative to vehicle centered controllers; multi-objective D3QN reduced conflicts by more than 16%, emissions by 4% and waiting by 18%; and explainable RL reduced travel time and queues by 44% and 50.8% in a peak-period test. These values demonstrate capability rather than a universal effect. The synthesis indicates that the most credible hybrid systems embed traffic-flow theory, expert demonstrations, multimodal policy priorities, regulatory signal logic, uncertainty-triggered fallback and operator-facing explanations. A deployment-oriented framework and research agenda are proposed for transport agencies and researchers.

446 A Study on λ-Array-type Fibonacci Polynomials and Their Properties through Golden F-Calculus

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This paper introduces a new family of two-variable λ-Array-type Fibonacci polynomials and their associated numbers, defined as λ-array type polynomials on Fibonacci sequences, within the framework of Golden F-Calculus. In the introduction, we recall essential definitions from F-calculus, including the Golden derivative, Golden exponential functions, Fibonacci trigonometric functions, and Stirling--Fibonacci numbers of the first and second kinds. Using generating function techniques and the F-Cauchy product rule, we derive key structural properties of these polynomials, including summation formulas, recurrence relations, and connections with r-Stirling--Fibonacci numbers of the second kind. We further introduce parametric cosine- and sine-type extensions of these polynomials and establish F-derivative identities, functional equations, and convolution-type formulas for this broader family. The results presented here extend the theory of λ-array type polynomials to the Fibonacci setting and reveal new connections among Fibonacci-based special polynomial families, combinatorics, number theory, and matrix analysis.



448 SymRegOpt: A Symbolic Regression Framework for Multi-Objective Optimization of Dry Turning Parameters

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Dry turning has emerged as a sustainable and environmentally conscious machining strategy due to the complete elimination of cutting fluids from the manufacturing process. However, the simultaneous optimization of machining responses such as crater wear, face wear, and surface roughness remains challenging because of the highly nonlinear interactions among cutting speed, feed rate, and depth of cut. This paper presents SymRegOpt, a symbolic regression-based multi-objective optimization framework developed for modelling and optimization of dry turning parameters. A factorial experimental design was conducted considering cutting speed, feed rate, and depth of cut as input variables, while crater wear, face wear, and surface roughness were considered as output responses. The input parameters were normalized using statistical standardization to improve symbolic search stability. Symbolic regression implemented in Julia was employed to generate interpretable analytical expressions correlating machining parameters with the output responses. The generated equations were subsequently integrated with the NSGA-II evolutionary optimization algorithm to identify Pareto-optimal machining conditions. The proposed framework enables transparent and optimization-ready analytical modelling without relying on black-box learning systems. Unlike conventional black-box machine learning approaches, the proposed framework generates explicit analytical equations that are directly interpretable, optimization-ready, and physically meaningful. The results demonstrate that SymRegOpt successfully captures the nonlinear machining behaviour of dry turning while simultaneously supporting sustainable and interpretable manufacturing intelligence, using Evolutionary Computation.

452 Real-Time Computer Vision Based Sign Language Recognition and Speech Conversion Using Convolutional Neural Networks for Assisting the Deaf, Mute and Disabled Community

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A CNN model is learned from scratch using MediaPipe land mark renderings from the AtoZ 3.1 dataset, comprising 4,681 images across 26 classes, with a 70/15/15 training, validation, and test split. The proposed work achieves an accuracy of 99.43% on the 700-sample test dataset, with macro-averaged



recall, precision and F1-score of 0.994. The proposed system requires only a standard webcam, while pyttsx3 provides offline text-to-speech conversion. Fourteen related works are reviewed and compared in Section 4.5, considering differences in dataset scale, experimental settings, and input representation. Therefore, the reported performance is presented as a strong result for the proposed pipeline rather than as a state-of-the-art claim.

454 XAI-Driven Analysis of the Indian Startup Funding Ecosystem

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The amount of money it takes to start a business is a vital consideration for investors and entrepreneurs, but past statistics are not necessarily the best indicator. This work is explainable machine learning research which looks at investment outcomes in the Indian startup ecosystem and provides explanations based on the transactions between the year 2015 to 2024. To simulate real-world forecasting, the models were trained from 2015-2022 and tested on transactions from 2023-2024. The results indicate that there is a significant difference between predicting dollar amounts and predicting dollar ranges. It's not possible to predict exact monetary figures, since certain human aspects like founder negotiations, and the general investor mood are absent from static datasets. But four simple funding categories (Micro, Small, Mid and Large/Mega) did much better. Gradient boosting models, especially LightGBM were successful in predicting these categories and were very good at predicting the smallest and largest rounds. The study also reveals that the funding stage significantly influences the amount of investment for a startup, with Explainable AI features such as SHAP values and feature profiles also having a role to play, albeit a smaller one, along with deal timing and regional industry activity. Finally, the results illustrate that although precise valuation amounts are hard to predict, explainable classification models provide both clear and trustworthy advice to the VC decision makers.

462 DrowsiGuard: A Real-Time Vision-Based Bus Driver Drowsiness Detection System Using YOLO and StyleGAN Augmentation

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Drowsy drivers frequently cause accidents in public transport settings (like buses), since driving for extended periods of time under high demand from the environment creates conditions conducive to make mistakes due to fatigue. DrowsiGuard is a real-time driver drowsiness detection system that is non-invasive and can be used on a bus. Drowsiguard monitors an individual's face while driving (using a CCTV-type camera) and uses computer vision techniques with low power communication to measure observable signs of fatigue from the driver's facial expressions. An example would be the extent of the driver's eye closure, the frequency of blinks, and yawning, all of which have been shown to be valid signs of decreased alertness. The study performs analysis of YOLO-based fatigued driver detection models using the YOLOv8 framework as the primary detection model based on its excellent speed and classification performance. A StyleGAN data generation pipeline based on YOLOv8 further improves training by enhancing class balance and adding variability to drowsy facial sample images. Additionally, geometric facial measures are applied, including Eye Aspect Ratio and Mouth Aspect Ratio, to enhance the robustness of decision-making within the realistic driving scenarios associated with pose differences, light level changes and partial conditions. Results from testing show that YOLOv8+StyleGAN augmentation have an accuracy of 93% and an F1 score of 0.89 and exceeded all baseline models tested. This demonstrates that a hybrid vision system combined with generative data augmentations provide a valid platform for fatigue-aware safety systems in transport environments.

466 The Impact of AI-Driven Service Innovation on Entrepreneurial Performance in Indian Hospitality Industry: An Empirical Analysis

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Artificial intelligence (AI) has the capacity to disrupt and transform the service industry in unprecedented ways, and the Indian hospitality industry is not an exemption. However, the existing literature rarely discusses the specific impact of individual AI service innovations on the entrepreneurial performance of the hospitality industry. This study aims to empirically examine the influence of AI-driven service innovation on entrepreneurial performance through the mediation of operational efficiency and competitive differentiation. The quantitative survey was conducted across 250 respondents representing the hotels of Nagpur, Pune, Mumbai and Nashik. The Analysis of Variance (ANOVA) was applied to explore the performance differences of hotels of different categories and localities. In addition, the mediation and regression analyses were conducted. The results indicated a positive impact of AI-driven service innovation on entrepreneurial performance ($F = 28.46$, $p < 0.001$). The hotels that integrated AI technologies demonstrate substantially higher levels of performance compared to the hotels that do not apply them (Mean difference = 1.84, $p < 0.01$), which is evident in Fig. 2. Furthermore, the results showed



significant performance differences (F = 6.379%, p= .002) between the localities, with Mumbai recording the highest rate of AI adoption at 68% compared to other cities (see Fig. 1). The mediation analysis revealed that operational efficiency and competitive differentiation significantly influenced the relationships be-tween AI service innovation and organizational performance. The findings contribute to the extant literature by providing evidence in support of the conceptual model that integrates theoretical premises concerning the relationships between AI, service performance, and business performance.

467 Data-Driven Analysis of Thermal–Physical Behavior of Heat Transfer Fluids

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Effective thermal management is an important task for industries such as electronics, computers, and automobile engines to ensure reliable and secure device performance. Conventionally used heat transfer fluids, like ethylene glycol, fail to meet the requirements of thermal management due to their limited heat-carrying capacity. However, nanoparticle-added heat transfer fluids seem to be a better solution for dealing with such high amounts of heat loads. The thermal properties of nanoparticle-loaded heat transfer fluid depend on parameters like the size and concentration of nanoparticles, the temperature of the fluid, concentration of surfactants used. Therefore, it is vital to inspect the performance of heat transfer fluid based on these parameters. In the proposed study, we develop relationships between thermal conductivity and the independent variables it is based upon. For this purpose, we utilize well-known regression models like linear and Gaussian process regression (GPR), support vector machine (SVM), and classification tree, and use non-normalized data to achieve a robust regression model. Predictions made with these regression models indicate that GPR performs well with low and large data variations. Also, it can efficiently handle outliers in the data. The R-squared value achieved with GPR is nearly 1 in most of the data scenarios. Also, the root mean squared error is on the lower side for GPR.

468 Multi-Modal Ransomware Detection Using Deep Learning for Zero-Day Threats

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Ransomware continues to be one of the most damaging and destructive categories of malware, leading to worldwide financial losses which exceeds $20 billion annually. Despite continuous advance technology in cybersecurity, existing detection system still face some challenges. This information include high rate of false positives when dealing with previously unseen variants, a decline in model performance overtime due to concept drift and limited capability to effectively generalize across different and evolving malware families. The current paper presents a novel DeepRansom-X unified detection framework that addresses all three challenges through a three-stage pipeline such as (i) unsupervised multi-scale feature extraction via Deep Contractive Autoencoders (DCAE)which operates on the op-code frequencies. API call sequences, network flow statistics, and registry behaviour (ii) multi-modal feature fusion using an attention-weighted concatenation mechanism with dynamic feature importance scoring; and (iii) a cost-sensitive Pareto-optimal ensemble classifier that balances false negative minimization against precision. Evaluated on the EldeRan benchmark (1,524 samples), the EMBER dataset (300,000+ samples), and our newly constructed DriftBench-2024 dataset containing ransomware variants from 2019-2024, DeepRansom-X achieves 99.47% detection accuracy, 0.11% false positive rate, and 99.81% recall on zero-day attack scenarios-surpassing all prior state-of-the-art methods. Concept drift experiments demonstrate sustained accuracy above 96.2% on ransomware vari-ants two years beyond training data. Our framework is designed for real-time deployment with sub-2-second detection latency.

469 Cross Attention Transformer Fusion Framework for UAV Vehicle Object Detection Using Point Transformer and Deformable Detection Transformer

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Unmanned Aerial Vehicle (UAV) based object detection has become an essential technology for traffic monitoring and autonomous navigation to capture compre-hensive aerial scene information. However, existing methods often rely on single-modal data, inefficient sensor fusion techniques, and exhibit high computational complexity, leading to poor detection of small and occluded vehicles in complex environments. To overcome these limitations, this paper proposed a multi-model sensor fusion framework for UAV vehicle object detection. Initially, synchro-nized LiDAR (Light Detection and Ranging) point clouds and RGB (Red, Green, and Blue) images are collected from a multi-LiDAR, multi-UAV dataset. LiDAR point clouds are pre-processed using Statistical Outlier Removal (SOR) to re-move unwanted noise. Voxel grid downsampling to minimize the point density, Region of Interest (ROI) filtering removes



the unwanted backgrounds, coordinate normalization to ensure data consistency. While, RGB images are enhanced through data augmentation to acquire images from multiple, Gaussian filtering to remove the noise, and Contrast Limited Adaptive Histogram Equalization (CLAHE) to improve the image brightness. Point transformer performs semantic segmentation by learning local and global geometric relationships, Finally, Deformable Detection Transformer (Deformable DETR) performs accurate vehicle classification and lo-calization by predicting object categories three dimensional bounding boxes, con-fidence scores, thereby improving the accuracy of UAV based vehicle object de-tection. The proposed framework achieves Inference time 70.142ms, Precision 95.400%, and IoU 0.880 respectively for the efficient prediction of UAV vehicle object detection

470 Where Does Alternative Data Add Value? Evidence from Proxy, Text, and Segmentation-Level Tests in Personal Loan Credit Risk

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Since it is difficult to obtain real transaction data, many studies of credit risk define proxy features that are used in its place, the typical method in markets that mandate data localisation. Elsewhere, it has been found that when SHAP is used along with correlated features, the predictive value of the feature may seem larger than it actually is, as attribution can be misleading in such scenarios. This paper considers both issues simultaneously, and provides tests of proxy formulas that approximate the UPI-style behaviour on new-to-credit, thin-file borrowers within four segments: Prime, Transitional, Constrained, and High-Risk. The dataset is a harmonized sample of 1,345,310 records from the LendingClub from 2007 to 2018. The proxy features added to each of the four segments do not contribute significant AUC gain after multiple comparison correction, but achieve 1.75% to 4.81% of total SHAP weight; this may be due to the fact that these proxies have a correlation of 0.81 to 0.90 with the source bureau variable. A second, unrelated, source, free-text sentiment features, exhibits the same pattern. It doesn't mean anything substantial to break the proxies into segmentation. In a comparison with four different clustering methods, there was a real trade-off: K-Means creates tighter clusters, while rule-based segmentation remains completely stable when retrained and requires no subsampling trick when it scales. These findings are related to this data, this construction, and should be interpreted as one datum in the service of the question whether alternative-data value is offered by revealing something that a model does not or cannot see, not by adding more features.



487 Explaining the Antecedents of Online Brand Advocacy on Generative AI Platforms: A Technology Management Perspective

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Generative Artificial Intelligence (GenAI) is increasingly positioned as consumer brands however it remains unclear how users' perceptions of this technology effect their online brand advocacy. Drawing upon the Technology Acceptance Model (TAM), theory of Trust in Automation, and Relationship Marketing Theory, this study develops and empirically test a framework in which received perceived usefulness, AI trust, perceived intelligence, and personalization, which act as drivers of brand trust. This brand trust subsequently fosters brand engagement and OBA. Survey data were gathered from 350 GenAI users through a validated 28-item questionnaire following by reliability testing and assessment of convergent and discriminant validity, and structural equation modelling with bootstrapped significance tests. All seven hypotheses received support ($p < .001$), with the model accounting for substantial variance in brand trust ($R^2 = 0.579$), brand engagement ($R^2 = 0.547$), and OBA ($R^2 = 0.606$). AI Trust and Perceived Intelligence were the best predictors of brand trust, while brand engagement was the best predictor of advocacy. The study has important implications for technology management and branding literature as it clarifies the process through which AI perceptions result in advocacy.

489 Cross-Country Financial Named Entity Recognition Using Transformer Models: A Comparative Study on a Unified Kenyan and Indian Financial Text

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Named Entity Recognition (NER) is an important task within the scope of financial information extraction, which enables automatic extraction of named entities from unstructured financial documents. While there have been major advancements in NER accuracy with the use of transformer-based language models, existing researches mainly concentrate on single-country datasets or datasets in a general domain, and there are relatively few studies related to cross-country financial text. In order to bridge the gap in the literature, this study offers a comparative analysis of the performance of six different transformer-based language models on a consolidated financial NER dataset based on manually annotated financial text from Kenya and India, where both countries' texts are annotated using a unified



scheme. Models under consideration include BERT, DistilBERT, DeBERTa, XLM-RoBERTa, FinBERT and AfriBERTa, which represent general-purpose, lightweight, advanced attention-based, multilingual, financial domain specific and African language specific transformers respectively. All models are trained and evaluated using the same experimental setup in order to allow for a comparable assessment of their performance. The performance metrics used in the analysis include Precision, Recall, F1-score and token-level Accuracy. Experimental findings have shown that XLM-RoBERTa performed well with the highest F1-score of 0.9149 and accuracy of 0.9795, proving the efficiency of multilingual pre-training for cross-country financial Named Entity Recognition. The current work presents a systematic review and comparison of transformer architectures and provides a modular experimental baseline that could be extended further for other financial entity types, other multilingual datasets, and cross-country transfer learning in future research.

496 Progressive Optimization of DETR for UAV-Based Road Damage Detection

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Inspecting Road damage using drone images is difficult because defects differ in size, shape, visibility, and the amount of road surface they cover. This study gradually improved a pre-trained Detection Transformer (DETR) model to identify seven types of road conditions. At each stage, changes were made to address problems found in the previous experiment. The initial model was trained for only a short period and evaluated using training loss. This was later replaced with standard COCO object detection measures. The study also compares original images with images enhanced using CLAHE and a combination of CLAHE and sharpening. The original, unprocessed images produced the best results during the short training tests. The final model used 800-pixel images and allowed all parts of the ResNet-50 backbone to learn during training. It also included separate learning rates for different model components, the AdamW optimizer, gradual learning rate adjustments, mixed-precision training, gradient accumulation, and testing of 54 combinations of confidence and non maximum-suppression settings. After training for 150 epochs, the model from epoch 139 produced the best results. It achieved 86.07% mAP@0.50, 62.72% mAP@0.50:0.95, 71.18% AP@0.75, 74.40% AR@100, and 98.21% recall. These results show that the model can identify nearly all possible road defects. However, until its confidence threshold is properly adjusted, it is best used as a screening tool to assist human inspectors rather than as a fully automatic decision-making system.

497 Data Driven Analysis: Impact of War on Stock Management

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The stock market exhibits sudden price changes in response to geopolitical events, which include wars, since these events create unpredictable conditions that result in rapid transformations of financial markets. The current study inves-tigates how the Russia-Ukraine War and other major conflicts have affected the stock market through the analysis of empirical data and observable market trends. The study evaluates key market indices, which include the S&P 500 and NIFTY 50, to assess their performance across three time periods, which include the time before the events, during the events, and after the events. The study uses time series analysis and volatility metrics along with regression models to detect market behavior patterns. The research tracks stock data changes during conflicts through Python tools to study return variations, investor sentiment, and sector performance. The research measures the immediate market disruptions that it tracks until markets reach recovery through its research. Wars lead to two distinct market reactions, which start with immediate market losses that result from heightened volatility and stock price declines before the market begins to stabilize through economic policy and market forces. The defense and energy sectors show different responses to market conditions, which allow them to either maintain stability or expand their operations during wartime periods. The study con-tributes knowledge on the impact of geopolitics on finance and offers lessons for investors, policymakers, and academics. The study shows how data analytics can be used to predict market trends during times of geopolitical uncertainties.

501 A Machine Learning Framework for Intrusion Detection in IoT Environments

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In a world that is more connected, ensuring Internet of Things (IoT) environments are not affected by cyber intrusions is a critical issue. In this paper, a complete Machine Learning (ML) Framework of Intrusion Detection in IoT Environments is introduced. The framework combines curated datasets of IoT



network traffic, preprocessing of data in multiple stages, feature engineering, and comparative analysis of four supervised classifiers: Logistic Regression, Random Forest, LightGBM, and XGBoost. Experimental evidence shows that LightGBM has the highest accuracy of 97.4, precision of 96.8, recall of 97.0, and F1-score of 96.9, which is much higher than the results of the conventional rule-based systems and the linear baseline. Compared to traditional methods, the false positive rates are minimized by more than 80%. The suggested framework is scalable, dynamic to changing attack patterns, and applicable to be deployed in resource-heterogeneous IoT ecosystems. The findings of the detailed ablation studies, per-attack-type analysis, and training convergence are provided to support the strength of the method.
Index Terms—IoT security, intrusion detection systems (IDS), machine learning, random forest, LightGBM, XGBoost, logistic regression, feature engineering, anomaly detection, network security, ensemble learning.

511 TitanTrack- Real-Time Equipment Rental Management System with ML Powered Demand Forecasting & Anomaly Detection

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Challenges in the construction industry and infrastructure sector include inefficiencies in check-out processes, lack of fleet visibility, reactive maintenance, and inaccurate demand forecasting. This paper presents TITANTRACK, a proposed framework full-stack intelligent equipment rental management system implemented using Django, which incorporates a QR code-based rental process, an operational dashboard, machine learning based rental demand forecasting, and sensor-based equipment health monitoring. In the demand forecasting module, a Random Forest Regressor model was trained using historical rental data from 2006–2024 with more than 20 engineered features, including lag variables, rolling statistics, seasonal encodings, and utilization rates. The forecasting model achieved a Mean Absolute Error (MAE) of 0.10 rentals/week, a Root Mean Square Error (RMSE) of 0.34 rentals/week, an R2 score of 0.77, and a Mean Absolute Percentage Error (MAPE) of 4.76% across multiple equipment categories. Equipment health monitoring was performed using a K-Nearest Neighbors (KNN)-based anomaly detection model trained on more than 10,000 sensor observations comprising 11 operational features. The model generates anomaly scores, identifies abnormal equipment behavior, and provides severity-based alerts through the operational dashboard. Experimental evaluation further demonstrates that the QR codebased rental workflow achieves a scanning success rate exceeding 95%, completes equipment checkout/check-in in less than one minute, and improves overall operational efficiency by approximately 60% compared with conventional manual processes. The proposed approach demonstrates that integrating QR code-based rental workflows, machine learning, and real-time



equipment monitoring significantly improves equipment utilization, supports predictive maintenance, and enhances operational decision making.

518 A Lightweight MobileNetV2-Based Deep Learning Framework for Automated Cervical Screening from Colposcopy Images

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Cervical cancer ranks among the top reasons for cancer-related fatalities among women globally, especially in developing nations due to inadequate screening facilities. This study presents a lightweight deep learning-based, non-invasive cervical cancer screening system capable of classifying colposcopy images into normal and abnormal through the publicly available Intel & MobileODT database. The proposed model incorporates customized MobileNetV2 architecture with a two-stage transfer learning approach coupled with image pre-processing methods like resizing, converting to greyscale, normalization, CLAHE and data augmentation techniques aimed at enhancing feature extraction and generalization. Grad-CAM is used to produce heatmaps showing which cervical areas impact on the prediction of the model. The presented model achieved a validation accuracy of 99.1%, meaning that it reliably classifies validation images; a precision of 98.0%, implying a very low false-positive rate; a recall of 99.0%, thus effectively detecting abnormal cervical cases with a negligible false-negative rate; and an F1-score of 99.1%, thereby indicating a good balance of classification. Its lightweight nature is exhibited in its architecture that involves 2.42 million parameters and a 11.5 MB deployment size. The model has been implemented as a Streamlit-based web application with fast production of screening results with corresponding confidence scores.

520 QuPTA: Quantum Pre-Training Assessor for Quantum Machine Learning Models

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QuPTA (Quantum Pre-Training Assessor) is a pre-training diagnostic framework that characterises the trainability and robustness of Quantum Machine Learning (QML) models before any optimization takes place. Training parameterized quantum circuits (PQCs) in the NISQ era is resource-intensive and unpredictable: circuits frequently fail to converge due to barren plateaus, insufficient expressibility, or



excessive noise sensitivity, wasting significant compute. QuPTA computes five pre-training diagnostic quantities---gradient variance, entanglement entropy, Neural Tangent Kernel (NTK) spectral features, expressibility, and noise sensitivity---and feeds the most discriminative subset into a meta-learning classifier that outputs a trainability verdict before a single training step is taken. The system is validated on four benchmark datasets (Iris, Breast Cancer, Image, and Wine) across 52 PQC configurations spanning depths $L\in\{1,\dots,6\}$ and three entanglement topologies (linear, circular, and full). QuPTA achieves 78.8\% leave-one-out cross-validation (LOO-CV) accuracy, statistically comparable to a structural baseline (82.7\%) given the LOO-CV standard error of ≈ 5.5 percentage points on 52 samples. An ablation identifies entanglement entropy as the single most predictive diagnostic, followed by NTK condition number and gradient variance. Barren plateaus do not manifest at six qubits, indicating that the regime in which quantum diagnostics are expected to surpass structural heuristics lies at larger circuit widths. QuPTA is hardware-agnostic, deployable on commodity hardware via a cross-platform Streamlit interface, and provides an interpretable per-metric pre-training risk report for NISQ circuit design.

521 Quantum Intrusion Detection System Using QKD and QML for High Security Networks

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QIDS (Quantum Intrusion Detection System) is a cybersecurity framework that unifies Quantum Machine Learning (QML) with Quantum Key Distribution (QKD) to detect network intrusions while keeping attackers unaware of detection. An 8-qubit Variational Quan-tum Circuit (VQC) with fixed random weights acts as a randomised quantum kernel, projecting classical network traffic features into a high-dimensional Hilbert space; these quantum features are concatenated with classical features and fed to a weighted Random Forest and XGBoost ensemble that classifies traffic across multiple attack categories. Upon detection, QIDS silently applies attack-specific countermeasures shadow blocking, honeypot redirection, WAF filtering, quarantine, or rate limiting without generating any visible network alert, eliminating the adversary's ability to adapt upon detection. All intelligence collected is transmitted to the command centre over a BB84 QKD-secured channel which uses the sifted key that is hashed via SHA-256 to derive a 256-bit AES key, and messages are encrypted with AES-256-GCM, providing authenticated end-to-end confidentiality. QIDS is evaluated on three standard benchmarks using canonical (NSL-KDD) and deduplicated, natural-prevalence (CICIDS2017, UNSW-NB15) splits, achieving binary detection accuracies of 84.3%, 99.2%, and 92.8% respectively. A controlled, classifier-fixed ablation shows the fixed random quantum kernel performs on par with a dimension-matched classical random feature map, with no consistent quantum advantage at NISQ scale; QIDS's contribution is the integrated detection, response, and QKD pipeline together with a rigorous NISQ-scale evaluation. The



entire system runs through a cross-platform Streamlit interface, requiring no specialised quantum hardware.

526 Large Language Models and Foundation Models for Alzheimer's Disease Diagnosis and Early Prediction: A PRISMA-Informed Systematic Review of Clinical, Multimodal, and Agentic AI Approaches

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The application of CNNs and vision transformers to structural MRI for the computational diagnosis of Alzheimer's disease (AD) has been extensively studied and reviewed, so we will not repeat that here. In contrast, a newer strand uses large language models (LLMs) and other foundation models to aid in the diagnosis of AD based on clinical notes, genetic and tabular data, spontaneous speech, paired imaging-text data, knowledge graph, and multi-agent reasoning without any existing review categorizing these literature by the functional role these models play in the diagnostic pipeline. We conduct a PRISMA-informed search on PubMed, Consensus and web sources, resulting in 49 primary and benchmark studies (2019–2026) that are categorised into five functional groups: clinical/structured-data LLMs, speech/language biomarker models, vision-language foundation models, retrieval-augmented LLMs and agentic multi-agent models. We review benchmark datasets and evaluation conventions, discuss the relationship between reported accuracy and the level of validation, and identify a recurring disconnect between high validation scores and lower external testing, and provide suggestions on how to move forward to auditable, clinically deployable diagnostic tools.

529 Multimodal Alzheimer’s Risk Prediction Using Deep Learning and Explainable AI

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Prior to detection, signs of Alzheimer-disease, which is a Functional Neurological Disorder (FND) that evolves with time, were observed. It is possible that the opportunity for timely monitoring, caregiver preparedness, response changes, and professional advice may be missed if the disease is detected late.



In this research paper, the concept of a Flask-powered web application that acts as a multimodal risk predictor for Alzheimer's disease will be discussed. A intended procedure will include a DL-based model for MRI image categorization, tree-based algorithms, explainable techniques for displaying risk factors, and a rule-based CAD system for the fusion of information from all inputs. As compared to a single input approach for predictive analysis, the suggested application gives a better overview of the screening process using association based on imaging, behavioral interactions, and patient's medical background along with information about memory and response tests, intuitive dashboard, and risk group categorization (low, medium, and high). The clinical risk prediction framework attained accuracy of 93.48%. This project can be further enhanced by checking recommendation rules, MRI assessment, and validation from outside sources.

536 A Smart Software-Based Digital Twin AI Framework for Landslide Monitoring and Prediction

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Landslides are one of the most destructive natural hazards, leading to significant damage to infrastructure, human lives and the environment, particularly in hilly and mountainous regions where effective landslide risk management strategies are lacking. Conventional methods of landslide monitoring are often isolated, passive and lack early warning systems. In this paper, we present a software-based Digital Twin approach for landslide monitoring and prediction to create a virtual representation of a landscape and predict how it might react to various environmental conditions. The system uses geospatial data (Digital Elevation Model- DEM) and environmental factors (rainfall intensity and duration) to predict slope stability and terrain characteristics. By combining digital terrain models, simulation-based assessment and machine learning-based prediction models, the system can dynamically assess the risk and inform proactive management. The system is based on software engineering principles, such as modularity, scalability and maintainability, so that it can be easily applied to different geographical regions. The proposed approach reduces dependency on expensive sensor-based systems while offering a scalable and cost-effective solution for landslide risk assessment. The final results achieved by a prediction accuracy of approx 90 % with a reduced error margin of 10% outperforming traditional models by a significant margin. Additionally, the system demonstrates the improved scalability of 88% percent with reduced response time , enabling efficient real-time landslide risk assessment. Keywords: Digital Twin · Geospatial Information System (GIS)· Disaster Management · Risk Assessment · Simulation Based Analysis.



537 Edge Computing in 5G/6G Networks: An Infrastructure-Grounded Analysis and Adaptive Offloading Framework for the Tamil Nadu Telecom Circle, India

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Edge computing is a key enabler of low latency, high availability, and throughput in 5G/6G mobile networks, particularly in Tamil Nadu, which operates one of India's largest telecom circles and hosts the country's larg-est Smart Cities Mission footprint. This paper presents an infrastructure-grounded analysis of edge-computing potential for the circle, integrating four public datasets – OGD Platform India, BharatNet statistics, DoT reports, and Smart Cities Mission data – with a discrete-event simulation of a three-tier Device–Edge–Cloud architecture. Using observed BharatNet Point-of-Presence density, fibre-route kilometres, and Smart City Command Centres as siting priors, we derive an Adaptive Task Offloading and Edge-Resource Allocation (ATOERA) algorithm and an edge-site placement heuristic, evaluated against cloud-only and static edge-assisted baselines on latency, of-floading success, and energy. An ablation study isolates ATOERA's dead-line-, load-, bandwidth-, and energy-aware criteria, with Monte-Carlo results reported as mean, standard deviation, and 95% confidence intervals. The scheme cuts average latency by up to 86% versus cloud-only and 51% ver-sus static edge assignment, sustains ~88% offloading success under high concurrency (800 req/s) against 65.5% for cloud-only, and reduces normalised energy per task by ~46%. The infrastructure assessment shows that although 86.7% of Tamil Nadu's gram panchayats were BharatNet service-ready as of December 2025, edge-readiness remains concentrated in a small number of urban Smart City nodes, revealing a rural–urban edge-capacity divide relevant to 6G planning. The paper offers an open-data-based template replicable for other telecom circles, with policy implications for DoT, the Tamil Nadu government, and mobile network operators.

541 INFRASCAN: AI-Driven Pothole Detection System

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Potholes are a common occurrence on the roads and can have an effect on the safety of vehicles, driver experience, and road maintenance. The conventional ways of pothole detection are mostly manual in



nature and take a significant amount of time and efforts. In order to resolve the issue of pothole detection and classification, this paper proposes INFRASCAN, which is an AI- based solution for pothole detection and classification. The system uses the YOLOv8 object detection model to detect potholes from the images of roads and to classify them as Low, Medium, and High in terms of severity according to the visual area of the pothole within the image. Techniques like image preprocessing and augmentation are employed to improve the performance of the model in various road conditions and lighting scenarios. Performance of the proposed system is tested using conventional measures such as precision, recall, F1-score, and mean Average Precision (mAP).

545 QuantShield- An AI-Based Portfolio Risk Monitoring and Classification System for Indian Equity Markets Using Ensemble Learning and Composite Fuzzy Labeling

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Current portfolio-management practices in Indian equity markets are not very dynamic: they involve laborious manual computation instead of providing a real-time risk vision. This paper introduces a non-trading portfolio risk assessment method called QuantShield for classifying any portfolio into Low, Medium, and High risks based on a Random Forest classifier trained on a panel of NSE prices that spans two decades. A sliding-window technique is employed. With a 252-day window size and a 21-day overlap, as much as 6,500 to 6,800 samples were extracted from 30 hypothetical Indian ETF portfolios. Eleven risk characteristics per window - including annualised volatility, VaR, max draw-down, diversification raio, skewness, kurtosis, various rolling volatilities, sharpe/sortino ratio,beta - are subsequently used as input for a composite scoring function that can assign soft true labels. A time-series cross-validation is used where 5 folds will be utilized via use of TimeSeriesSplit to avoid lookup period (lookahead) bias, where the interface and deployment are done via FastAPI with a React frontend. Real-world generalization was tested via unseen sectoral portfolios of size three . The use of a composite scoring function rather than the classifying model can be evaluated to determine whether our pipeline or classifier was responsible for it: We evaluated these three tree based classification against two standard classifier -Logistic Regression which achieved a score of accuracy 84.41% compared to that of Tree models like CatBoost: accuracy of 93.58%; macro F1 = 0.9340 - which goes towards confirming the need to employ soft tagging for our problem, to make classification a genuinely non linear task..



550 A Comprehensive Empirical Evaluation of the Addax Optimization Algorithm and Pelican Addax Optimization Across Continuous, Combinatorial, and Machine Learning Optimization Tasks

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Metaheuristic algorithms are widely used to solve complex optimization problems, but it is often difficult to find an appropriate balance between exploring new solutions and exploiting existing solutions. In this paper, we compare the performance of the Addax Optimization Algorithm (AOA) and the Pelican Addax Optimization Algorithm (PeAOA) with traditional metaheuristics algorithms (DE, PSO, GA, ACO and ABC). We evaluated the performance of these algorithms using CEC benchmark functions, the Travelling Salesman Problem (TSP), the Knapsack Problem, and for hyper-parameter optimization of Random Forest and XGBoost classifiers. We show that PeAOA significantly reduces the computational time to solve optimization problems while producing solutions of a similar quality to the other algorithms. When it comes to machine learning algorithms, PSO and GA-PSO had the highest classification accuracies. However, a trade-off exists between the optimization accuracy and computational cost.

568 ForestXAI:An Explainable Machine Learning Framework for Large-Scale Forest Cover Classification and Environmental Driver Attribution

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Forest cover classification is indispensable for sustainable forest management, ecological planning, and environmental monitoring. ForestXAI is a machine learning framework that is explainable and designed for the classification of forest cover on a large scale. It is based on the UCI Forest CoverType dataset. SHAP, LIME, and Permutation Feature Importance are integrated into the framework to provide transparent global and local model explanations, and representative ensemble- and distance-based classifiers are evaluated. Ensemble learning models consistently outperform conventional classifiers, as evidenced by experimental results. Additionally, explainability analysis identifies elevation, horizontal distance to hydrology, and hillshade-related attributes as the most influential factors influencing forest cover classification. The proposed framework offers a dependable and interpretable decision-support



solution for environmental monitoring and forest ecosystem analysis by integrating scalability evaluation, predictive performance, and complementary explainability techniques.

602 Conformal Difficulty-Aware Learning for Multiclass Breast Histopathology Classification

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Multiclass breast histopathology classification is challenging because the dataset contains both unevenly represented subtypes and morphologically similar classes that remain difficult to separate during conventional fine-tuning. We propose Conformal Difficulty-Aware Learning (CDAL), a sample-aware fine-tuning framework that uses calibrated uncertainty to identify difficult training samples and adapt their contribution to learning. CDAL combines probability-based uncertainty from the model's predictive distribution with conformal uncertainty derived from the size of a Regularized Adaptive Prediction Set (RAPS), and converts these signals into per-sample fine-tuning weights. We evaluate probability-only (CDAL-P), conformal-only (CDAL-C), fixed combined (CDAL-PC), and iteratively recalibrated (Dynamic CDAL) variants on eight-class BreakHis classification at 224×224 and 128×128 image resolutions. All variants improve over the SE-Conformer baseline. At 224×224, CDAL-C achieves the best Accuracy (88.62%) and Macro-F1 (85.97%), improving Macro-F1 by 6.19 percentage points over the baseline, while CDAL-PC achieves the lowest ECE (0.0126). At 128 × 128, Dynamic CDAL performs best, reaching 80.28% Accuracy and 75.13% Macro-F1, a 2.46 percentage-point improvement over the baseline. Boundary-level analysis further shows substantial reductions in several dominant class confusions, while revealing limited error redistribution between closely related subtypes. These results demonstrate that calibrated uncertainty can provide an effective sample-level signal for multiclass histopathology fine-tuning, with the benefit of static versus dynamic refinement depending on model resolution

606 VikalpSahay: An End-to-End NLP Framework for Regional-Language Police Complaint Drafting

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The linguistic diversity, the abundance of legal jargon, and the lack of well-defined processes generally hinder the filing of complaints in Indian courts. In this paper, we introduce VikalpSahay, an end-to-end NLP-based system designed to help automate and facilitate the drafting of complaints for lost-and-found cases under Section 154 of the CrPC. It combines the processes of intent recognition, entity extraction, and context-based dialogue management using an innovative dynamic entity mapping process without requiring hard-coded rules. A translation module based on Indic language models translates from Hindi to Marathi without losing legal semantics. The conversational AI module emulates a skilled police constable, asking all the questions necessary to complete every section of the complaint draft. The proposed system generates reports in Marathi PDF format that assist police personnel during FIR preparation, which can be edited via text-based interactions while preserving user privacy through local offline processing.

611 HD²L-CMNet: Hybrid Drift-aware Dual Learning based Convolutional Memory Network for Cyber Attack Detection

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With the latest advancements in information and communication technologies, large volume of information is shared across the network, making it susceptible to cyber-attacks, which threatens the availability, confidentiality and integrity of network resources. Hence, cyber-attack detection is significant to monitor the network actions dynamically and to provide data security and safeguard the network system. In recent years, several cyber-attack detection models are developed, but these mechanisms faced difficulties like low performance, higher false positive rate, poor generalizability and so on. In this research, a Hybrid Drift-aware Dual Learning based Convolutional Memory Network (HD²L-CMNet) is designed to overcome the above limitations. The incorporation of Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) enables the approach to learn spatio-temporal relationships in the network traffic. The evidential learning provides fine-grained uncertainty quantification to increase the reliability and robustness of the approach. The hybrid drift-aware mechanism enhances the detection performance by analyzing the variations in the input data, and the integration of proposed fractional incremental learning enhances the adaptability of the model across unseen threats. Therefore, the proposed HD²L-CMNet obtains improved performance compared to the traditional mechanisms by achieving an accuracy of 98.28%, precision of 96.17%, recall of 99.3%, and F1-score of 97.72% based on the MSCAD dataset with 80% training data, respectively.



614 Cryptocurrency Anti-Money Laundering: A Review of Graph Neural Networks, Explainable AI, and Retrieval-Augmented Approaches

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Cryptocurrency anti-money-laundering (AML) research has progressed from feature-based classifiers toward graph neural networks (GNNs), temporal and subgraph learning, explainable AI (XAI) and emerging language-model-assisted methods. Reported performance is hard to compare because studies differ in datasets, prediction units, class distributions, protocols, imbalance treatment and metrics. This structured critical review synthesizes 26 studies from 2021–2026, comparing datasets, models, validation, imbalance handling, explanation mechanisms and limitations. Graph and temporal models better represent relational behaviour but raise scalability and validation concerns; severe imbalance makes accuracy and isolated ROC reporting insufficient; and explainability remains dominated by post-hoc attribution, with little quantitative evidence of fidelity or investigator usefulness. Retrieval-augmented generation (RAG) systems validated for cryptocurrency AML remain scarce. The review outlines a conceptual, not experimentally validated, hybrid-intelligence direction linking graph detection, explanation, retrieved evidence and human oversight.

615 Spectral and Leverage-based Filter Pruning for CNN Compression

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Structured filter pruning reduces the computational cost of convolutional neural networks by removing redundant and less important filters while preserving predictive performance. A filter pruning framework is proposed to separately determine the effective number of filters to retain and identify the most relevant filters. First, singular value decomposition and spectral entropy are applied to convolutional weights to characterize the information distribution of each layer. An entropy-guided energy threshold with a depth-aware adjustment determines the layer-specific filter retention. Second, leverage scores computed from the dominant feature-response subspace of a representative calibration dataset identify the most representative filters. Experiments demonstrate that the proposed method achieves 93.81\% accuracy with 51.48\% FLOPs reduction and 93.34\% accuracy with 71.91\% FLOPs



reduction on ResNet-110/CIFAR-10, while achieving 73.18\% accuracy with 54.07\% FLOPs reduction on VGG-16/CIFAR-100. These results demonstrate the effectiveness of the proposed framework for high-ratio structured pruning.

626 Statistical Discovery of Late-Emerging Physiological Signatures Across Increasing Fatigue States in Industrial Workers

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Industrial fatigue is often investigated as a prediction or classification problem, whereas less attention is given to understanding at which fatigue-state transition physiological changes become statistically detectable. This study presents a statistical framework for discovering late-emerging physiological signatures across increasing fatigue states in industrial workers. A balanced dataset comprising 60,000 observations from 50 workers, with 20,000 observations each for Low, Moderate, and High fatigue states, was analyzed using seven physiological signals: ECG, EEG, heart rate (HR), foot-GSR, hand-GSR, temperature (TEMP), and SpO_2. Worker-level physiological summaries were constructed for each fatigue state, followed by Friedman repeated-measures testing and pairwise Wilcoxon signed-rank testing with Benjamini–Hochberg false discovery rate correction. To assess the stability of the discovered signatures, median-based analysis, directional consistency, and leave-one-worker-out sensitivity analysis were additionally performed. The results revealed a distinct transition pattern: none of the physiological signals showed a significant Low-to-Moderate transition after FDR correction, whereas four signals namely, EEG, HR, foot-GSR, and hand-GSR, showed significant Moderate-to-High differences in the primary analysis. Among these, EEG, foot-GSR, and hand-GSR demonstrated robust late-emerging signatures across the sensitivity analyses, while HR provided a significant but comparatively less robust supporting finding. These results suggest that measurable physiological alterations may become more pronounced and consistently detectable at higher fatigue states. The proposed statistical discovery framework provides an interpretable, model-free approach for characterizing fatigue-related physiological transitions and provides transition-level insights that may inform future fatigue prediction and classification studies.



627 EmotionCRNN: Multimodal Emotion Recognition Using Audio and Facial Feature Fusion

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The use of just one medium to detect human emotions may result in the wrong or incomplete interpretation of the emotions, which happens because of the limited range of sentiments that can be analyzed. EmotionCRNN is introduced as a new algorithm that employs two media recognition process where the emotions are recognized based on vocal cues and facial expressions in order to gain a more profound understanding of emotions. Concerning the analysis of the audio data, EmotionCRNN operates with a three-layer neural network structure that comprises convolutional features extractor, bidirectional recurrent sequential model, and scaled dot-product attention pooling in order to translate the input 128-band log-Mel spectrograms into ternary sentiment representations including positive, negative, and neutral sentiments. Speaker-independant normalization with the help of frequency based cepstral coefficients removes individual-specific characteristics of the spectra, and two steps of augmentation with the use of waveform-level and spectrogram-level augmentation techniques were used to reduce the risk of overfitting. When it comes to video-based data analysis, the Deep Face algorithm is used by EmotionCRNN to detect seven different emotions, while coherence checking was used to identify whether both verbal and facial expressions match. To perform sentiment evolution evaluation for each utterance, EmotionCRNN uses windowing technique with one second overlap and splitting arbitrary duration speech into 3-second fragments. EmotionCRNN is trained using a strict speaker-disjoint strategy on 8,690 audio clips from 115 speakers of the RAVDESS and CREMA-D data sets, which leads to 74.30% balanced accuracy and 0.902 ROC-AUC value. EmotionCRNN is tested on 1,089 clips from 116 speakers of the TESS dataset with no shared speakers and recording conditions with the training set.

631 Log-Based Detection and Behavioral Analysis of SSH Brute Force Attacks

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Brute force attack is also a common and continuous cause of network security risks, especially systems that offer Secure Shell (SSH) network services. Attacks consist of numerous efforts to determine various



combinations of passwords and avoid illegal access to a system, and in order to facilitate the attack, it is often associated with specially created computer programs to make the attacks as quicker and more common. Common methods of identifying security threat usually involve set limits, which recognize anomalous activity upon a restricted proportion of attempts made to log-in. However, the techniques can only record a small fraction of the behavioral patterns thus associated with automatically or distributed attacks. The article has described a framework that can be used to detect brute force attacks and analyze the behavior of the attackers by examining the SSH authentication logs, which are recorded in logs. It also records access to log-in details such as password attempts, use of a specific IP address and time of activities log-in activities by using structured records access. With a threshold-driven model, it is able to identify bursts of activities, profile IP addresses, and can analyze the occurrences of the logins on repeating timelines. Also, there are techniques of behavioral analysis. The framework is verified on a dataset of 14,795 records of logins to confirm that it prefers perfect performance with a range of artificial attacks. The findings signify that threshold method serves as an effective capture of large scale attacks whereas behavioral analysis helps give more accurate information about the methods of attacks, like assaulting multiple users or making a burst of login attempts. The approach improves the detection of the attack and gives a more in-depth insight into the behavior of attackers in actual scenarios.

632 A Study on Reinforcement Learning Algorithms for Connected Vehicles under Mountain Terrain for Enhancing Driving Decisions

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Connected vehicles deployed in mountain terrain faces numours challenges due to geographic structure such as sharp curves, steep gradients, limited visibility, and dynamic traffic interactions. Such kind of infrastructure creates challenges in safe and reliable decision-making for connected vehicles (CVs). Presented study checks the real time challenges and solutions for implementing safe reinforcement learning (Safe RL) techniques for decision-making in CV systems. This paper presented a mountain terrain specific decision-making framework that includes road curvature, elevation, and Time-to-Collision (TTC) parameter. For that framework integrates vehicle-to-vehicle (V2V) communication with state representations which is important for safety. Comparison study focuses on including Deep Q-Networks (DQN), Proximal Policy Optimization (PPO), Soft Actor-Critic (SAC), and Multi-Agent Reinforcement Learning (MARL) algorithms and checks their suitability for safety-critical decision-making process by connected vehicles in mountain road scenarios. Study involved in checking how all these policies are stable for terrain under consideration. It also highlights what is the capacity of these algorithms in handling changing traffic situations and behavior and how sensitive they are to risk factor. Connected



vehicles can use these algorithms while facing mountain driving challenges. The study advices in selecting reinforcement learning methods to improve safety and efficiency in mountainous areas.

637 Experimental Evaluation of Deep Learning Models for Multi-Class Skin Disease Classification

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Skin diseases can show identical visual characteristics, the symptoms associated with different skin diseases have similar characteristics making their detection through image classification very challenging, especially when the detection relies on the visual appearance alone. Thus deep learning technique helps, learns visual features from medical images to classify these images into various classes. In this research paper, a comparative deep learning technique is used for the classification of skin diseases in five categories such as Acne, Lupus, Rosacea, Unknown/Normal, and Vasculitis. Four models, namely traditional CNN, MobileNetV2, DenseNet121, and Incep-tionV3, are trained for image classification using the same framework for comparison. The images are resized to 224×224-pixel size and normalized followed by data augmentation prior to being presented to these models. The performance of the mod-els is evaluated based on classification accuracy, precision, recall, F1-score and con-fusion matrix analysis. As observed from the experimental results, the transfer learn-ing models achieve better classification results than the traditional CNN and Dense-Net121 model achieves an overall accuracy of about 92%. Therefore, the results of the experiment have shown that the transfer learning-based models perform better than the traditional Convolutional Neural Network model in terms of accuracy and reliability.

638 An Efficient Hybrid CNN–Attention Model with Adaptive Lesion Weighting for Grading Multi-Class Diabetic Retinopathy

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Diabetic Retinopathy (DR) is one of the retinal complications which occurs in a person with diabetes, and it has been named as one of the main reasons for people going blind, which, with a suitable treatment, can be preventable. The condition mainly targets the adult working population. Although detection at the beginning stages plays an important role in the prevention of DR, in reality manual examination by the specialist doctors is slow and subjective. Besides that, it hardly can be done for a big number of people, which means that automatic screening of diabetic retinopathy is required. In traditional machine learning methods, which work with hand-engineered features, variations in the image, like differences in brightness, the shape of the lesions, and the quality of the image, can make the algorithm have limited precision and generalise incorrectly. The proposed method for classifying images with different severities of diabetic retinopathy is a fully automatic deep learning approach which uses fundus retinal images from the APTOS 2019 dataset. The images are manipulated in a number of steps, including grayscale conversion, region cropping, resizing, normalisation, and data augmentation to make the robustness of the model. Three different convolutional neural network architectures are created, and the performance of a custom CNN, a transfer learning model based on InceptionV3, and Xception is compared. The model is trained in two steps: initially with frozen layers of the base model, then unfrozen for fine-tuning, with dropout, early stopping, and an adaptive learning rate scheduler to improve performance and prevent overfitting. The outcomes of the experiments reveal that the classification accuracy for the five classes of diabetic retinopathy is very dependable, and the model is more capable of generalizing to new data.

639 Comprehensive Preprocessing Framework Flower Image: A Comparative Evaluation of Denoising, Enhancement, Morphological Operations, and Segmentation Preparation

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This study presents a systematic comparative evaluation of image preprocessing techniques for flower images obtained from the Kaggle database, with the aim of identifying suitable methods for improving image quality prior to segmentation, feature extraction, and machine learning analysis. A comprehensive preprocessing framework incorporating denoising, image enhancement, morphological operations, thresholding, and edge detection was developed and quantitatively evaluated. Five denoising filters—Mean, Gaussian, Median, Bilateral, and Non-Local Means—and five enhancement techniques, including Histogram Equalization, CLAHE, Gamma Correction, Sharpening, and Unsharp Masking, were investigated along with seven morphological operations and multiple thresholding and edge detection



methods. Performance was assessed using MSE, RMSE, MAE, PSNR, SSIM, entropy, edge preservation, contrast index, and computational time. Among the denoising methods, Non-Local Means achieved the best overall performance, with the lowest MSE (44.72), RMSE (6.69), and MAE (4.82), while achieving the highest PSNR (31.63 dB), SSIM (0.9215), and entropy (7.244). For enhancement, Unsharp Masking produced the highest PSNR (27.94 dB) and SSIM (0.9412). Opening and closing effectively reduced segmentation artefacts, while Otsu thresholding provided reliable foreground-background separation and Canny detection generated well-localized boundaries. Overall, the proposed framework provides an effective preprocessing strategy for subsequent image analysis and machine learning applications.

640 Causal-Adaptive Multi-Agent Intelligence System for Smart Public Transportation

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The lack of intelligent planning can lead to limited utilization of the transport fleets, fixed schedules and overcrowding on public transport systems. This paper proposes an Intelligent Multi-Agent System to optimize public transport operations using machine learning, deep learning, ensemble learning and multi-agent decision intelligence. The framework consists of stacked Graph Attention Networks, Temporal Transformers and LightGBM, CatBoost and XGBoost, which are trained to predict passenger demand, load factor and utilization status from spatio-temporal transport data. Monte Carlo Dropout al-lows uncertainty estimation, and Isolation Forest are used to identify anomalies. The multi-agent architecture enables deci-sions, like prioritizing routes or allocating the fleet to be made intelligently. The high predictive accuracy and improved operational efficiency of the results highlight the potential of this framework for sustainable data-driven public transport management.



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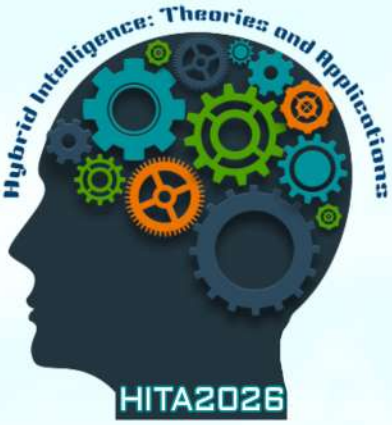
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