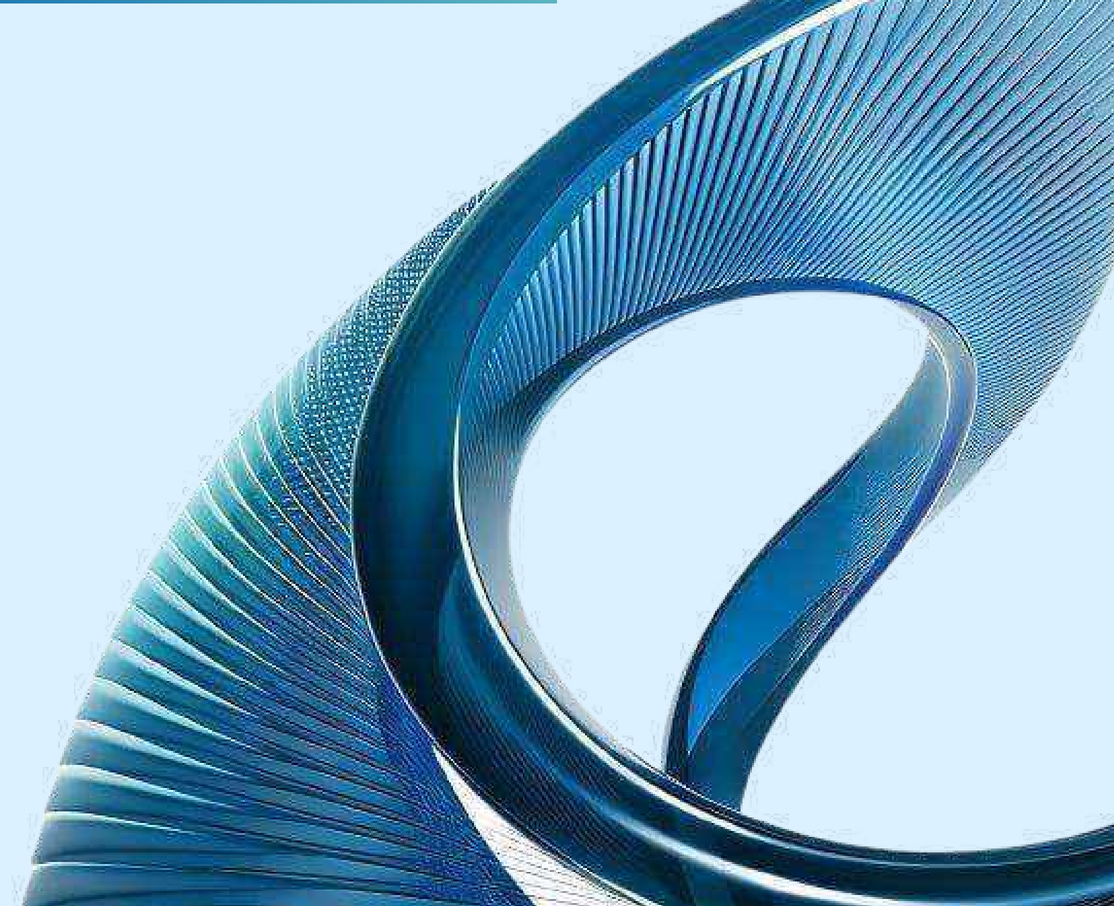
CONFERENCE PROCEEDINGS

2025 IEEE INDICON

REGENERATIVE ARTIFICIAL INTELLIGENCE:
ADVANCING AI FOR INDUSTRIAL, SOCIETAL, AND ENVIRONMENTAL IMPACT

18-20 December, 2025
IIITB, Bengaluru, India



PROCEEDINGS OF

IEEE 22ND INDIA COUNCIL INTERNATIONAL CONFERENCE

IEEE INDICON - 2025

THEME : REGENERATIVE ARTIFICIAL INTELLIGENCE - ADVANCING AI FOR INDUSTRIAL, SOCIETAL, AND ENVIRONMENTAL IMPACT

18–20 DECEMBER 2025,

INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY (IIIT-B)
26/C, ELECTRONICS CITY, HOSUR ROAD
BANGALORE, KARNATAKA, INDIA - 560100

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IEEE INDICON 2025

22nd Edition | 18–20 December 2025 | International Institute of Information Technology, Bengaluru, India

The IEEE International Conference on Industrial, Societal, and Environmental Applications of Regenerative Intelligence (INDICON 2025), in its 22nd edition, is the flagship annual international conference of the IEEE India Council, jointly organized with the IEEE Bangalore Section. Guided by the theme "Regenerative Intelligence: Advancing AI for Industrial, Societal, and Environmental Impact," IEEE INDICON 2025 highlights cutting-edge innovations that address pressing industrial needs, societal challenges, and environmental sustainability.

This year's technical program reflects the diversity and depth of contemporary research across academia and industry. The focus areas include:

- Next-Generation Communication Systems, Networking, and IoT
- Robotics, Automation, Instrumentation, and Intelligent Control Systems
- Photonics, Quantum Technologies, and Optical Intelligence
- Power Electronics and Power Systems, Smart Grids, and Industrial Automation
- Electronic Devices, Circuits, VLSI, and Embedded Systems
- Biomedical Engineering, Wearable Systems, and Healthcare Technologies
- Advanced Signal and Image Processing
- Software Engineering, Distributed, Secure, and Privacy-Aware Systems, and Machine Learning
- Sensors, Remote Sensing, and Intelligent Perception Systems
- Intelligent Mobility, Vehicular Systems, and Transportation Technologies

These domains represent the core of IEEE INDICON 2025, providing a comprehensive platform for knowledge exchange, interdisciplinary collaboration, and the advancement of technologies shaping the future.

MESSAGE FROM

GENERAL CHAIR

DR. CHANDRAKANTA KUMAR
Chair, IEEE Bangalore Section

On behalf of the IEEE Bangalore Section, it is my privilege to welcome all delegates, authors, speakers, and guests to IEEE INDICON 2025. As one of the most active and vibrant Sections of IEEE globally, the Bangalore Section is delighted to host the 22nd edition of this flagship conference of the IEEE India Council, in collaboration with the distinguished IIIT Bangalore.

The theme “Regenerative Intelligence” reflects a crucial and timely direction for technological innovation. As AI systems evolve to not only learn from data but to enable sustainable, restorative, and human-centric outcomes, the discussions at INDICON 2025 will help shape a thoughtful and responsible technological future.

Hosting INDICON is an important milestone for the Bangalore Section, and I extend my sincere appreciation to the Organizing Committee, the Technical Program Committee, and the many volunteers who have worked tirelessly to bring this conference together. Their dedicated efforts, coupled with the active participation of researchers and industry leaders, ensure a rich and rewarding experience for all attendees.

I express my gratitude to the authors whose contributions form the backbone of this conference, and to our keynote speakers and panelists for bringing valuable insights and perspectives.

I warmly welcome you to IEEE INDICON 2025 and wish you meaningful interactions, new collaborations, and an inspiring conference experience in the heart of India’s technological hub—Bangalore.

MESSAGE FROM

GENERAL CHAIR

PUNEET KUMAR MISHRA
Vice President (Education), IEEE AEES Society.
Chair- IEEE AESS Bangalore Chapter

It is my pleasure to welcome you to the 22nd edition of IEEE INDICON, the flagship conference of the IEEE India Council, organized in association with the IEEE Bangalore Section and hosted at IIIT Bangalore.

The theme, “Regenerative Intelligence,” highlights the transformative potential of next-generation AI in driving industrial innovation, societal progress, and environmental sustainability. INDICON 2025 brings together a distinguished community of researchers, academicians, industry experts, and innovators to exchange ideas, share research findings, and explore emerging technological frontiers.

I extend my sincere appreciation to the Technical Program Committee, Organizing Committee, reviewers, volunteers, and contributors for their dedicated efforts. My heartfelt thanks to all authors and participants for enriching the technical strength of INDICON.

I warmly welcome you to IEEE INDICON 2025 and wish you an insightful and rewarding conference experience.

MESSAGE FROM
GENERAL CO-CHAIR

DR. CHENGAPPA MUNJANDIRA
Vice-Chair (Technical Activities),
IEEE Bangalore Section

It is my privilege to welcome you to the 22nd edition of IEEE INDICON, the flagship conference of the IEEE India Council and IEEE Bangalore Section. This year, we come together under the theme "Regenerative Artificial Intelligence: Advancing AI for Industrial, Societal, and Environmental Impact"-a theme that resonates strongly with the transformative shifts shaping technology, communities, and economies worldwide.

INDICON has long served as a premier forum where pioneering research meets real-world relevance, where interdisciplinary dialogue fuels innovation, and where collaborative spirit drives impact. The 2025 edition continues this legacy by bringing together an exceptional community of researchers, industry professionals, academicians, innovators, and students who are collectively advancing the frontiers of science and engineering.

Our technical program spans a broad spectrum of contemporary and emerging domains-ranging from next-generation communication systems, robotics and automation, quantum and photonic technologies, VLSI and embedded systems, smart grids, AI and machine learning, biomedical systems, vehicular technologies, and more. Each track represents a critical pillar of our technological future and showcases the depth of innovation across India and the global research ecosystem.

I extend my sincere appreciation to all authors for their submissions, to the reviewers for their rigorous evaluations, to the technical committee for curating a high-quality program, and to the dedicated organizing team for their tireless efforts in shaping this conference.

We are deeply grateful to the International Institute of Information Technology, Bengaluru (IIIT-B) for hosting this year's INDICON. The institute's continued support, collaborative spirit, and exceptional facilities have been instrumental in enabling us to conduct this conference at the highest standard. We thank the leadership, faculty, staff, and student volunteers of IIIT-B for partnering with us in delivering this impactful edition of INDICON.

To all participants, I encourage you to immerse yourselves fully in the discussions, presentations, workshops, and networking opportunities. May this conference spark new insights, foster meaningful collaborations, and inspire you to innovate responsibly and purposefully for societal and environmental good.

Thank you for being a part of IEEE INDICON 2025. I wish you an enriching and memorable conference experience.

MESSAGE FROM
STEERING COMMITTEE

DR. DEBABRATA DAS

2025 Immediate Past Chair, IEEE India Council
Director, IIIT Bangalore

It is my pleasure to extend warm greetings to all participants, authors, reviewers, and delegates of IEEE INDICON 2025. INDICON has grown to become one of the most respected and influential conferences of the IEEE India Council. It continues to provide a distinguished platform for sharing knowledge, presenting research, and fostering collaboration across Computer Science and Engineering, Electrical Engineering, and Electronics and Communication Engineering.

The origins of INDICON lie in the Annual Convention and Exhibitions of the IEEE India Council. During the ACE 2003 meeting, the Council formally resolved to restructure the event into a high quality technical conference that would also host the annual meeting of the Council. This decision marked the beginning of INDICON, which has since evolved into a conference of national importance and international recognition.

I have had the privilege of being associated with INDICON in various leadership roles, including serving as a Co Organizer of the thirteenth edition held at the Indian Institute of Science in Bangalore in 2016. It is therefore a matter of special pride that the present edition of INDICON is being hosted at IIIT Bangalore where I serve as Director. The Institute is committed to excellence in education, research, and innovation, and we are pleased to provide an enabling environment for this year's deliberations.

I extend my sincere appreciation to the Organizing Committee of IEEE INDICON 2025, the IEEE Bangalore Section, and the IEEE India Council for their dedicated efforts in planning and executing this conference. I also acknowledge the valuable contributions of the authors who submitted their work and the reviewers who ensured rigorous evaluation and high technical quality.

I am confident that INDICON 2025 will inspire meaningful discussions, promote impactful collaborations, and contribute to advancements that benefit the engineering and scientific community. I wish all participants a productive and enriching conference experience.

MESSAGE FROM
STEERING COMMITTEE

DR. PRERNA GAUR
Chair, IEEE India Council

It is my pleasure to extend warm greetings to all participants of 22nd IEEE INDICON 2025, the flagship conference of the IEEE India Council. INDICON has evolved into a significant platform that brings together academia, researchers, and industry professionals to exchange knowledge and promote technological advancement across the country.

This year's theme, "Regenerative Intelligence," comes at a time when artificial intelligence is reshaping the way we innovate, collaborate, and build sustainable solutions for the future. INDICON 2025 provides an excellent forum to explore these new directions and their impact on society and the environment.

I would like to specially acknowledge the IEEE Bangalore Section for its dedicated effort in hosting this year's conference with exemplary professionalism and vision. The Section has consistently demonstrated leadership in advancing engineering education, research, and industry collaboration, and its continued commitment has played a crucial role in shaping the success of INDICON 2025.

I also appreciate the Organizing Committee, Technical Program Committee, reviewers, and volunteers for their tireless contributions. My sincere thanks to all authors and participants for enriching the technical depth and diversity of this conference.

I welcome you all to IEEE INDICON 2025 and wish you an engaging, insightful, and fruitful experience over the next three days.

MESSAGE FROM
STEERING COMMITTEE

PROF PREETI BAJAJ
Chair Elect IEEE India Council

It is a matter of great pride for IEEE India Council that signature conference of IC 'INDICON' in its the 22nd edition as INDICON 2025 and is being organized in collaboration with the IEEE Bangalore Section.

The theme 'Regenerative Artificial Intelligence: Advancing AI for Industrial, Societal, and Environmental Impact' shows its synergises with the advancement of technology and reflects a crucial shift toward AI systems which is restorative, sustainable, self-improving, and deeply aligned with the needs of society, environment, and industry. Regenerative Artificial Intelligence (RAI) represents an emerging paradigm where intelligent systems can continuously learn, adapt, and regenerate knowledge to enhance long-term reliability, resilience, and ethical performance. Regenerative AI already finds impactful applications in various domains.

I extend heartfelt appreciation and gratitude to Organising committee in particular General Chair and Organising chairs and IIIT Bangalore for graciously hosting this prestigious conference with exceptional professionalism and warmth.

My gratitude is to Prof Debbrata Das, Director, IIIT Bangalore, for his visionary leadership, unwavering support, and dedication to fostering an environment that enables impactful discussions and innovation.

My sincere appreciation also goes to the IEEE India Council Dr. Prerna Gaur, Chair for her dynamic leadership and ExCom for successfully organising the this flagship conference and strengthening India's technological ecosystem and promoting collaborative progress in emerging domains such as regenerative and responsible AI.

INDICON has consistently served as a premier platform for researchers, academicians, and practitioners to showcase pioneering work that shapes our nation's technological narrative. The 2025 edition continues this legacy by bringing together diverse perspectives that will influence the future of AI-driven solutions and their real-world impact.

I appreciate the dedication of the organizing committees, technical teams, reviewers, and volunteers who have contributed to this prestigious event. I am confident that the knowledge shared through INDICON 2025 will inspire meaningful advancements and strengthen India's position as a global leader in responsible and regenerative AI.

MESSAGE FROM
TECHNICAL PROGRAM COMMITTEE CHAIRS

DR. MOHIT P. TAHILIANI
(NITK SURATHKAL, INDIA)

DR. VASUDEVA
(NMAMIT NITTE, INDIA)

It is our privilege to present the 22nd edition of IEEE INDICON, hosted at the International Institute of Information Technology Bangalore (IIIT Bangalore) during December 18–20, 2025. The technical program of 2025 IEEE INDICON reflects the sustained commitment of the IEEE community to fostering high-quality research and innovation across diverse areas of electrical, electronics, computer, and interdisciplinary engineering. This year's conference featured 10 technical tracks, carefully curated to address both foundational research and emerging trends of contemporary relevance.

We received an overwhelming response from the research community, with a total of 964 paper submissions from academia, industry, and research organizations worldwide. After a rigorous and thorough peer-review process, 149 papers were accepted for presentation and inclusion in the conference proceedings, reflecting a highly selective acceptance rate and ensuring the technical excellence of the program.

The success of the technical program is the result of the collective efforts of a dedicated team. We would like to express our sincere gratitude to the 20 Track Chairs for their leadership, coordination, and meticulous oversight of the review process. We are also deeply thankful to the 392 reviewers, whose careful, timely, and constructive evaluations were instrumental in maintaining the high standards expected of an IEEE flagship conference. Their voluntary service and technical expertise form the backbone of the peer-review process. We would also like to acknowledge the support and guidance of the General Chairs, the Organizing Committee, and the 2025 IEEE INDICON Steering Committee, whose vision and coordination have been invaluable throughout the planning and execution of the conference.
It is our sincere belief that the technical sessions, keynote addresses, and professional interactions at 2025 IEEE INDICON facilitated rigorous intellectual exchange and supported sustained advancement in research and professional practice.

MESSAGE FROM

PUBLICATION COMMITTEE CHAIR

DR M DEVANATHAN

SAC Chair - IEEE Bangalore Section

As the Publication Chair, pleased to present the proceedings of the 22nd edition of IEEE INDICON 2025, the flagship conference of the IEEE India Council, hosted by the IEEE Bangalore Section at IIIT Bangalore. These proceedings comprise peer-reviewed technical papers aligned with the conference theme, “Regenerative Intelligence: Advancing AI for Industrial, Societal, and Environmental Impact,” reflecting high-quality research contributions from academia, industry, and research organizations.

The papers included in this volume have undergone a rigorous review process coordinated by the Technical Program Committee, ensuring compliance with IEEE quality and publication standards. We sincerely acknowledge the efforts of the reviewers, Track Chairs, and organizing team, and thank the authors for their valuable contributions and cooperation throughout the publication process.

It is expected that the work presented in these proceedings will be disseminated through IEEE Xplore and serve as a meaningful reference for researchers and practitioners worldwide.

STEERING COMMITTEE

Dr. Prerna Gaur
Chair, IEEE India Council

Dr. Debabrata Das
Immediate Past Chair, IEEE India Council

Dr. Preeti Bajaj
Chair-Elect, IEEE India Council

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Day - 01

18 December 2025 (Thursday)

Time	Duration	Agenda	Venue
10:00 AM – 12:00 PM	2 Hours	Paper Presentations	Rooms 101–110
12:00 PM – 01:00 PM	1 Hour	**Invited Talk:** *“Visual AI: History and Future Path — How computer vision evolved from hand-crafted rules to foundation models, unlocking scalable, real-world industrial impact”*	Level 0
01:00 PM – 02:00 PM	1 Hour	Networking Lunch	Basement
02:00 PM – 05:00 PM	3 Hours	**AI Workshop:** *“From Rules to Reasoning: The Journey Toward Agentic AI”*	Level 0
05:00 PM – 06:00 PM	1 Hour	Inaugural Ceremony & INDICON Keynote	Level 0
06:00 PM – 06:30 PM	30 Minutes	High Tea & Networking	Basement

DAY - 02
19 DECEMBER 2025 (FRIDAY)

Time	Duration	Agenda	Venue
10:00 AM – 12:00 PM	2 Hours	Technical Paper Presentations (10 Sessions)	Rooms 101–110
10:00 AM – 12:00 PM	2 Hours	**MOVATHON**	Level 1 (Amantran)
12:00 PM – 01:00 PM	1 Hour	**Invited Talk:** *“ADAS (Advanced Driver Assistance Systems)”*	Level 0
01:00 PM – 02:00 PM	1 Hour	Networking Lunch	Basement
02:00 PM – 05:00 PM	3 Hour	**Hardware Workshop:** *An Industrial Perspective on Analog, Mixed-Signal and RF Design, Verification and Test – Opportunities for AI/ML*	Level 0
02:00 PM – 03:00 PM	1 Hour	IEEE India Council Execom Meeting	Boardroom
03:00 PM – 05:00 PM	2 Hours	**IEEE FINE Workshop** by Prof. Debatosh Guha	Room 104
05:00 PM – 06:00 PM	1 Hour	IEEE India Council AGM	Room 104
06:00 PM – 08:00 PM	2 Hours	IEEE India Council Awards Ceremony	Level 1 Auditorium
08:00 PM – 09:00 PM	1 Hour	Networking Dinner	Basement

DAY - 03

20 DECEMBER 2025 (SATURDAY)

Time	Duration	Agenda	Venue
10:00 AM – 01:00 PM	3 Hours	Paper Presentations	Level 0
01:00 PM – 02:00 PM	1 Hour	Networking Lunch	Basement
02:00 PM – 04:00 PM	2 Hours	Valedictory Ceremony	Level 1 Auditorium
End of the Conference			

Reviewers list

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Paper ID : 10

Voxel-Level Quantum Simulation of X-Ray Scattering Dynamics

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Abstract

X-ray scattering is foundational to imaging and spectroscopy across medical diagnostics, crystallography, and materials science. Classical simulation frameworks, while effective for bulk photon transport, typically rely on stochastic sampling and precomputed cross-sections that do not directly capture quantum coherence, interference, or entanglement effects. In this work, we investigate the feasibility of modeling X-ray photon electron interactions using quantum computation. We develop a voxel-local interaction unit-cell Hamiltonian that captures both Rayleigh (elastic) and Compton-like (inelastic) scattering channels within a minimal 4-dimensional Hilbert space. The system is simulated on Noisy Intermediate-Scale Quantum (NISQ) hardware using Variational Quantum Eigensolvers (VQE) to obtain stationary energy states and Trotterized time evolution to model scattering dynamics. Using a compact 3-qubit encoding implemented in Qiskit, we analyze photon energy redistribution and angular dependence, and qualitatively compare the resulting trends with theoretical predictions such as the Klein-Nishina relation. The results demonstrate that even small-scale quantum processors can reproduce core qualitative features of X-ray scattering, though full physical fidelity remains limited by Hilbert space dimension, decoherence, and noise. We discuss scalability pathways toward multi-voxel simulation, model generalization to higher photon modes and electron states, and the prospective integration of quantum-native scattering modules into spectral

CT and phase-sensitive imaging frameworks.

Index Terms-quantum simulation, x-ray, Reyleigh scatter, quantum computing, Compton, NISQ

Paper ID : 39

A Comparative Evaluation of YOLOv8 and Detectron2 for Real-World Aerial Segmentation on a Resource-Constrained Dataset

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Abstract

This paper presents a comparative evaluation of two state-of-the-art object detection frameworks, YOLOv8 and Detectron2, for aerial image analysis using unmanned aerial vehicles (UAVs) in resource-constrained environments. A custom UAV-based dataset of high-resolution RGB images was annotated across nine land-use categories, including agricultural fields, buildings, roads, trees, and water bodies, enabling applications in precision agriculture and infrastructure monitoring. The lightweight YOLOv8-nano model was compared with Detectron2 (ResNet-50-FPN) in terms of detection accuracy, inference speed, and memory usage. YOLOv8-nano achieved a mean Average Precision (mAP@0.5) of 91.2, outperforming Detectron2 in inference speed (45 FPS vs. 12 FPS) and memory usage (1.5 GB vs. 3.8 GB). It also demonstrated superior generalization with higher confidence and fewer false positives, while Detectron2 exhibited increased class confusion under domain shifts. Unlike prior UAV detection studies that rely on high-resource datasets, this work uniquely benchmarks YOLOv8-nano and Detectron2 on a resource-constrained custom UAV dataset, highlighting YOLOv8-nano's suitability for real-time, edge-deployable UAV applications.

Index Terms—YOLOv8, Detectron2, aerial object detection, UAV imagery, precision agriculture, edge deployment, real-time inference, resource-constrained systems.

Paper ID : 110

Dual Attention Guided Wavelet Domain ISTA-Net for Noise-Resilient Underwater Passive Sonar Detection and Classification

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Abstract

A narrow band of spectral lines observed in the low frequency analysis and recording (LOFAR) of the underwater acoustic signal received by the passive sonar indicates the presence of underwater targets. However, low signal-to-noise ratio (SNR) conditions degrade the quality of the LOFAR spectrum, causing these spectral lines to become weak or buried in ambient noise. Traditional line enhancing often struggle to suppress residual noise effectively due to weighted noise in adaptation.

This paper presents a robust spectral enhancement framework that integrates frequency domain ALE preprocessing with an dual attention guided iterative shrinkage thresholding algorithm (ISTA) in the wavelet domain. The ALE stage effectively reduces broadband noise and preserves spectral line structure. The subsequent ISTA block utilizes the wavelet transform's multi resolution and localized time-frequency analysis capabilities and incorporates a learnable attention mechanism that adaptively

weights wavelet coefficients to perform enhancement by preserving spectral features and promoting sparsity. Experimental evaluations show that the proposed method, namely dual attention guided wavelet domain ISTA-Net spectral line enhancer achieves an SNR improvement of 4.45 dB over fast block-processed sparsity-based ALE and 6.37 dB over conventional frequency domain ALE. To further study the recognition accuracy of the proposed method, a ResNet-based classifier is used. The proposed method attains a classification accuracy of 96.32% outperforming existing state-of-the-art techniques. These results confirm the method's effectiveness in enhancing target detection and recognition in underwater environments.

Index Terms—Adaptive Line Enhancer, LOFAR spectrum, Passive sonaR, Sparse signal, Underwater target detection, Wavelet domain.

Swara-Net: A Deep Learning Baseline and Curated Dataset for Five Under-Represented Carnatic Ragas

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Abstract

This paper addresses a critical gap in computational musicology: the lack of robust datasets and baselines for specific, under-represented Carnatic ragas. We introduce a new, manually-curated dataset of 638 audio snippets for five prominent ragas: Shankarabharanam, Revathi, Abheri, Brindavanasaranga, and Mayamalavagowla. This collection, sourced from public recordings, is designed to be timbrally diverse. To establish a strong performance benchmark, we compare a standard Support Vector Machine (SVM) against a 3-layer Deep Neural Network (DNN). The results are striking: the SVM achieves only 57.03% accuracy, while our proposed DNN (Swara-Net) achieves 99.0% accuracy. This demonstrates the superior ability of deep learning to navigate the complex, high-dimensional feature space of raga. We further provide a musicological analysis of the model's single
misclassification. This work contributes both a valuable, opensource dataset and a reproducible, high-performance baseline, paving the way for more nuanced research on these specific ragas.

Index Terms—Raga classification, Indian classical music, machine learning, dataset, audio processing, deep neural networks

MedMe: Decentralized Medical Data Storage System Integrating Blockchain, IPFS and Edge Computing

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Abstract

With healthcare data becoming increasingly digital, ensuring security, privacy, and easy access is more important than ever. This paper introduces a decentralized medical storage system that combines blockchain, edge computing, and InterPlanetary File System (IPFS) to create a secure and scalable solution. Blockchain acts as a decentralized ledger, preventing single points of failure and enabling easy auditing. IPFS provides decentralized storage, ensuring that data remain private and accessible without relying on a central server. By integrating these technologies, our system offers a secure, private, and resilient way to store and facilitates access to medical records between organizations.

Index Terms—Blockchain, Edge Node, IPFS, Ledger

Paper ID : 150

Autonomous Utility Robotic Assistant

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Abstract

Material handling is vital for productivity and safety in industrial and commercial settings, yet traditional manual methods cause physical strain, especially for workers and the elderly. In industries, f atigue and accidents are common, while elderly shoppers struggle to navigate crowded spaces and carry heavy loads. This paper presents a dual-domain autonomous smart cart system with human-following and obstacle avoidance capabilities to tackle both scenarios. Using advanced tracking and sensor fusion, the cart adapts to user movements and cluttered environments, autonomously or under manual control for precision. In industrial contexts, it reduces worker fatigue
by transporting heavy items, improving safety and consistency. In retail, it helps elderly users by minimizing physical effort and enabling independent shopping through smooth navigation and item handling. Initial implementations show 20–30% faster task completion for industrial workers and better accessibility for elderly users, including less strain and increased confidence. The modular design of the system ensures seamless integration into existing infrastructures without major updates, focusing on scalability and user adaptability. By merging assistive robotics with automation, this smart cart provides a practical, versatile solution to modern material handling needs—enhancing safety,
inclusion, and efficiency across diverse environments.

Index Terms—Human-robot collaboration, autonomous navigation, obstacle avoidance, assistive robotics, elderly assistance, industrial automation.

Paper ID : 160

TRAIL-D: Ternary Restoring Array Integrated Logic – Division

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Abstract

Division is widely used in digital signal processing tasks, such as calculating filter coefficients, normalizing signals, and scaling data, which are key steps in improving audio quality or processing images. By allowing accurate adjustments and fine-tuning of signal values, division helps ensure that processed signals closely match the original, reducing errors and maintaining quality. Despite growing advancements in ternary logic implementations using carbon nanotube field-effect transistors (CNTFETs), ternary restoring division lacks systematic exploration. This work advances the field by proposing a ternary restoring division algorithm and a novel designed circuit architecture, adapting binary division principles to ternary logic. Novel modules for division specific subtraction and control logic are introduced, complemented by optimized reuse of existing ternary combinational circuits. The proposed architecture demonstrates inherent scalability for 2n/n digit divisions through modular replication. Functional correctness of the circuit is verified via exhaustive HSPICE simulations for 6/3 and 8/4 division operations.

Index Terms—Ternary Restoring Division, Array Circuit, Ternary Array Block, Special Full Subtractor, Control Logic, 2n/n Division

Siamese-Based Deep Architecture for Face Verification and Gender Detection in Adverse Weather Condition

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Abstract

Surveillance systems are crucial for public safety, especially in urban areas where law enforcement relies heavily on CCTV footage. However, adverse weather conditions can significantly reduce image clarity, making it difficult to identify individuals or basic characteristics like gender. To address this issue, a deep learning-based dual-stage system has been introduced. This system combines a face verification system with a gender classification model to determine if a distorted face corresponds to a known reference image, even in the presence of blurriness, noise, or environmental disruptions. Experimental findings show promising performance across various distortions, indicating the system's potential for real-world surveillance applications. This work aims to improve identity recognition accuracy in difficult environments, contributing to quicker and more reliable decision making during critical situations.

Index Terms—Face recognition, Adverse weather, Deep Learning, Survellience System, Image Processing

Paper ID : 222

Solving Inverse Kinematics for Quantised Joint Manipulators Using Metaheuristics and Discrete Gradient Descent

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Abstract

Inverse Kinematics (IK) is a core problem in robotics, typically solved using continuous methods that assume differentiable joint spaces. However, many real-world systems, such as stepper motor-driven arms and embedded manipulators, exhibit discrete or quantized joint behaviour, where classical IK solvers often fail or produce unstable, jittering outputs. To address this, we formalise the Inverse Discrete Kinematics (IDK) problem and propose a hybrid solution combining discrete metaheuristic search with a local refinement step using Discrete Gradient Descent (DGD). The method optimises joint configurations within a quantised space to minimise end-effector error while maintaining energy efficiency. Experiments on 5-DOF and 6-DOF manipulators demonstrate sub-millimetre accuracy and improved robustness over brute-force and naive rounding approaches, establishing IDK as both tractable and practically significant. Statistical analysis was performed on each of the runs to determine significant differences and equivalence before and after the DGD process.

Index Terms—Discrete Angle, Inverse Kinematics, Metaheuristic, Quantised Joints, Kinematic Chain

Paper ID : 237

Layerwise Noise Sensitivity in Quantum Neural Networks for NISQ Devices

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Abstract

Quantum Neural Networks (QNNs) offer a compelling approach to quantum machine learning, but their effectiveness is heavily constrained by noise on Noisy Intermediate- Scale Quantum (NISQ) hardware. Prior studies examine global noise effects, yet the sensitivity of individual QNN layers remains Under explored. This paper presents a layer wise noise sensitivity analysis framework that isolates the impact of depolarizing, amplitude damping, and phase damping noise on the encoding, variational, and measurement layers of QNNs. Using Qiskit Aer, we simulate targeted noise injection and evaluate performance on the Iris dataset. We introduce the Layer wise Sensitivity Drop (LSD) metric to quantify degradation under noise. Results show that the encoding layer is most vulnerable (LSD up to 42.9%), while the measurement layer is comparatively robust. Additionally, entangling gates are found to be more noisesensitive than rotational gates. These insights inform future QNN design strategies, emphasizing layer-specific error mitigation to improve resilience on near-term quantum hardware.

Index Terms—Quantum Neural Networks, Noise Sensitivity, NISQ, Qiskit, Quantum Machine Learning

Paper ID : 238

Face Based Health Monitoring : An AI Driven BMI Estimation Framework

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Abstract

Accurate and non-invasive health monitoring is essential for early disease detection, personalized healthcare, and continuous health assessment without requiring frequent clinical visits. Traditional BMI measurement methods, such as weight and height-based calculations, can be impractical in remote areas, telemedicine consultations, or for individuals with mobility limitations. Automated facial analysis offers a valuable alternative, enabling BMI estimation from facial images without direct physical contact. In this study, we present a robust framework that integrates Multi-Task Cascaded Convolutional Neural Network (MTCNN) for facial detection, FaceNet for feature extraction, and eXtreme Gradient Boosting (XGBoost)
for BMI estimation. By leveraging both frontal and side-profile face images, the proposed approach has achieved a MAE of 0.7019, RMSE of 2.0186, R2 value of 0.84 and Pearson Correlation Coefficient (PCC) of 0.90.The proposed method outperforms other techniques in the literature. [5] [3] These results highlight
the effectiveness and reliability of the model in BMI estimation. With its scalable and adaptable design, this framework is well suited for real-time health monitoring, fitness tracking, and tele-medicine applications. It can be particularly beneficial in remote healthcare settings, fitness assessments, and large-scale health screenings where traditional BMI measurement may be inconvenient or inaccessible.

Index Terms—Body Mass Index (BMI), Facial Landmark detection, MTCNN, FaceNet, Health-metrics, Non-invasive Health Monitoring, Tele-medicine.

XAI-Enabled Framework to Estimate Mental Disorder Using Fusion Approaches

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Abstract

EEarly and accurate diagnosis is essential for treating mental health issues, including depression and PTSD. This work introduces a deep learning architecture powered by explainable AI (XAI) that uses text and audio data to detect mental illnesses automatically. Using the DAIC-WOZ clinical interview dataset, the proposed model uses Long Short-Term Memory (LSTM) and Bidirectional LSTM (BiLSTM) networks to capture semantic and auditory patterns related to psychological distress. To ensure model transparency and facilitate clinical decision-making, explainability tools like attention visualizationand SHapley Additive exPlanations (SHAP) values are included. The approach outperforms unimodal methods, achieving 92% depression and 93% PTSD classification accuracy. By adding interpretability to a solid multimodal pipeline, AI-assisted mental health evaluation becomes open and allows for morally and clinically sound diagnostic tools.

Index Terms—Mental Health Diagnosis, XAI, Multimodal Fusion, BiLSTM, LSTM, SHAP.

Paper ID : 260

A Two-stage Hybrid Lossless EEG Data Compression Technique for Fog-assisted IoHT

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Abstract

This work presents a hybrid lossless compression technique for Electroencephalogram (EEG) data, featuring clustering and encoding stages in fog enabled Internet of Healthcare Things (IoHT) network. With the recent advancement in the EEG devices, multichannel EEG sensors generate huge volume of patients' data, emphasizing the necessity for low-latency transmission in IoHT networks. Recently, fog-assisted healthcare networks have played a significant role in efficient data management and analysis. This paper proposes fog-enabled Hybrid Lossless EEG data Compression method, termed as HLoECo, employing a lossless approach that achieves strong compression performance.
The proposed technique is tested on two real-time EEG datasets. Dataset-1, the Bonn University dataset, notably gives enhanced average compression ratio of 8.72 and a maximum compression power of 93%. Further, the simulation involves thorough analysis of Z subject using k-means clustering across various K values (ranging between 10 to 190). Dataset-2, the Physionet Motor Movement/Imagery dataset, exhibits 97% compression power and a maximum compression ratio of 38.50 on applying the proposed technique. Moreover, HLoECo is performed on five distinct evaluation metrics and compared with both conventional and recent EEG data compression techniques. Furthermore, the work illustrates the relationship between codec time and compressed data size for all the techniques. The finding shows that the proposed technique outperforms all other compared methods and is suitable for low-latency healthcare deployments.

Index Terms—Clustering, Electroencephalogram (EEG), Encoding, Fog computing, Internet of Healthcare Things (IoHT), Lossless compression.

Paper ID : 261

Improved mammogram mass segmentation and classification using low complexity FLANN model

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Abstract

Digital mammograms must be detected and diagnosed early in order to lower the death rate from breast cancer in women. An effort has been made to segment and classify mammograms in order to accomplish this goal. For mass segmentation and classification, this paper proposes an enhanced adaptive thresholding-based method utilizing exponential functional link artificial neural network (EFLANN). The Gray Level Co-occurrence Matrix (GLCM) features are extracted from the segmented mammogram which are fed to the FLANN model for classification task. The proposed method achieves sensitivity of 93.06% and specificity of 96.15% when tested with 200 images from MIAS and DDSM databases. With a 95% overall classification accuracy, the suggested model may be extremely useful in the diagnosis of breast cancer.

Keywords— Mammography, FLANN, mass segmentation, GLCM, mass classification

Paper ID : 265

Terminal Impedance-Based Detection of Radial Deformation in Disc-Type Transformer Windings Using Euclidean Spectral Distance

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Abstract

Power transformer windings are susceptible to radial deformation (RD) during operation, potentially causing catastrophic failures. This paper presents a novel non-intrusive diagnostic technique for detecting and localizing RD using terminal impedance measurements exclusively. The methodology comprises three key elements: (1) electrical parameter extraction from frequency response analysis, (2) fault detection through ground capacitance deviation analysis, and (3) fault localization using Euclidean spectral distance comparison between measured and simulated eigenvalue spectra. The approach eliminates requirements for baseline reference data, complex model fitting procedures, and training phases while achieving real-time diagnostic capability. Comprehensive validation through circuit simulations, finite element analysis, and experimental studies demonstrates 100% localization accuracy across diverse fault scenarios with exceptional computational efficiency.

Index Terms—Power transformer diagnostics, winding deformation, impedance measurement, condition monitoring, fault localization

Paper ID : 266

Hardware-Efficient Logarithmic Multipliers for Power-Aware Neural Network Applications

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Abstract

Floating-point multiplication is a core operation in signal processing, machine learning, and high-performance computing, yet conventional IEEE-754 implementations suffer from high power, area, and latency overheads. This work presents efficient logarithmic floating-point multipliers that approximate the logarithm and antilogarithm functions using curve-fitting techniques tailored to the IEEE-754 single-precision format. The designs offer configurable trade-offs between accuracy and hardware efficiency, making them suitable for energy-constrained applications. Synthesis results from Cadence Genus indicate that low-cost variants achieve up to 2× reduction in area, 2.1× lower power, and 1.6× improvement in delay, while accuracy optimized versions reduce MAED and NRMSE by 46% and 60%,respectively. Experimental validation using JPEG compression benchmarks shows minimal quality degradation, with over 98% SSIM for efficient designs and less than 0.02% SSIM difference from exact multipliers for high-accuracy variants. Neural network inference on FOURCLASS datasets demonstrates less than 1% classification accuracy drop, confirming the practicality of the proposed multipliers in approximate computing systems. These results highlight the potential of logarithmic multipliers for low-power, high-throughput AI accelerators and embedded platforms.

Index Terms—Logarithmic Multipliers, Approximate Computing, Floating-Point Units, Hardware Accelerators, Low-Power Design, Artificial Intelligence, Image Processing.

Paper ID : 275

Explainable AI for Deep Gait-based Fall Detection Models: Smartphone vs. Wearable Inertial Sensors

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Abstract

Explainable AI for gait assessment is an emerging approach that combines the capabilities of artificial intelligence with the interpretability of automated gait assessment systems. Gait-based fall prediction generally uses motion data captured using wearable inertial measurement unit (IMU) sensors, vision sensors, and pressure sensors. Despite growing interest in Smartphone-based fall prediction, these systems often face distrust among clinicians, questioning its clinical reliability. In this experimental study, we present a comparison of the interpretability and trustworthiness of automated fall prediction models trained on mobile IMU data and wearable IMU data. For this purpose, a bidirectional Long Short-term Memory model is trained on two standard datasets - MobiFall and KFall. The MobiFall dataset incorporates data from a smartphone of participants engaging in various activities and a range of falls. The KFall dataset includes falls and daily activities of individuals, collected using waist-worn IMUs. We utilize SHapley (SHAP) Additive exPlanations and Layer-wise Relevance Propagation (LRP) approach to explain the model's predictions for both datasets. The predictor variables are analyzed for their contribution to the performance of the prediction models. The interpretability of the variables derived from smartphone and wearable IMU devices is compared to validate the applicability of mobile sensors for fall prediction. The maximum SHAP values reported for the MobiFall and the KFall datasets are 0.01877 and 0.0202, respectively. The visualization of the LRP relevance score demonstrates a deeper understanding of the features in the deep learning model that enhance the trustworthiness of systems designed to predict falls, enabling clinicians to provide more informed patient care, treatment plans, and interventions.

Index Terms—Explainability, Fall, IMU, bidirectional LSTM, SHAP, LRP.

Paper ID : 276

Assistive Wearable for Real-Time Posture Monitoring and Correction in Elderly Using Using Inertial Sensing

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Abstract

Poor posture among elderly individuals contributes significantly to musculoskeletal disorders, chronic pain, and reduced mobility. Existing posture correction solutions suffer from high costs, bulky designs, and lack of real-time feedback mechanisms. This paper presents a cost-effective, lightweight wearable device that provides real-time posture monitoring and correction using an MPU9250 inertial measurement unit and ESP32 microcontroller. The system continuously monitors trunk angle deviations and provides immediate haptic feedback through a vibration motor when posture falls outside the optimal range of 70° to 110°. Additionally, the device integrates with the Blynk cloud platform to deliver real-time alerts to mobile applications. Experimental validation demonstrates accurate posture detection with response times less than one second and sustained operation exceeding eight hours on a single battery charge. The proposed system offers a practical alternative to traditional posture correction methods with applications in healthcare, office ergonomics, and elderly care.

Index Terms—Posture correction, wearable sensors, inertial measurement unit, ESP32 microcontroller, elderly care, real-time monitoring, haptic feedback

Paper ID : 323

Dynamic Therapeutic Style Adaptation in LLM-based Chatbots: A Psychologist ChatBot

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Abstract

The worldwide demand for easily accessible mental health care calls for conversational AI systems that go beyond common responses. Traditional chatbots often lack the contextual sensitivity and emotional depth required for meaningful therapeutic interaction. Many individuals avoid conventionaltherapy due to stigma or discomfort, making anonymous AI platforms a valuable alternative. This paper presents a novel multi-LLM framework for a psychologically aware chatbot that dynamically adapts to five therapeutic styles - Cognitive Behavioural Therapy(CBT), Person-Centred, Psychodynamic,Solution-Focused Brief Therapy(SFBT), and Dialectical Behaviour Therapy(DBT)based on user intent. An intent classifier selects the appropriate style, a second LLM generates the response, and a third independently evaluates its quality and fidelity. Key contributions include dynamic therapy style switching, a multi-scenario evaluation using varied LLM pairings (e.g., LLaMA-Gemma), and the use of LLMs as evaluators for empathy, guidance, and alignment. Across 250 distinct queries, the system achieved an average empathy score of 4.2/5, active listening score of 3.88/5, style adherence score of 4.92/5, and intent classification accuracy of 95%. Our work lays a foundation for adaptive, ethical, and person-centred AI support in settings where human therapy is inaccessible.

Index Terms—Therapeutic Chatbots, Large Language Models (LLMs), Mental Health AI, Dynamic Style Adaptation, Psychotherapy, Multi-LLM Framework

A Systematic Evaluation of Non-IID Estimation Methods in Federated Learning

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Abstract

Federated Learning (FL) protects data privacy while enabling decentralized training across distributed clients. However, a primary challenge in FL is the presence of non- Independent and Identically Distributed (non-IID) data among clients. This data heterogeneity, common in real-world scenarios, can lead to several issues such as degraded global model performance, slow convergence, biased local updates, and increased consumption of computational resources and network bandwidth. Effectively addressing non-IID data across distributed clients requires an accurate estimation of its degree in their local datasets. Despite the variety of statistical methods used in the FL literature for non-IID degree estimation, different studies often adopt diverse approaches and assert their effectiveness without clear justification. This lack of explanation has resulted in no clear consensus on the most accurate and effective non- IID estimation method. This paper aims to bridge this critical gap by systematically comparing and evaluating several widely used non-IID estimation methods. We consider eight popular statistical methods used to estimate the degree of non-IIDness in client data within FL. We conducted extensive experiments on the CIFAR-10 dataset to evaluate each method based on its impact on global model performance, communication costs, and computation costs. The findings of this research are intended to guide future studies in selecting appropriate non-IID estimation
methods and offer crucial insights into the efficiency of various estimation techniques. Furthermore, this work contributes to identifying the most effective and reliable non-IID estimation method for characterizing client data distributions.

Index Terms—Federated Learning, Non-IID, Data Heterogeneity, Distributed Learning, Machine Learning, AI.

Paper ID : 345

Slime Mould Algorithm Based HRV Feature Selection for Enhancing Stress Classification

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Abstract

Heart rate variability (HRV) is a crucial biomarker for recognizing and monitoring stress, widely utilized in machine learning (ML) frameworks. This paper presents a feature selection mechanism based on the Slime mould algorithm (SMA), a novel nature-inspired optimization method. The foraging behavior of Physarum polycephalum inspires slime mould algorithm. This algorithm is applied to HRV-based features determined for WESAD and SWELL-KW multimodel stress datasets. The Knearest neighbor (KNN) algorithm is utilized for multiclass stress classification, employing a feature selection mechanism based on the SMA. This SMA-KNN mechanism reduces approximately 90% of the features and training time without degrading the model's performance. The performance of SMA is found to be superior with fast convergence and least steady-state error among other algorithms: Differential Evolution (DE), Grey Wolf Optimizer (GWO), Particle Swarm Optimization (PSO), Manta ray foraging (MRF), and Whale Optimization algorithm (WOA). This KNN-SMA achieves the highest accuracy (0.99, 0.99), precision (0.99,0.99), F1-score (0.97,0.99), and recall (0.97,0.98) for both WESAD, SWELL-KW multiclass classification, compared to other algorithms.

Index Terms—Slime Mould Algorithm, Feature Selection, Mental Stress Detection, Heart Rate Variability

Paper ID : 360

Evaluation of Low-Cost Pressure Sensors for IoT and ML-based Water Flow Estimation

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Abstract

Water scarcity and inefficient resource management present critical challenges, with conventional flow measurement techniques often relying on expensive and invasive methods. This work evaluates the performance of three low-cost pressure sensors (HK3022, MBS3000, and Series 21Y) for internet of things (IoT) and machine learning (ML) based water flow estimation. Tests were conducted in a closed-loop experimental setup across pressure ranges from 1.0 to 2.0 bar, generating over 8,640 pressure readings and 2,160 flow measurements. Sensor performance was assessed through pressure measurement accuracy metrics (RMSE and CV), and flow estimation reliability was assessed using five ML algorithms. Results demonstrate that all sensors achieve comparable flow estimation accuracy. While calibration improves absolute pressure measurement accuracy, it provides minimal advantage for flow estimation tasks. This lowcost, non-invasive approach offers a promising water monitoring solution that is accessible and economically viable.

Keywords: flow estimation, IoT, ML, pressure sensors, sensor Calibration

Paper ID : 379

Deep Learning-Based Sign Language Communication System with Multi-Language Support

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Abstract

Speech impairment is regarded as one of the significant disabilities. When it comes to communicating with others, people with this limitation employ sign language. However, individuals with speech disabilities are unable to communicate with those who do not understand sign language. Therefore, our initiative aims to bridge this communication gap. The primary goal of this work is to develop a vision-based system that can recognise sign language motions in real-time and provide translation in multiple languages. We trained a CNN model on both spatial and temporal features present in real-time video sequences, achieving an accuracy of 97.5%. For multilingual translation, we employed the T5 transformer, achieving an average BLEU score of 0.193, ROUGE-L score of 0.038, and 0.224 seconds per sentence for English-to-Hindi, and a BLEU score of 0.048, ROUGE-L score of 0.022, and 0.434 seconds per sentence for English-to-Kannada translation.

Index Terms—Sign Language Recognition, American Sign Language, Multilingual Translation, Real-time Processing, Deep Learning.

Paper ID : 403

AI-Powered Test Automation Framework for MERN Applications A Hybrid Approach Using Visual and Structural Analysis

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Abstract

The proliferation of MERN (MongoDB, Express.js, React, Node.js) stack applications has increased the demand for robust and efficient testing methodologies. Traditional automated testing frameworks, while effective, often struggle with brittle selectors and the dynamic nature of modern web UIs,
requiring significant manual effort for maintenance. This paper introduces a novel AI-based framework for automated UI and functional testing of MERN applications. Our approach utilizes a hybrid model that combines visual analysis of application screenshots with structural analysis of the Document Object Model (DOM). A Convolutional Neural Network (CNN) is trained to detect visual anomalies and layout inconsistencies from screenshots, while a Transformer-based model (BERT) is finetuned to identify structural and semantic errors within the DOM. We generated a custom dataset by programmatically injecting common bugs into open-source MERN projects. Our hybrid model achieved an accuracy of 94.2% in classifying UI states as "buggy" or "clean," outperforming single-modality models. This framework demonstrates a significant improvement in both speed and bug detection capability over traditional script-based testing, paving the way for more intelligent and resilient CI/CD pipelines.

Keywords—Automated Testing; MERN Stack; Artificial Intelligence; Deep Learning; Computer Vision; Natural Language Processing; UI/UX Testing.

Paper ID : 413

α-aggregator SegLoss: A Novel Loss Function for Medical Image Segmentation

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Abstract

Traditional loss functions encounter difficulties in effectively segmenting medical image, specifically when classes in dataset are imbalanced. Furthermore, many of these loss functions require extensive hyperparameter tuning, which limits their adaptability to different segmentation tasks and datasets. To overcome these limitations, this paper presents a novel loss function, named α-aggregator SegLoss, which
dynamically sets the Tversky index over a range of α values. The performance of the proposed α-aggregator SegLoss is evaluated for segmenting White Blood Cell (WBC) from microscopic blood smear images using two popular deep learning-based segmentation architectures, U-Net and Deeplabv3+. The α- aggregator SegLoss demonstrates significant performance improvements. It improves the validation Dice coefficient y
0.39 – 5.01% and IoU by 0.68 – 9.01% over the traditional loss functions using the U-Net architecture. It achieves 0.16 – 3.42% increase in the Dice coefficient and -0.18 – 4.65 % increase in IoU using DeepLabv3+ architecture. Moreover, the F1 score achieved with the proposed loss is 82.20% and 81.05% for UNet and DeepLabv3+, respectively. These findings confirm the effectiveness and generalizability of α-aggregator SegLoss in tackling challenges in medical image segmentation.

Keywords – Binary cross entropy loss, deepLabv3+, deep learning, dice loss, IoU loss, loss function, medical image segmentation, semantic segmentation, tversky loss, U-Net, white blood cells.

Paper ID : 417

Victim Position Detection Using Swarm Robots

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Abstract

This paper examines the scenario of a swarm of robots in the aftermath of a disaster. In the field of swarm robotics, a group of individual and relatively simple robots collaboratively work towards a common objective through local communication and diverse control strategies. As these robots engage with their environment or with one another, the primary goal is to establish effective collaborative behaviour. For search and rescue operations, swarm robots play a key role in sensing and sharing information within themselves very effectively. A practical real-life application for this example is, It is used in solving nonlinear optimization problems. Finding the victim's location during a search and rescue operation is similar to the best solution that we find while performing linear optimization problem. The robot which finds the victim with the best position is referred to as the master robot, and the rest as slave robots. These roles can change at any point during the mission based on the new information. The collaborative behaviour of he robots makes it easier to locate the victim more effectively. The efficacy and optimality of suggested approach has been evaluated on a number of common benchmark functions. Simulation results demonstrate that the proposed methods effectively locate the victim while exhibiting variations in exploration efficiency. The comparative analysis clearly shows the strengths and limitations of each algorithm in dynamic search environments.

Index Terms—Swarm Robotics, Victim Detection, Search and Rescue, Maze Exploration, Pathfinding Algorithms, Multi-agent Systems.

Paper ID : 418

Point-of-Care Breast Cancer-on-Chip Diagnosis Using Linear SVM Model

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Abstract

Breast cancer is the second-leading cause of cancer worldwide. Researchers have utilized machine learning classifiers on FPGA to increase the effectiveness of breast cancer diagnosis. The proposed approach features an optimized real-time breast cancer detection system utilizing a Support Vector Machine (SVM) linear classifier for point of care. To minimize hardware complexity, this method incorporates a wrapper-based feature selection technique, identifying the most significant features, and utilizes an approximated adder design. The system achieves an accuracy of 96% while employing a reduced feature subset. FPGA implementation demonstrates a 14% reduction in hardware requirements compared to existing methods. For a singlechip solution in 45nm technology, the system achieves an area of 63,903 μm2, power consumption of 43 mW, and a delay of 6.6 ns. Overall, the proposed system integrates high accuracy with reduced hardware requirements, enabling efficient real-time diagnostics in resource-constrained environments with a target of point-of-care diagnostic tools.

Index Terms—Point-of-care, Feature extraction, Support vector machines, Hardware acceleration.

Monitoring Water Level in Open Wells using String Tension based IoT Device

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Abstract

This paper presents an IoT-based water level monitoring system deployed across three stepwells, which are a type of open wells, at a public institute in the Bolarum region of Hyderabad. This has been deployed along with IoT-based current and rainfall sensing nodes. It has been demonstrated that using rainfall data from open-source websites, which are based on sparse data or models, may be less accurate in estimating rainfall in a given local geographical area. Using IoT-based rain gauge is more accurate in such scenarios. High-frequency, precise, and automatic readings of stepwell water level, coupled with motor usage data and rainfall, allow the determination of different quantities such as consumption, yield, water table, and recharge. Key findings from hydrological analysis include distinct water level behaviours among the studied stepwells, variations in yield, the area water table over time, and the potential for longterm groundwater monitoring. The methodology offers a robust, scalable approach to environmental monitoring, showcasing how IoT technologies can provide precise, long-term data collection for understanding water resource management.

Index Terms—shallow aquifer, stepwell, string-tension, water consumption, water level, yield.

Paper ID : 447

A Fuzzy-Based Clustering and Routing Protocol for Enhancing the Lifetime of Wireless Sensor Networks

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Abstract

In this paper, we propose a fuzzy-based clustering and routing (FBCR) protocol to enhance the lifetime of wireless sensor networks (WSNs). FBCR protocol uses a fuzzy-based technique to compute the optimum number of CHs in a round. In this technique, the input is the average residual energy of alive SNs. Further, the FBCR protocol ensures that each round has the optimum number of CHs. Furthermore, FBCR protocol uses the hyper round technique (HRT) to reduce the energy consumption of SNs in clustering. We compare the performance of the FBCR protocol with the EDFIKM, FR-LEACH and LEACH protocols. Results show that the FBCR protocol provides 10.0%, 14.0%, and 22.0% higher network lifetime than EDFIKM, FR-LEACH and LEACH protocols, respectively.

Index Terms—Cluster heads (CHs), cluster members (CMs), fuzzy logic, routing protocols, sensor nodes (SNs), wireless sensor networks (WSNs).

Exploring Colour Space Correlations for Non-Destructive Assessment of Banana Ripeness

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Abstract

Determining the ripeness of bananas is important for reducing post-harvest losses and improving supply-chain management. Since peel colour of the banana changes rapidly during ripening, this work focuses on colour-based feature extraction supported by accurate fruit segmentation. The proposed approach begins with K-means clustering on the saturation channel, followed by morphological closing and GrabCut refinement to handle common imaging and fruit surface issues like bruises, fungal spots and uneven lighting. After isolating the fruit region, colour features from HSV, LAB and YUV spaces are extracted and used to train machine-learning models for ripeness prediction. Experimental results show that certain colour channels exhibit a strong correlation with ripening stages, leading to more consistent and reliable classification. These results strengthen our claim of the creation of a non-destructive models for estimating
banana ripeness, benefiting everyone involved in the supply chain.

Index Terms—Banana Ripeness, Image Segmentation, Colour Analysis, K-means Clustering, GrabCut, Colour Spaces, Non- Destructive Estimation, Post-Harvest Quality, Morphological Processing, Correlation Analysis, Supply chain Management

Executional Error Detection in Robotic Surgery using a Hybrid Dual Pathway Architecture

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Abstract

Robotic-assisted surgery, enabled by systems like the da Vinci Surgical System, enhances minimally invasive procedures through high-definition 3D visualization and precise instrument control. However, executional errors, such as improper needle orientation or loss of instrument visibility, pose significant risks to patient safety. This paper proposes a novel deep learning framework for detecting executional errors in surgical videos using the JHU-ISI Gesture and Skill Assessment Working Set (JIGSAWS) dataset, focusing on suturing and needle-passing tasks. The model integrates a ResNet-50 backbone for spatial feature extraction with a temporal modeling pipeline comprising 1D Convolutional Neural Networks (1D CNNs), Gated Recurrent Units (GRUs), and self-attention mechanisms. A dualpathway architecture, combining gesture-aware and gestureagnostic branches, employs dynamic fusion to adapt predictions based on contextual reliability. Evaluated through Group KFold cross-validation, the model achieves robust performance with metrics including F1-score (87.2%), Jaccard index (77.2%), accuracy (87.4%), AUC (89.6%), and recall (87.0%). These results highlight its potential for real-time surgical feedback, skill assessment, and enhanced training systems, advancing safer surgical practices.

Index Terms—Robotic surgery, executional error detection, deep learning, video signal processing, attention mechanisms, surgical skill assessment.

Vu-Do-Ku Game Puzzle Methodology for Reconfiguration of PV Modules in Partially Shaded Array System

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Abstract

Photovoltaic (PV) systems are more popular than other renewable energy sources because they are low maintenance, easy to use, and eco-friendly nature. Energy harvesting from sun is easy as just exposed into the sun irradiance. Besides this, PV power generation is affected due to unfavorable climatic conditions because of partial shading conditions (PSCs) or non-uniform sun irradiance levels. As a result of the non-desirable PSCs, multiple power points i.e. local maximum power point (LMPP) and global maximum power point (GMPP) are observed on current- voltage (I-V) curve. In present paper, a 9×9 size mathematical puzzle Vu-Do-Ku (VDK) is introduced, which is fully based on the arithmetic operations (addition & subtraction). Proposed VDK is assessed during the PSCs and compared with conventional PV array configurations such as Series-parallel (SP), Total-cross-tied (TCT) and Su-Do-Ku (SDK). The performance parameters of VDK are observed as minimum power loss (99.2W & 96.9W), improved fill factor (0.794 & 0.731), and GMPP (308.9W & 305.8W) values as compared to existing methods. Present study shows the feasibility of the concept and power enhancement of PV system during PSCs based on the outcomes.
Keywords— Photovoltaic array system, partial shading conditions, power loss, fill factor, maximum power point

Paper ID : 487

Modeling Dopaminergic Stimuli-Linked Patterns in Children's YouTube Videos Using Interpretable Machine Learning

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Abstract

Algorithmically recommended children's media now dominates early entertainment, raising urgent concerns about its neurodevelopmental effects. We present a computational system to automatically audit content for dopaminergic, hyper-stimulating features. Using a hand-annotated video dataset, we built an explainable machine learning pipeline employing decision-treebased models. XAI analysis with SHAP revealed that high view counts, rapid scene cuts, and short video durations are key overstimulation drivers, reflecting algorithmic feedback loops that amplify such content. Notably, the absence of a dominant stimulus
is a strong indicator of low-risk content. The system offers a scalable, evidence-based framework for auditing child-directed platforms, providing regulators and researchers with actionable insights.

Index Terms—Computational Media Analysis, Interpretable Machine Learning, SHAP Values, Dopaminergic Stimuli, Child Development, Tree-Based Models

Paper ID : 494

Implementation of Sensor Data Processing with Advanced Safety features using Automotive Communication Protocol

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Abstract

This manuscript presents the design and implementation of a triple-redundant communication and data acquisition system for an automotive airbag Electronic Control Unit (ECU) using Controller Area Network (CAN) protocol. The system comprises three nodes: a sensor node (ultrasonic, crash sensor, accelerometer, DHT11), a display node (TFT display), and a data acquisition node (airbag ECU). The airbag ECU node employs three levels of redundancy—power, storage, and communication—to enhance reliability and safety. Power redundancy ensures uninterrupted operation during supply failures, storage redundancy secures sensor data on both local SD card and a remote web server (via ESP8266), and communication redundancy switches from CAN to UART in case of CAN failure. Experimental results demonstrate robust fault tolerance, making the proposed ECU architecture highly secure and reliable for automotive safety applications.

Fault Detection Using Kernel Nonnegative Matrix Factorization

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Abstract

This manuscript presents the design and implementation of a triple-redundant communication and data acquisition system for an automotive airbag Electronic Control Unit (ECU) using Controller Area Network (CAN) protocol. The system comprises three nodes: a sensor node (ultrasonic, crash sensor, accelerometer, DHT11), a display node (TFT display), and a data acquisition node (airbag ECU). The airbag ECU node employs three levels of redundancy—power, storage, and communication—to enhance reliability and safety. Power redundancy ensures uninterrupted operation during supply failures, storage redundancy secures sensor data on both local SD card and a remote web server (via ESP8266), and communication redundancy switches from CAN to UART in case of CAN failure. Experimental results demonstrate robust fault tolerance, making the proposed ECU architecture highly secure and reliable for automotive safety applications.

IEEE INDICON 2025 PROCEEDINGS

Paper ID : 528

Dynamic Precision-Tunable Multiplier For Image Processing Applications

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Abstract

Approximate multipliers enhance speed and energy efficiency by reducing area, power, and delay at the cost of minor computational inaccuracy. This study proposes an optimized 8- bit multiplier using 6:3 and 4:2 compressors to minimize partial products, integrating CSA techniques for reduced propagation delay. The design achieves significant hardware efficiency, with an error rate of 77.99%, an area footprint of 513.178 µm2, and a power consumption of 76.5 µW, making it suitable for applications like image processing and low-power embedded systems. The reconfigurable compressor architecture allows scalability
for higher-bit multipliers, with potential future improvements in adaptive error-tuning for optimized performance.

Index Terms—Approximate Computing, 8-bit Multiplier, Compressor Circuits, Carry Save Adder (CSA), Power Efficiency, Partial Product Reduction, Image Processing, Low-Power Design, Hardware Optimization, Digital Arithmetic.

Paper ID : 529

Hybrid Quantum Key Distribution for Secure Open Banking Platforms

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Abstract

Open Banking exposes regulated financial capabilities through standardized open APIs to third-party providers (TPPs). While the ecosystem is protected today by TLS, mutual TLS (mTLS), OAuth 2.0/OIDC, JWT, and the FAPI profiles, the emergence of cryptographically relevant quantum computers (CRQC) introduces a "harvest-now, decryptlater" risk that threatens long-lived financial confidentiality, non-repudiation, and systemic integrity. This paper proposes a hybrid security architecture that fuses Quantum Key Distribution (QKD) with Post-Quantum Cryptography (PQC) to secure inter-organizational open banking communications across data centers, metro fiber, and cloud backbones. We map each integration point in an end-to-end Open Banking flow—PSU device, TPP platform, ASPSP/bank API gateway, consent management, clearing/settlement rails, observability, and audit—to concrete cryptographic mechanisms, define deterministic fallback behavior, and present deployable key-management patterns. We provide a threat model, protocol bindings to FAPI 1.0/2.0, performance and cost models, and a migration blueprint that preserves compliance while enabling quantum-safe resilience.

Index Terms—Open Banking, FAPI, OAuth 2.0, OIDC, Mutual TLS, JWT, DPoP, Quantum Key Distribution, Post-Quantum Cryptography, Kyber, Dilithium, SPHINCS+, MDI-QKD, CV-QKD, Key Management, Financial Infrastructure Security.

Paper ID : 532

Comparative Analysis of Machine Learning Regression Models in EMG-Based Muscle Fatigue Prediction

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Abstract

Monitoring muscle fatigue progression is critical for optimizing training, preventing injury, and guiding rehabilitation. This study proposes a machine learning framework to estimate Time-to-Failure (TTF) during sustained isometric contraction using surface electromyography (sEMG) signals. Raw EMG signals were segmented into sliding windows and transformed into physiologically relevant features across time, frequency, and nonlinear domains. Four regression models—Gaussian Process Regression (GPR), Neural Network (NN), Support Vector Regression (SVR), and Random Forest (RF) were trained and evaluated on their ability to predict remaining TTF in realtime. The results show that GPR outperformed other models with the lowest Root Mean Squared Error (RMSE) (4.75 s), highest R2 (0.92), and a relatively unbiased residual distribution. Residual analysis revealed consistent underestimation by SVR and RF, while GPR maintained symmetric residuals across fatigue stages. Statistical comparisons using the Wilcoxon signedrank test confirmed significant differences ($p < 0.05$) between most model pairs, establishing the superiority of GPR over both conventional and ensemble-based approaches. The proposed framework enables interpretable and continuous fatigue estimation using minimal sensor input, highlighting its applicability in ergonomics, neuro rehabilitation, and sports science. Unlike previous studies limited to fatigue classification, this regression based TTF prediction offers finer granularity and real-time deployability, especially when integrated into wearable EMG systems. Future work will extend this approach to dynamic tasks, subject-independent generalization, and feature-level fusion with neuromechanical variables to enhance robustness and clinical translation.

Index Terms—sEMG, Time-to-Failure, Muscle Fatigue, Regression, Gaussian Process, Machine Learning, Wearable sensors

Paper ID : 536

U-PnP-ADMM: Uncertainty-Aware Plug-and-Play ADMM for Robust Night Vision Enhancement

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Abstract

Night vision enhancement is essential in surveillance, autonomous navigation, and defense, where extremely low-light conditions severely degrade visibility through photon-limited noise and contrast loss. Existing deep learning and Retinexinspired approaches have often produced visually pleasing results
but remain unreliable, as no measure of confidence is provided for the restored details. To overcome this limitation, U-PnP-ADMM, an uncertainty-aware Plug-and-Play Alternating Direction Method of Multipliers (PnP-ADMM) framework, is introduced for robust night vision enhancement. The task is formulated as a constrained optimization problem with a physics driven fidelity term based on Poisson–Gaussian noise statistics and a plug-and-play prior realized through a pretrained deep denoiser. Beyond deterministic restoration, uncertainty is propagated through ADMM iterations to generate a pixel-wise variance map that quantifies the confidence of enhancement. Experiments on benchmark low-light datasets demonstrated that U-PnP-ADMM outperforms state-of-the-art methods, achieving PSNR improvements of up to 3 dB, SSIM gains of 0.07–0.10, and perceptual quality enhancements with NIQE reduced to as low as 3.10. These results establish U-PnP-ADMM as a reliable optimization-based night vision enhancement framework.

Index Terms—Low-light imaging, uncertainty quantification, Plug-and-Play priors, ADMM, perceptual quality.

Contextually Aware Navigation Systems using Environmental and Interest-Based Data

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Abstract

Navigation systems typically focus only on the distance from the user's origin to their destination and traffic optimization, which provides a solution for travelers to reach their destination, but adding more amenities to navigation systems can provide travelers with richer, actionable information that supports safer, healthier, and more comfortable journeys. In this regard, the current study provides a new context-aware navigation system by integrating the OpenStreetMap (OSM) application programming interfaces (APIs) with APIs of real-time environmental data such as air quality index (AQI), temperature, wind speed, rainfall forecasts, and cloudiness, as well as APIs of various important points of interest, including hotels, restaurants, cafes, fuel filling stations, bus stops, and railway stations. Incorporating these features into OSM provides travelers with key insights into the environmental conditions under which they choose to travel, visibility of other amenities close to their interests, which improves trip planning convenience, and it also provides information on other public transport modes for multimodal navigation before planning their itinerary. The current research work demonstrates the technical viability and real-world benefits of a unified navigation platform, which adjusts user needs and external factors via a multi-source, API-driven approach. In addition, this study underlines the significance of comprehensive, contextual mapping tools that enhance individualized travel experiences and promote human well-being.

Keywords - Navigation System, Application Programming Interfaces, OpenStreetMap, Air Quality Index, Real-Time Weather Conditions, Points of Interest

MILITARY SURVEILLANCE AND LANDMINE DETECTION WITH SAFE PATH PLANNING

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Abstract

In modern military and defense applications, landmine detection and surveillance face more rigorous challenges that require sophisticated autonomous solutions. This paper presents a multi-functional autonomous surveillance robot that integrates dual-layer landmine detection using metal sensing and chemical residue analysis and SLAM-based navigation for GPS-denied terrains, and CNN-based environmental threat classification. Experimental results show a detection accuracy of 94.9% (fire detection), 25 FPS real-time streaming, and successful SLAM-based mapping with dynamic obstacle avoidance, validating the system's reliability and real-world applicability for defense operations. It comes up with a fire detection using machine learning and temperature detection. The system also utilizes an innovative air vacuum pump with a chemical filter that captures air particles, for explosive detection with trained dogs. The surveillance functionality is complemented by a Raspberry web camera, with real-time video streaming via a Flask-based web interface. The system is proposed for battlefield safety improvement, human risk reduction, and provision of the optimal solution for threat detection.

Index Terms—SLAM, Multi-Sensor Fusion, Autonomous Navigation, Landmine Detection, ROS, Defense Robotics.

Paper ID : 558

Predicting Integrated Flux Density from VLA XMM-LSS/VIDEO Deep Field Observations

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Abstract

Accurate estimation of integrated flux density (Sint) in deep radio surveys is challenging due to complex source morphologies, noise, and scale, which limit manual or fitting-based approaches. We predict Sint from the multi-attribute VLA XMMLSS/ VIDEO catalogue (5,762 sources) using classical ML, deep learning, and quantum ML with standardized preprocessing, 3-fold cross-validation, and data augmentation, while profiling latency, energy, and model size. A CNN attains R2 = 0.97, MSE = 4.22, RMSE = 2.05, MAE = 1.44; across strata, Classical DL averages R2 = 0.94 } 0.03 versus Classical ML 0.89 } 0.04 and Quantum ML 0.65 } 0.10; bootstrapping shows the best distributional fidelity (silhouette 0.068, Calinski–Harabasz 330.76, Davies–Bouldin 3.52, Wasserstein 0.012, KS 0.009), and an MLP offers an efficient trade-off (0.0001 s/sample, 0.0051 J/sample, 0.087 MB). These results enable accurate, low-cost, and scalable flux-density prediction for automated SKA-era pipelines and provide a reproducible benchmark across algorithmic strata.

Index Terms—Integrated flux density (Sint), radio astronomy, VLA XMM-LSS/VIDEO, radio continuum surveys, SKA-era Pipelines

Paper ID : 561

Hierarchical–Global Transformer Gated Fusion for Alzheimer's Stage Prediction from Brain MRI

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Abstract

This study introduces a Hierarchical–Global Transformer with Gated Fusion framework for brain MRI scans aiming Alzheimer's Disease (AD) stage prediction which has been very crucial in AD treatment. Several works particularly deep learning based techniques, have showed notable performance but have not emphasized subtle and spatially distributed anatomical variations, resulting imprecise staging identification. For this purpose, a dual-transformer model were employed in this work, where the conventional Vision Transformer (VT) and the Swin Transformer were integrated as backbones to jointly capture global and fine-grained anatomical features. These features were then hierarchically integrated based on contextual dependencies through an adapted gated fusion mechanism. Experimental validation has been performed on the well-known benchmark ADNI and AIBL datasets. For results and analysis, the proposed method achieved accuracy (η) up to 98.8% (ADNI) and 97% (AIBL), with F1 of 98% (ADNI) and 96% (AIBL) , which is significantly high, surpassing state-of-the-art methods. Further, Grad-CAM visualizations displayed the local-global subtle anatomical changes in MRI scans. In addition, the ablation study justifies the importance of several components, while its robustness has been verified through McNemar's Test. Thus, the proposed framework demonstrates its superiority in analysing anatomically relevant features, enabling its broader applicability to MRI-based clinical analysis.

Index Terms—Alzheimer's, anatomical planes, gated fusion, swin, vision.

A Cloud-Based Generative AI Architecture for Integrated Multimodal Content Analysis and Automated Documentation

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Abstract

The world is generating unprecedented data and becoming increasingly available in unstructured formats such as text files, images, and audio files. This presents a challenge for intelligent systems geared towards information generation. Here, we present an innovative solution called Cloud-Based Generative AI System for Multi-Modal Content Analysis and Documentation. It enhances the capabilities of generative AI and cloud technologies for the automation of analysis and synthesis of inputs, such as PDF, DOCX, PPTX, TXT, MP3, and MP4. Transcription, audio contentbased summarization, and document generation are achieved using LLMs, the speech-to-text model Whisper, and cloud computing infrastructure like AWS S3. Customizable topic inputs allow users to define their requirements and obtain fine-tuned results. Extensive testing on academic, business, and conversational corpora verifies its ability to generate accurate, abridged, and semantically correct summaries and Q&A reports even when the input does not contain structured context. The accuracy on all modalities shows its applicability in the real-world production pipelines of research, education, and enterprise.

Index Terms—AWS S3, Content Summarization, Document Generation, Generative AI, Large Language Models, Speech-to-Text, Streamlit, Whisper Model.

Paper ID : 575

Intelligent Multi-Drone Detection Using 5G Wireless Sensing

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Abstract

The detection and classification of drones using wireless signal characteristics has become an important area of research, particularly with the increasing use of drones in civilian and restricted zones. In this study, we investigate the effectiveness of machine learning (ML) and deep learning (DL) models for classifying the number of drones based on Received Signal Strength Indicator (RSSI) values from fifth-generation (5G) wireless communication. An experimental setup comprising a 5G transmitter and receiver is established using Ettus E312 software- defined radios. Then, multiple drones were allowed to fly between this transceiver pair and collect the RSSI values at the receiver. A balanced dataset comprised of continuous RSSI samples is prepared, which is then segmented into windows for training and evaluation. These RSSI samples are trained using various deep learning architectures, including LSTM, GRU, BiLSTM, BiGRU, and their hybrid models with CNN, alongside traditional machine learning models such as Logistic Regression, KNN, Decision Tree, Random Forest, and XGBoost. The performance of these models is evaluated using several metrics, including accuracy, precision, recall, F1-score, and area under the curve (AUC). The results showed that XGBoost achieved the highest accuracy of 89.72% and a macro-average AUC of 0.9923, while CNN reached an accuracy of 89.38% and a macro-average AUC of 0.9937. Experimental results show that simpler models like XGBoost and CNN outperform more complex DL architectures in terms of both accuracy and AUC.

Index Terms—Deep Learning, Drone Classification, Machine Learning, RSSI, Supervised Learning, Time Series Classification

Eye Disease Prediction from Textual Symptoms Using DistilBERT with Bayesian Optimization and Hyperband

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Abstract

Early diagnosis of eye disease can lead to cure or mitigation of many visions related problems. While there are many studies that use images for predicting eye diseases, fewer studies focus on eye disease prediction from textual symptoms. Disease prediction using textual descriptions is a challenging task as many of the symptoms are common for multiple diseases. This paper proposes a deep learning model based on DistilBERT with Bayesian Optimization combined with Hyperband that can predict 87 eye diseases from text-based symptoms. The proposed model achieved an accuracy of 96.65%, with a precision of 95.00%, recall of 96.65% and F1- score of 95.59% showing its effectiveness in understanding contextual relationships in symptom descriptions, while the standalone DistilBERT model yielded evaluation measures of 95.62%, 93.01%, 95.62% and 94.05% respectively. To further evaluate the performance of the proposed model, we compared it with other deep learning frameworks. The hybrid DistilBERT-BiLSTM model recorded 95.85%, 94.16%, 95.85% and 94.49%, whereas the BiLSTM model reached 95.85%, 95.65, 95.85%, and 95.68%. The LSTM model provided weaker results of 87.56%, 84.91%, 87.56% and 84.50%.

Index Terms—Eye Disease Prediction, DistilBERT, Text Classification, Hybrid model, Deep Learning, Bayesian Optimization, Hyperband.

Resilient Navigation for UAVs: GNSS Attack Detection and Seamless Transition to Visual-Inertial Localization

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Abstract

Modern aerial surveillance and autonomous drone operations rely heavily on Global Navigation Satellite System (GNSS) technology for precise navigation and mission execution. However, this dependency exposes critical systems to significant vulnerabilities from signal interference, including malicious spoofing and jamming attacks, which can compromise operational integrity. This paper presents a resilient navigation framework designed to ensure mission continuity in GNSS compromised environments by integrating real-time attack detection with a seamless transition to alternative navigation methodologies. We first demonstrate these critical vulnerabilities by conducting controlled signal injection attacks on commercial navigation modules using portable software-defined radio (SDR) platforms. Addressing these risks, we propose and validate the core components of an autonomous framework that intelligently detects signal anomalies and seamlessly transitions the navigation state from GNSS-dependent to a map-aided visual-inertial or any other situational awareness-based localization mode. This system is designed to enable robust autonomous navigation in GNSS denied or degraded environments, ensuring resilience for a wide range of mission scenarios. Experimental validation confirms the system's ability to detect malicious interference in real-time and execute a rapid, reliable handover to sensor-based localization, ensuring operational continuity and safety even under adverse GNSS signal condition.

Index Terms—GPS spoofing, GPS Jamming, autonomous drones, Visual-Inertial Odometry (VIO), 3D map-based localization, GNSS-denied environments, security resilience, UAV Security, sensor fusion, Regenerative Navigation

Signal Conditioning Electronics for Soft X-ray Diagnostic of ADITYA-U Tokamak

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Abstract

This paper focuses on the development of compact, modular signal conditioning electronics for the soft X-ray (SXR) diagnostic system of the ADITYA-U Tokamak. The SXR diagnostic has a multi-channel, vertical view configuration and provides line-integrated electron temperature measurement. For the measurement, the diagnostic utilizes a pair of AXUV linear photodiode detector arrays. These detectors typically generate current outputs as low as 10 nA, and their placement near the central solenoid poses significant challenges for accurate measurement in the harsh electromagnetic environment of the Tokamak. To address this, the designed signal conditioning unit (SCU) achieves a sensitivity of 1V/10nA with a high-gain transimpedance amplifier (15 kHz bandwidth) based on a lowbias- current integrated circuit. The SCU integrates preamplifier, amplifier, filter, isolator, and driver circuits for 32 channels in a single module, interfaced with the in-house developed SBC-64 data acquisition system. SBC-64 provides 64 analog inputs, simultaneous sampling at 1–200 kHz, on-board memory, and LAN accessibility. The electronics also enable variable biasing to configure the AXUV diode arrays in photoconductive mode. The design, system fabrication, and experimental results are presented, demonstrating that the diagnostic operates reliably and contributes to the routine characterization of core plasma behavior in ADITYA-U.

Keywords— Soft X-ray diagnostic, Transimpedance, Data acquisition system, Signal conditioning unit, ADITYA-U, SBC

Paper ID : 608

Elderly FallGuard: An AI-Driven Assistive Technology for Fall Risk Prediction using Motion and Health Monitoring

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Abstract

Falls are the leading cause of injury, immobility, and death in elderly individuals, with one in four elderly individuals falling each year, creating enormous health, emotional, and economic consequences. While current fall detection systems are mostly reactive, only acting to respond to events after they have occurred, proactive prediction strategies are necessary. In this research, an innovative fall prediction system is introduced based on the integration of inertial measurement unit (IMU) sensors and vital monitoring technologies to predict and mitigate fall risks. The IMU placed on the foot tracks gait and movement patterns, and the wrist-worn device monitors health metrics like heart rate and oxygen saturation. The system uses a two stage predictive framework that first analyzes data from IMU sensors and vital monitors independently to detect anomalies and combines these results using Multimodal Fall Prediction Algorithm (MFPA) to enhance accuracy. Users receive timely warnings and are alerted in real time, using a smart stick with an actuator that alerts users before they fall. The proposed system, with an accuracy of 95.2% using GRU for vitals and an accuracy of 99% using GRU for IMU, shows that integrating biomechanical and physiological data strongly improves the accuracy and reliability of fall risk prediction.

Index Terms—Fall Detection, Health Monitoring, Elderly Care, Safety Technology, IMU Sensors, Vital Sign Monitoring, Multimodal System, Fall Risk Prediction, Edge Computing, Real-Time Alerts, Gait Analysis.

Paper ID : 614

First-Principles Investigation of NO2 Sensing via MoS2/PANI Hetero junction Transistor

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Abstract

This article analyzes the sensing performance of molybdenum disulfide (MoS2) and polyaniline (PANI) heterostructure for nitrogen dioxide (NO2) gas through the evaluation of charge transfer and adsorption energy. Density function theory is utilized to calculate the charge transfer and adsorption energy for a single molecule, both at the material interface and on the surface of this ambipolar structure. Through these calculations, it is investigated that the proposed heterostructure is almost 4.3 folds better than the pristine MoS2. Additionally, sensing behavior is analyzed for transistor geometry for gas molecules. The proposed device exhibits 14.8% sensitivity for 0.1 ppb NO2. Also, a noticeable shift in threshold voltage has been investigated. This novel structure for gas sensing demonstrates promising results and can be further extended for different ppb and ppm levels.

Index Terms—MoS2, PANI, NO2, charge transfer, adsorption energy, DFT.

Synthetic Ventilator Waveform Signal Detection Using Vision Transformers and Attention Mechanisms

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Abstract

In this work, we propose an automatic Ventilator Dyssynchrony (VD) classification framework that leverages synthetically generated pressure waveforms to address the critical challenge of detecting and categorizing various types of VD. Given the absence of publicly available, well-annotated datasets in this domain, in our previous work we developed a conditional generative adversarial network (cGAN) to generate a diverse and clinically representative dataset. This dataset encompasses all major VD categories, including auto trigger, flow-limited, double trigger, delayed cycling, and early cycling. The proposed classification model, porposed in this manuscript, employs a vision transformer (ViT) architecture enhanced with a novel triple-attention mechanism that combines spatial, dilated, and channel attention to improve global information acquisition and feature representation. We evaluate the individual contributions of each attention mechanism and demonstrate the effectiveness of the combined approach. On a six-class pressure waveform classification task, the model achieves an impressive accuracy of 95.37%. This high level of accuracy underscores the model's potential for accurate and automated VD detection, which could greatly assist clinicians in identifying and addressing dyssynchrony in realtime.

Index Terms—ViT, VD Detection, Attention Mechanism

An Integrated Sensor-Based Machine Learning System for Predicting Crops and Fertilizers

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Abstract

Selecting suitable crops based on soil nutrient composition, including nitrogen (N), phosphorus (P), potassium (K), and other essential elements, is a significant challenge for farmers. Traditional soil testing methods are time-consuming, requiring several weeks for laboratory results, and often do not include crop recommendations. To address this issue, we propose a system integrating sensor technology with machine learning algorithms such as Random Forest, Na¨ıve Bayes, and KNN classifiers to analyse soil properties in real time. Sensors measure key soil parameters such as N, P, K, pH, temperature, and humidity, transmitting real time data to three machine learning models implemented in Python. The proposed system then predicts three optimal fertilizer and crop choices, enhancing both yield and soil sustainability. Instead of suggesting generic fertilizers, the model detects nutrient deficiencies and recommends only the necessary supplements. Using multiple algorithms, it generates three crop and fertilizer options, giving farmers the flexibility to choose the best fit for their needs. For random data samples collected from nearby our areas, proposed method predicts Nitrogen, Phosphorous, Potassium and pH with the accuracy of 95.24%, 97.96%, 97.23% and 100% respectively.

Index Terms—Soil, Fertilizer, crop, prediction, optical sensors and machine learning.

Paper ID : 622

Social Theoretic Modeling and Simulation Study of Trust and Interoperability in Social Internet of Things (SIoT)

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Abstract

*The Internet of Things (IoT) is reshaping connectivity across industries, yet continues to face persistent challenges related to scalability, interoperability, trust, resource management, and privacy. To navigate these complexities, the Social Internet of Things (SIoT) framework extends conventional IoT by embedding social networking principles into device interactions. The paper explores the foundational social theories—Social Network Theory, Social Exchange Theory, Actor-Network Theory, Social Penetration Theory, Fiske's Relational Models Theory, Knapp's Relational Model, and Homophily Theory that serves as conceptual tools to address these IoT challenges. By mapping these theories to specific issues such as trust-building, dynamic service relationships, and ethical data exchange,an interdisciplinary approach to structuring intelligent, collaborative device networks is proposed. To validate the applicability of these theories, a lightweight simulation inspired by Knapp's model is developed, in which IoT devices form and strengthen relationships through discovery, interaction, and bonding stages. A "friendship score" is computed based on service quality metrics to reflect relationship strength. Device interactions are evaluated using a composite friendship score derived from three metrics: update accuracy, response consistency, and interaction duration. Simulations across 180 polling events show that devices consistently achieve high trust scores, ranging between 0.83 and 0.89, reflecting stable and reliable cooperation. The results highlight the effectiveness of social-theoretic constructs in enhancing device cooperation and network resilience, suggesting that SIoT offers a meaningful evolution in how connected systems collaborate and scale.

Index Terms—Actor-Network Theory, Social Penetration Theory, Fiske's Theory, Homophily Theory,Knapp's model,IoT Challenges,Social Internet of Things (SIoT),Trust, Interoperabilit

Synthetic-Text Detection Using Deep Learning – An Ensemble Practical Comparative Analysis

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Abstract

The rapid advancement of large language models (LLMs) such as GPT-3 and ChatGPT has revolutionized natural language generation by producing text with remarkable fluency and coherence. However, their widespread use raises serious concerns regarding authenticity, authorship, and misuse of digital content. This work investigates the detection of AI-generated text through two complementary strategies. The first leverages contextual embeddings from a pre-trained BERT model, followed by classification using XGBoost. The second employs a hybrid deep learning framework integrating n-gram vectorization, Bidirectional LSTMs, Transformer blocks, and Convolutional Neural Networks to capture both local and global text features. A dataset of 10,000 balanced samples of human- and AI-authored text was used for evaluation. Experimental findings show that both approaches achieve high accuracy, with the hybrid network providing superior F1-scores and stronger generalization. These results emphasize the value of ensemble-based detection methods and offer insights into the development of robust verification systems. The study also lays a foundation for future research in adversarial robustness and domain adaptability.

Index Terms—AI-generated text, BERT, XGBoost, hybrid neural networks, NLP, deep learning, transfer learning.

Design of RF Matching Networks Using Retrieval-Augmented Deep Learning for Power Amplifiers

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Abstract

This paper introduces a deep learning-based system to automatically design RF matching networks. Traditional methods constrained by labor-intensive tuning and inflexible templates are ineffective and unstable results. To resolve these challenges, we represent the layout of matching networks as a 4x4 grid structure represented as a 4-digit hexadecimal string. Data are collected by performing electromagnetic simulations to train the model using a retrieval-augmented generation function, which also uses a Feedforward Neural Network, a specific type of Artificial Neural Network. Our proposed method, trained on a dataset of 1,169 impedance grid pairs ≈ 1.78% of all 65, 536 possible4× 4 grid configurations simulated for a 2 GHz Rogers RO4350B substrate has a 91% prediction accuracy and macro-F1 score of up to 93%. The implemented FeedForward Neural Network uses localized learning for grid transformation, the Gaussian Error Linear Unit function, Impedance transformation preservation through activations, combined with contextual optimization enabled by retrieval augmentation.

Index Terms—Impedance matching, microstrip networks, power amplifiers, retrieve-augmented generation, RF layout generation.

Paper ID : 637

Design and Analysis of a Polarization-Insensitive, Broadband Tunable THz Absorber Using Graphene on SiO2, COC, and HfO2 Substrates

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Abstract

This paper proposes and investigates a near unity compact Graphene-based broadband Terahertz absorber (GBTA). This structure comprises a periodic graphene pattern spread over a SiO_2 substrate backed by thin gold metal. The dimensions of a unit cell λL 16 • λL 16 • λL 11 where λL denoted as the wavelength of the lowest frequency, i.e., 2.95THz . The absorption band can reach 90% in the range of 2.95-5.27 THz, this wide band is flexibly tuned from a low-frequency band to a higher frequency band by changing the graphene chemical potential using DC biasing. The proposed absorber is present so that it maintains the four-fold symmetry. Therefore, this absorber is insensitive to the polarization angle. It shows more than 80% absorptivity for an inclined incidence angle of 65°for TE and TM polarization. The relative permittivity is lower and higher than SiO_2 substrates like Cyclic olefin copolymer (COC) and Hafnium Oxide (HfO_2) .Also used in this paper. Altogether, this proposed absorber is compact and tolerates diverged incoming waves up to 65°, much better than other existing designs. It has a variety of potential applications in civilian sectors.

Index Terms—Graphene, Metamaterial, Tunable, Polarization insensitive, ECM.

SolarPredict: A Lightweight Machine Learning Model for Hourly Rooftop Solar Energy Forecasting Using Weather and Temporal Features

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Abstract

Accurate forecasting of rooftop solar energy is essential for grid stability and large-scale Rooftop Solar (RTS) integrations. Many existing approaches are computationally intensive, limiting their suitability for real-world deployment. To address this issue, SolarPredict is proposed as a lightweight and scalable framework that integrates weather and temporal features with multiyear RTS data to deliver precise hourly predictions. A broad benchmark of 19 machine and deep learning models was conducted, where CatBoost, trained on an optimized set of 13 features, stood out by achieving state-of-the-art precision (RMSE = 0.0389, R2 = 0.9631, nRMSE = 0.0417) while maintaining high efficiency. Compared to LightGBM, the next-best model, CatBoost offered over twice the inference speed and required less than half the storage size, making it ideal for edge devices and large-scale deployments. RNN-based deep learning models, including LSTM and GRU, were also assessed. While GRU performed the strongest among them (RMSE = 0.0585, R2 = 0.9179, nRMSE = 0.0662), it came with a significantly higher resource footprint. The proposed framework has been deployed as a responsive web application to support real-time forecasting. These results confirm the practicality of SolarPredict for RTS optimization and smart-grid applications.

Index Terms—Solar Forecasting, CatBoost, Renewable Energy, Machine Learning

Comparative Investigation of Low-Cost Paper-Based Capacitive Sensors: A Sustainable Approach

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Abstract

In the present work, two low cost paper based capacitive humidity sensors, a semi cylindrical capacitor and a cross capacitor, have been characterized and compared. Although paper based humidity sensors have been widely studied, most existing designs still rely on screen printing or ink-jet printing, which involves silver nano-particle inks or multi component formulations. These methods often result in ink penetration into the substrate, increased fabrication complexity, while also requiring expensive equipment setup, which can limit accessibility for low-cost applications. To overcome these limitations, in the present work a simple and scalable bench top fabrication method has been employed. In this approach, the paper is folded into the cylindrical geometry, and electrodes are carefully applied to the outer surface in accordance with the intended sensor configuration. This technique enables clean and low cost fabrication while preserving the flexibility and structural integrity of the sensor, thereby offering a sustainable and accessible solution for humidity sensing in applications such as respiratory monitoring, smart packaging, breather condition monitoring in transformers and environmental sensing.

Index Terms—paper-based sensor, humidity sensor, low-cost, cross capacitor, semi cylindrical capacitor, green sensor

A Novel Hybrid GWO-ACO Algorithm for Multimodal UAV Trajectory Optimization in Emergency Communication

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Abstract

Unmanned aerial vehicles (UAVs) play a crucial role in 5G-assisted emergency communication, where optimal trajectory planning in complex disaster environments remains a significant challenge. In this research, a novel hybrid Grey Wolf Optimizer–Ant Colony Optimization (GWO-ACO) method is proposed, combining local exploitation skills with global exploration. An extensive comparative evaluation against seven metaheuristic algorithms (PSO, GA, ACO, GWO, DE, PSO-GA, and DE-GWO) demonstrates the superiority of our method, achieving the best fitness value (999.68), the lowest standard deviation (19.96), and the fastest convergence. In crowded 3D environments, the proposed method enhances obstacle avoidance while maintaining dependable communication channels. According to simulation results, GWO-ACO outperforms all comparable algorithms in various performance parameters, confirming its efficacy for real-time UAV trajectory planning in emergency.

Paper ID : 651

FinFET-Based Fast-Recovering Radiation-Hardened 14T (FRRH14T) SRAM for Space Applications

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Abstract

Memory circuits in space are susceptible to instability and reliability issues as a result of charged particles such as alpha particles, neutrons, heavy ions, and photons. When these particles pass through a memory device, they generate an ion track that can interfere with stored data. Traditional 6T SRAM is particularly prone to such disruptions. To address this issue, researchers have developed radiation-hardened SRAM cells by adding redundant nodes to improve reliability. This study introduces a fast FRRH14T SRAM cell with redundant nodes to protect against soft errors. The performance of the proposed cell is evaluated using Cadence Virtuoso in 18 nm FinFET technology at a 0.8 V supply. Its performance is compared with other radiation-hardened designs, including RSP12T, RHB12T, HSLC12T, NRHC14T, and SIMR18T. The
FRRH14T cell is designed to resist Single Event Upset (SEU) disruptions by optimizing node placement to minimize sensitivity, achieving a recovery time of 1.2 ns. Additionally, it demonstrates significantly improved write access time (1.09X to 2.2X faster) compared to existing hardened designs.

Index Terms—Radiation Hardening, Single Event Upset, SRAM, Static Noise Margin (SNM)

Paper ID : 657

Integrating BFV Homomorphic Encryption and BB84 QKD: A Simulation Study of Quantum-Resilient Encrypted Computation

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Abstract

In order to investigate quantum-resilient encrypted computation, we create and assess a prototype framework that combines a simulated BB84 quantum key distribution (QKD) protocol with the Brakerski–Fan–Vercauteren (BFV) homomorphic encryption scheme. We benchmark encrypted polynomial evaluations under identical parameter settings using Qiskitbased BB84 simulation and Microsoft SEAL for BFV, contrasting a pure-BFV baseline with the integrated BFV+QKD workflow. The hybrid design achieves comparable end-to-end latency, stable ciphertext sizes, and correct decryption across all tested parameter sets in our experiments on a single commodity server, suggesting that it is possible to integrate QKD-derived session keys for evaluation-key protection in this setting without incurring prohibitive overhead. These findings are restricted to single-node experiments and idealized QKD simulation; they do not account for physical quantum channels, network latency, or large-scale multi-tenant deployments, which are left for future research. The evaluation is conducted under an honest-but curious server model and an idealized BB84 simulation, and does not provide a composable security proof of the integrated QKD–HE workflow.

Index Terms—Post-quantum cryptography, homomorphic encryption, quantum key distribution, BB84 protocol, BFV scheme, quantum-resistant security, privacy-preserving computation, quantum computing threats, secure cloud computing.

Detecting and Counting Human Presence using Device Free Wi-Fi Channel State Information

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Abstract

This work introduces a method for human presence detection and counting based on Channel State Information (CSI). We address the problem of noisy CSI data by applying a Hampel and Savitzky-Golay filter as pre-processing, followed by segmentation of data to extract significant features. The segmented data are classified with Convolutional Neural Networks (CNNs) and Residual-CNN networks. The results from the experiments exhibit high accuracy classification of 98.75% for human presence detection and 97.78% for crowd counting in differentiating between 0–5 persons. Notably, for presence

detection and crowd counting experiment, the data is obtained from three rooms of varying occupancy loads and different transmitter– receiver distances, and the models performed equally well in these varied test settings. Further, The model is tested on an external dataset not used during training and 95.60% accuracy proves its robustness and generalizability across different device placements and environmental conditions. After classification the output is sent via UDP from PC to IoT device which then sends the message to authorized user devices for notification or control. This shows the capability of combining signal processing and deep learning for human presence detection and counting in real world scenarios.

Index Terms—Human Presence Detecting and Counting, Wi-Fi sensing, Channel state information, IoT

Paper ID : 665

Gain-Scheduled-PID Controller design for Anti-Lock Braking System of Automobile

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Abstract

Brake systems are crucial for ensuring the reliability of automobiles. In modern automobiles Antilock braking systems (ABS) is employed to improve vehicle stability and safety by mitigating wheel lockup during braking. The objective of the research is to improve ABS functionality and reduce the likelihood of accidents resulting from skidding under uncertain road conditions. To accomplish this, an open-loop adaptive gain scheduled PID control is designed for ABS to control the wheel slip so as to achieve optimal stopping distance while preserving steering control and minimizing wheel lock-up. The novelty of the proposed control design is validated through various performance metrics introduced here and further compared with traditional control for ABS.

Index Terms—Anti-Lock Braking System, Burckhardt Tyre model, Gain-Scheduling control, Adaptive control.

Paper ID : 669

YOLO Based Diabetic Foot Ulcer Detection and Disease Progression Analysis

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Abstract

Diabetic foot ulcers (DFUs) are a dangerous side effect of the disease that, if left untreated, can result in lower limb amputation and severe infection. Manual subjective wound assessments, which can be laborious and unreliable, are often used in the current standard of treatment. The proposed method is used to detect DFUs in an automated way. The YOLOv8 object detection model, which is trained on a specially labelled data set of DFU images, is utilized in this methodology and achieves an overall accuracy of 90% and mAP of 0.78575. This model locates the ulcer present in the image and the process creates a bounding box after first identifying the ulcer. Thereafter, we objectively monitor changes in ulcer size by computing the area of the bounding box across a sequence of consecutive patient images. This technology offers a data-driven approach to distinguish between ulcer development (enlargement) and regression (healing) by comparing the area of the boundary box over time. To help doctors provide timely and effective interventions, this method offers a valuable, objective tool that can improve patient outcomes and reduce healthcare costs.

Index Terms—Diabetic Foot Ulcer (DFU), YOLOv8, Object Detection, Wound Progression, Bounding Box, Computer Vision, AI in Healthcare.

Paper ID : 682

Integrated Segmentation and Classification Framework for Neonatal HIE Using SegResNet and XGBoost

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Abstract

Neonatal Hypoxic-Ischemic Encephalopathy (HIE) is a major brain injury in newborns resulting from insufficient supply of oxygen during the perinatal period, often leading to long-term neurological dysfunctions and delayed development . Timely and accurate diagnosis is essential for enhancing clinical outcomes. In this work, we propose a multimodal approach for automatically segmenting HIE lesions and severity classification using MRI scans. A SegResNet architecture was employed to segment lesions from Apparent Diffusion Coefficient (ADC) and Z-scored ADC (Z-ADC) maps. In the following stage, features derived from predicted lesion masks and clinical meta data were combined using an early fusion approach. The fused feature set was used for classifying the HIE lesions according to severity as mild, moderate and severe. Experiments were conducted on the Boston Neonatal Brain Injury Dataset (BONBID-HIE). The segmentation model achieved a Dice score of 0.749, while the severity classification obtained an accuracy of 88.64%. These findings show the effectiveness of the proposed structure in both clinically relevant severity classification and accurate lesion spot identification, indicating its ability to support early clinical decision-making in neonatal clinical care.

Index Terms—Hypoxic-Ischemic Encephalopathy (HIE), Magnetic Resonance Imaging (MRI), Deep Learning, Medical Image Segmentation, SegResNet, Multimodal Fusion, XGBoost

A Gallium Nitride-Based Approach to Sense Urine Glucose

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Abstract

A Projection to sense urine glucose by means of designing bio sensor via Two-dimensional (2D) photonic crystal (PhC) is exposed through this work. Gallium nitride (GaN) dielectric material made used over an air contextual square lattice as a photonic crystal to sense urine glucose. Bio-samples of four
different urine glucose levels of different refractive index (RI) are utilized to govern the contact with light and sample. This results in a noticeable shift in wavelength and effective confinement of light within the region of detection. The designed ring resonator photonic crystal is a square lattice structure, to detect glucose in urine samples. Wave-optics analysis, implemented through the finite element method (FEM), to measure the optical properties of light. Designed biosensor has achieved high Q-factor (QF) 15,209, sensitivity 200(nm/RIU), along with 99.97% transmission efficiency.

Index Terms—Gallium nitride, Photonic Crystal, Biosensor, Qfactor, Transmission Efficiency.

AUDRON: A Deep Learning Framework with Fused Acoustic Signatures for Drone Type Recognition

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Abstract

Unmanned aerial vehicles (UAVs), commonly known as drones, are increasingly used across diverse domains, including logistics, agriculture, surveillance, and defense. While these systems provide numerous benefits, their misuse raises safety and security concerns, making effective detection mechanisms essential. Acoustic sensing offers a low-cost and non-intrusive alternative to vision or radar-based detection, as drone propellers generate distinctive sound patterns. This study introduces AUDRON (AUdio-based Drone Recognition Network), a hybrid deep learning framework for drone sound detection, employing a combination of Mel-Frequency Cepstral Coefficients (MFCC), Short-Time Fourier Transform (STFT) spectrograms processed with convolutional neural networks (CNNs), recurrent layers for temporal modeling, and autoencoder-based representations. Feature-level fusion integrates complementary information before classification. Experimental evaluation demonstrates that AUDRON effectively differentiates drone acoustic signatures from background noise, achieving high accuracy while maintaining generalizability across varying conditions. AUDRON achieves 98.51% and 97.11% accuracy in binary and multiclass classification. The results highlight the advantage of combining multiple feature representations with deep learning for reliable acoustic drone detection, suggesting the framework's potential for deployment in security and surveillance applications where visual or radar sensing may be limited.

Index Terms—Acoustic Sensors, Intelligent Perception, Deep Learning, Drone Detection, Sensor Data Fusion, Autonomous Surveillance.

Paper ID : 692

Accelerating Graph Traversal Kernels with a Versatile, Lightweight RISC-V ISA Extension

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Abstract

Graph algorithms such as shortest-path and heuristic search form the computational backbone of applications in robotics, navigation, and communication networks. However, their tight inner loops remain performance bottlenecks on embedded CPUs, especially when branch-heavy or arithmetic-intensive kernels dominate execution. This paper proposes a minimalist yet powerful approach: a lightweight instruction set extension for RISC-V that directly accelerates core graph primitives. We introduce two custom instructions—UMIN (Unsigned Minimum) for branch-free selection and ADIFF (Absolute Difference) for efficient heuristic evaluation. These instructions are designed to integrate into a fully functional, hazard-aware 5-stage pipelined RV32I processor, replacing multi-instruction idioms with single operations, yielding consistent improvements across multiple graph kernels. Analytical cycle modeling shows up to 3x instruction count reduction and up to 3.67× projected speedup compared to standard branching baselines, while outperforming optimized branchless software by 3×. Our results demonstrate that carefully chosen, domain-relevant ISA extensions can deliver significant inner-loop efficiency within the footprint of a simple embedded CPU, striking a balance between programmability, performance, and modest hardware modifications.

Index Terms— RISC-V, ISA Extension, Custom Instruction, Graph Algorithms, Hardware Acceleration, Embedded Systems.

Short-Term Wind Power Forecasting: A Comprehensive Analysis of SARIMAX, SVR, Random Forest, XGBoost, and LSTM Models

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Abstract

Accurate short-term wind power forecasting is crucial for reliable integration of renewable energy into the grid. This work offers a comparative analysis of statistical, machine learning, and deep learning models using multivariate time series data from an individual turbine. Five models are assessed: Seasonal Auto-Regressive Integrated Moving Average with Exogenous Variables (SARIMAX), Support Vector Regression (SVR), Random Forest, Extreme Gradient Boosting (XGBoost), and Long Short-Term Memory (LSTM) networks. Results indicate that ensemble tree-based models, especially Random Forest, achieve the highest accuracy (R2 = 0.914), with SVR and SARIMAX also demonstrating competitive performance. XGBoost offers reasonable accuracy, while LSTM networks underperform due to insufficient temporal resolution in daily-aggregated data. The study emphasizes trade-off among accuracy, interpretability, and computational cost. The findings offer practical guidance on model selection for short-term forecasting under data constraints.

Index Terms—Extreme Gradient Boosting, Long Short-Term Memory, Random Forest, Support Vector Regression, Wind Power Forecasting.

Performance Degradation of Deep and Traditional Machine Learning Models Under Market Volatility: An Inter-Day Stock Trend Comparison

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Abstract

This paper presents an empirical analysis of how deep and traditional machine learning models degrade under market volatility in the Indian stock market. Using inter-day data from 2015–2025 covering key events such as the COVID-19 crash, 2022 rate hikes, and the 2023 AI surge, we evaluate Long Short-Term Memory (LSTM), Dense Neural Network (DNN), Gradient Boosting Classifier (GBC), and ensemble variants across stable (HDFC, Infosys, Reliance) and volatile (BHEL, Adani Ports, IFCI) equities. A time-aware five-fold cross-validation ensures chronological integrity and prevents look-ahead bias. Results show an average accuracy decline exceeding 20% and F1- score degradation above 0.18 under high volatility. The findings highlight that even advanced ensembles remain sensitive to nonstationarity, emphasizing the need for adaptive, regime-aware frameworks to maintain robustness under structural market shifts.

Index Terms—Deep Learning, Ensemble Learning, Inter-day prediction, Market Volatility, Regime Switching, Stock trend estimation, and Stock Market Prediction.

Fully Unrolled Two-Stage Pipelined AES-128 Hardware IP for High-Speed Encryption/Decryption on FPGA

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Abstract

This paper presents a high-speed and area-efficient AES-128 hardware accelerator implemented on the Zynq Ultra-Scale+ ZCU104 FPGA platform. The proposed design employs a fully unrolled two-stage pipelined architecture, integrating both encryption and decryption into a unified module for flexible mode switching. The pipeline is partitioned into an S-box transformation stage and a combined MixColumns, ShiftRows, and AddRoundKey stage. Operating at 170.1 MHz, the design achieves a throughput of 21.77 Gbps with a latency of 11.76 ns, producing 128-bit output per clock cycle. Resource utilization is limited to 7409 LUTs, 9653 flip-flops, and 51 BRAMs, with a power consumption of 3.462 W, resulting in an efficiency of 2.94 Mbps/LUT. AXI DMA-based communication between PS and PL ensures seamless high-speed data transfer. Compared with existing AES architectures, the proposed accelerator demonstrates superior throughput, latency, and resource efficiency. This makes it highly suitable for real-time encryption in embedded security systems and IoT devices that demand both high performance and optimized hardware footprint.

Index Terms—AES-128, FPGA, fully unrolled pipeline, unified encryption/decryption, hardware acceleration.

CLAP: Convolutional Lightweight Autoencoder for Plant Disease Classification

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Abstract

Convolutional neural networks (CNNs) have remarkably progressed the performance of distinguishing plant diseases, severity grading, and nutrition deficiency prediction using leaf images. However, these tasks become more challenging in a realistic in-situ field condition. Often, a traditional machine learning model may fail to capture and interpret discriminative characteristics of plant health, growth and diseases due to subtle variations within leaf sub-categories. A few deep learning methods have used additional preprocessing stages or network modules to address the problem, whereas several other methods have utilized pre-trained backbone CNNs, most of which are computationally intensive. Therefore, to address the challenge, we propose a lightweight autoencoder using separable convolutional layers in its encoder-decoder blocks. A sigmoid-gating is applied for refining the prowess of the encoder's feature discriminability, which is improved further by the decoder. Finally, the feature maps of encoder-decoder are combined for rich feature representation before classification. The proposed Convolutional Lightweight Autoencoder for Plant disease classification, called CLAP, has been experimented on three public plant datasets consisting of cassava, tomato, maize, groundnut, grapes, etc. For determining plant health conditions. The CLAP has attained improved or competitive accuracies on the Integrated Plant Disease (95.67%), Groundnut (96.85%), and CCMT (87.11%) datasets balancing a trade-off between the performance, and little computational cost requiring 5 million parameters. The training time is 20 milliseconds (ms) and inference time is 1 ms per image.

Index Terms—Agriculture, Lightweight Autoencoder, Plant Disease, Attention, Image Classification

A Low-Delay, Dual-Edge Pulse-Triggered Flip-Flop using Gated Pull-Up Control

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Abstract

In this paper, we present the design and implementation of a dual-edge pulse-triggered flip-flop (DE-PTFF), developed by systematically modifying a single-edge pulse-triggered flip-flop architecture. The proposed DE-PTFF captures data on both the rising and falling edges of the clock, allowing the clock frequency to be halved while maintaining data throughput, thereby reducing dynamic power consumption in the clock distribution network (CDN). Pulse-triggered flip-flops (PTFFs), due to their single latch structure and reduced clocking overhead, offer a low-power alternative to conventional master–slave flip-flops. The architecture integrates a dual-edge pulse generation scheme with minimal control complexity and was validated using Cadence tools on a UMC 28nm CMOS technology node. Extensive simulations were conducted to evaluate key performance metrics, including setup time, hold time, and clock-to-Q (CLK→Q) delay. Furthermore, Monte Carlo simulations and process corner analyses were performed to verify the robustness of the design under variability and manufacturing imperfections.

Index Terms—Flip Flop, DET, Pulse Triggered, Low Delay

Paper ID : 728

Privacy-enhanced and Time-efficient Human Activity Recognition using Decentralized Federated

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Abstract

Conventional human activity recognition approaches have several limitations, including security and privacy issues related to user data and high response times due to remote storage and processing. To address these challenges of the existing approaches, this paper proposes a decentralized federated learning-based framework for human activity recognition. In the proposed framework, both the ring and mesh topologies are considered for collaboration among the participating nodes. To enhance the security and privacy of conventional federated learning, the proposed framework encrypts model weights during transmission among the collaborating nodes. We have used an Internet of Things (IoT)-edge-cloud paradigm, where smartphone sensors are used to collect data. The collected data are analyzed using the proposed framework, and the results show that ≥80% accuracy is achieved for our dataset and existing well-known datasets. The experimental results also demonstrate that the proposed framework has lower response time compared to the edge-cloud and cloud-only frameworks.

Index Terms—Decentralized federated learning; human activity recognition; response time; privacy.

Paper ID : 734

Wrist-Mounted Hand Gesture System for Military Hand Signal Recognition Using Fiber Bragg Gratings

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Abstract

Silent, non-verbal communication is essential in military operations, yet most existing gesture recognition systems rely on cameras, inertial sensors, or EMG signals, which can be bulky, power-hungry, or easily disrupted by environmental conditions. To address these challenges, this work presents a wrist-mounted hand gesture recognition system using Fiber Bragg Grating (FBG) sensors, which are lightweight, passive, and immune to electromagnetic interference. The system captures subtle finger movements and processes the resulting signals to extract meaningful patterns, which are then analyzed using advanced machine learning models such as XGBoost, Light- GBM, CatBoost, and Extra Trees. Among the configurations tested, cross-validation provided the most reliable and balanced accuracy across all key military gestures, demonstrating the system's capability to translate hand signals into recognizable codewords in real time. This approach overcomes the limitations of conventional methods by providing a secure, non-intrusive, and robust communication tool suitable for field deployment.

Index Terms—Fiber Bragg Grating (FBG), Gesture Recognition, Machine Learning, Military Communication, Wearable Sensors

Paper ID : 736

Broadband High Power High Efficiency Pulsed VHF SSPA For Ground Penetrating RADAR Applications

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Abstract

This paper describes the methodology involved in the design, development and measured performance of broadband high efficiency 100 W pulsed solid state power amplifier (SSPA). The SSPA design consists of three amplifier stages to provide 100W output power, namely driver amplifier (DA) stage realized using TO-8 packaged device, medium power amplifier (MPA) stage using diffused metal-oxide semiconductor (DMOS) and high power amplifier (HPA) stage using DMOS in push-pull configuration. The matching circuits of the amplifier stages used lumped components where the input matching network (IMN) or output-matching network (OMN) of HPA uses semi-rigid (SR) cables balanced to unbalanced (BalUn) impedance transformer. The achieved measured performance of the SSPA in class AB mode provides 50 dBm peak output power, overall minimum gain of 48 dB with flatness below 0.5 dB and drain efficiency better than 47% at 45 MHz having bandwidth of 22.22%. This SSPA is highly suitable for satellite based ground penetrating radio detection and ranging (GPR) applications.

Keywords— SSPA, DMOS, VHF-band, Efficiency, push-pull.

Leveraging Large Language Models for a typical Speech Recognition

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Abstract

Atypical speech, that is, dysarthric or slurred speech, is a challenging task for mainstream automatic speech recognition (ASR) systems that are mostly designed and trained on standard datasets. In this paper, the authors examine the application of lightweight large language models (LLMs) as postprocessing correction layers to enhance the accuracy of recognition in atypical speech contexts. Some of the models like Phi-2, Tiny LLaMA, Mistral-7B, and Gemma-2B are compared in terms of how well they can improve noisy transcriptions from speech to- text systems. For checking performance, parameters such as BLEU, ROUGE-L, and BERTScore are evaluated together. Experimental findings point to an accuracy vs. Computational tractability trade-off, especially when the hardware used is consumer-grade with limited GPU memory. Smaller instruction tuned models like Flan-T5 and Phi-2 are able to achieve real-world efficiency without sacrificing competitive correction quality, while larger models become increasingly accurate but require hybrid GPU–CPU execution strategies. The results show that LLM-enabled correction is a highly efficient method for improving ASR for atypical speech, enabling more inclusive and accessible speech technology.

Index Terms—Atypical Speech, Large Language Models, Speech Recognition, Deep Learning, Transformer Models, Efficiency, Accessibility, Inclusive Technology.

Paper ID : 747

Multimodal Deepfake Detection: A Scalable AI Pipeline Combining Audio-Visual Analysis

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Abstract

Deepfake generation has advanced to produce convincing synthetic audio and video, creating serious challenges for ensuring the credibility of digital content. This work proposes a scalable multimodal detection framework that leverages CNNbased transfer learning in combination with transformer-based fusion to capture spatial, temporal, and cross-modal inconsistencies. Video analysis incorporates face tracking, temporal dynamics, and artifact localization, while audio analysis employs Melspectrogram features and pretrained embeddings. Additionally, speech–lip synchronization is evaluated to identify inconsistencies between phonemes and visemes. Experiments show that the system effectively distinguishes authentic content from manipulated variants (fake audio, fake video, or both), even under variations such as compression noise and resolution shifts.With applications in digital forensics, social media monitoring, and biometric verification, the proposed approach offers a robust defense against the growing sophistication of deepfake technologies.

Index Terms—Deepfake Detection, Multimodal Analysis, Convolutional Neural Networks, Transfer Learning, Audio-Visual Fusion, MFCC Features, Speech–Lip Synchronization, Transformer Fusion, Media Forensics, Biometric Verification.

Paper ID : 753

Unsupervised Discovery of Dominant Vehicular Motion Trajectory Patterns from Uncalibrated

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Abstract

This paper presents an unsupervised approach to discover dominant vehicular motion trajectories directly from raw traffic videos without requiring labeled data. Vehicles are first detected using a YOLOv11 based model and tracked over time using a StrongSORT tracker with a Constant Turn-Rate and Velocity (CTRV) motion model to yield per-vehicle centroid trajectories. To obtain a compact and interpretable descriptor from variable-length tracks, we compute segment-wise polynomial representation, where each trajectory is partitioned into fixed number of segements (sub-trajectories) along its length, fitted with local quadratic curves, and concatenated into a fixed-length feature vector augmented with traffic entry/exit points. These features are clustered using Density Based Spatial Clustering of Applications with Noise (DBSCAN), which automatically reveals frequent traffic flows while treating rare or inconsistent motions as outliers. We validate the approach on 28 minutes of an uncalibrated traffic video, representing each trajectory with 79-dimensional features, and evaluate clustering quality using internal indices (Silhouette Score, Davies–Bouldin, and Calinski–Harabasz). Results show that the discovered clusters align with the 12 possible dominant traffic routes. Visual overlays of reconstructed medoid trajectories confirm the interpretability and robustness of the method.

Index Terms—Intelligent Transportation Systems (ITS), Vehicle Tracking, Traffic Intersection Monitoring, Unsupervised Clustering.

Paper ID : 754

Robust Dysarthria Detection and Severity Classification Framework Using Multifeature Speech Representations and Deep Learning Models

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Abstract

Dysarthria is a motor speech disorder which is a result of neurological impairments, significantly affecting speech clarity and intelligibility. Hence, the detection and assessment of the severity of dysarthria is essential for clinical decision making. In this study, we propose a data-driven framework for both dysarthria detection and severity detection using speech data from the TORGO dataset and the UASPEECH dataset. On TORGO dataset, both convolutional models and recurrent architectures, alongside classical machine learning techniques and ensemble methods, demonstrate high classification performance with LSTM model achieving the best result of 0.9878 accuracy. On UASPEECH, performance is examined using two categories of input representations: handcrafted acoustic features (which include eGeMAPS, MFCC variations, Zero Crossing Rate, and energy) and deep self-supervised speech embeddings (Wav2Vec2 and HuBERT). Dense neural networks on auditory characteristics achieved an accuracy of 0.897, whereas transformer models significantly outperformed these findings, with HuBERT-based classification achieving an accuracy of 0.9822 in severity classification. These results highlight the importance of transformer based features in a reliable dysarthic severity categorization, providing significant potential for improving patient care and clinical diagnostics.

Index Terms—Dysarthria Detection, Severity Classification, TORGO Dataset, UASPEECH Dataset, Deep Learning, Machine Learning

Performance Analysis of an Optimum Multi-User MIMO Enabled Wi-Fi Network for Smart University Campus Applications

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Abstract

Current Wi-Fi networks often suffer from congestion, uneven coverage, and insufficient throughput in large academic environments due to sudden network demand resulting from the uncertain movement of users in a particular area of the campus for a continuous event. This work proposes a state of-the-art Wi-Fi 6 network (i.e., IEEE 802.11ax) that employs multiple users multiple input and multiple output (MU-MIMO) and orthogonal frequency division multiple (OFDM) to improve spectral efficiency, user capacity, and link reliability of the network. The proposed network is designed to simulate and support 4,000 connected devices and 1500 simultaneous users, while maintaining a minimum of 40 Mbps throughput per user. MATLAB-based simulation with path loss, additive noise, and user mobility is incorporated to evaluate various performance metrics. Comparative analysis of MIMO and single-input single output (SISO) configurations shows that MIMO achieves higher throughput, lower latency, spectral efficiency, and better resource allocation. The simulation results indicate up to 90% indoor coverage and consistent user throughput of 40 Mbps, validating that the MU-MIMO-enabled Wi-Fi 6 network satisfies the high density campus requirements.

Keywords—IEEE 802.11ax, MU-MIMO, OFDM, SISO, RSSI, SNR

Paper ID : 774

A Proposed Ultra Wide Band Low Noise Amplifier With Improved Gain Using Negative Impedance Circuit

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Abstract

IIn this paper, the performance of various Low Noise Amplifier (LNA) architectures is studied. The techniques like noise cancellation, gain boosting, current reuse methods, inductor less designs are explored for ultra-wideband applications. Each technique offers certain benefits and some demerits. Negative impedance based two stage LNA is designed with the help of incremental static power to provide significant improvement in power gain while maintaining the same noise figure. To validate this concept 40 nm CMOS technology is used. The small signal analysis of proposed architecture is done. The integration of negative impedance in differential outputs of the LNA can improve the gain upto 40 dB while using a power of 23.6 mW. The power addition is 1.5 mW compared to the conventional two stage LNA. This method is beneficial for battery operated devices like IoT transceiver chips required for short range wireless communication systems.

Keywords—CMOS, Negative Capacitance, LNA.

Paper ID : 779

Beyond Static Baselines: A Dynamic Multi-Agent Framework for Trustworthy and Auditable Fake News Detection

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Abstract

The emergence of digital misinformation, estimated to cost $78 billion a year in damages worldwide, requires proficient detection mechanisms that go beyond the limitations of existing models. Current Large Language Models (LLM) based approaches are computationally inefficient and rely on static knowledge bases, limiting their ability to detect dynamically changing misinformation. In this paper, a new multi-agentic approach to fake news verification is presented, allowing for reasoning in modularity and statefulness with LangGraph as the brokering agent. The system dynamically retrieves entities from a claim, retrieves, caches and prompts evidence from credible news sources, decodes and evaluates the claim to classify based on evidence using LLMs. Unlike general-purpose LLMs like ChatGPT, the framework ensures auditable and reproducible results by exclusively pulling evidence from a domain-constrained pipeline of trusted news sources. While the modularity and architecture using graphs is just one of the elements here, it highlights the ability to think and reason in a modular way outside of single-pass monolithic models. On the ”Indian Fake News” benchmark dataset, the framework produces a 0.93 F1 score, 0.91 accuracy, and superiority to existing transformer baselines. The mechanism used in this work has demonstrated how a languagebased, evidence-augmented agentic approach can provide a more interpretable, robust, and ultimately more effective mechanism against the dynamic threat of misinformation.

Index Terms—Misinformation Detection, Multi-Agent Systems, LangGraph, LLM, Real-time Fact-Checking, Evidence-Based Reasoning, LangChain

Paper ID : 780

Entropy-Guided Transfer Learning for Ground-Level PM2.5 Estimation from Satellite-Derived AOD over Three Indian Cities: Kolkata, Guwahati, and Delhi

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Abstract

Accurate, high-resolution estimation of ground-level fine particulate matter (PM2.5) is a critical public health challenge, frequently undermined by sparse and inequitable ground monitoring networks. This study introduces a novel entropy-guided transfer learning framework to estimate PM2.5 from satellite-derived Aerosol Optical Depth (AOD), specifically designed to overcome data scarcity. By leveraging data from a data-rich city (Delhi, India), we enhance prediction accuracy in data-scarce cities (Kolkata and Guwahati). Our methodology first establishes baseline performance using machine learning models (Random Forest, XGBoost, SVR, MLR). We then demonstrate that a standard transfer learning approach offers moderate improvements. The core innovation of our work is the integration of Shannon's entropy to intelligently weight the source data, forcing the model to prioritize the most informative samples and minimize negative transfer. This entropy-guided approach yields a dramatic increase in performance, elevating the prediction R2 from a baseline high of 0.88 to an exceptional 0.98. The framework presents a robust, accurate, and scalable solution for generating reliable air quality data in regions with limited ground infrastructure, holding significant implications for environmental policy and public health management.

Index Terms—PM2.5 estimation, aerosol optical depth, transfer learning, Shannon's entropy, machine learning, air quality monitoring, MODIS.

Speech Emotion Recognition Using Bark-Scale Cepstral Features and MLP Classifier on RAVDESS Speech Corpus

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Abstract

Automatic Speech Emotion Recognition (SER) is a critical component needed to build intelligent systems which would be capable of understanding human affective states through acoustic signals. Emotions modulate the speech production mechanisms, affecting prosody, spectral characteristics, and temporal dynamics, which carry rich information beyond the literal content present in a speech signal. In this paper, the most popular Mel Frequency Cepstral Coefficients (MFCC) and the Triangular Filter Bank Cepstral Coeffecients using Bark scale (TFBCC-B) are computed on the speech signals taken from the RAVDESS database. The signals after pre-processing are fed to the feature extraction and the ReliefF feature selection method is applied on the extracted features to obtain four different feature lengths which enables analysis of the effects of the feature length on an SER system. The four different feature lengths(Without and 25%, 50% and 75% dimensionality reduction) of the two feature variants – MFCC and TFBCC-B are fed to a Multi- Layer Perceptron classifier for emotion classification. The combination of the MFCC and Bark features at 25% dimensionality reduction yields the highest performance metrics of all SER models built. The combined feature model produces a recognition accuracy, precision, recall and F1-score of 77.70%, 77.17%, 77.59% and 77.13% respectively which is the highest among all SER models built in this paper.

Index Terms—SER Models, RAVDESS, Bark scale, Triangular Filter Bank, MLP

Paper ID : 782

Aircraft Performance Inference from Aerial Imagery via Deep Learning and OpenAP

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Abstract

In this paper, we present an end-to-end machine learning framework that performs comprehensive aircraft performance inference starting from a single satellite or aerial image. The proposed system integrates image-based classification using transfer learning with ResNet-50 and downstream performance simulation using OpenAP's physics-based aviation models. Upon predicting the aircraft model from the input image, we map it to a standardized ICAO aircraft code, which serves as input for estimating drag, thrust, climb/cruise/descent dynamics, fuel consumption, and emissions. To ensure robustness even when specific aircraft data is unavailable, our system utilizes OpenAP's synonym fallback mechanism. We visualize and quantify parameters such as takeoff distance, Mach cruise range, and CO2 emissions using both empirical and statistical modeling. The entire pipeline is implemented on Google Colab using PyTorch, SciPy, and Matplotlib, offering an accessible and modular research framework. This fusion of computer vision and aviation physics opens possibilities in passive surveillance, environmental emission profiling, and trajectory optimization for scenarios with limited ground infrastructure, and serves as a novel approach to augmenting aviation intelligence systems without dependence on onboard transponders or ground-based radar.

Index Terms—Aircraft Classification, OpenAP, Aviation Simulation, Fuel Flow Estimation, ResNet, Emission Modeling, Google Colab, Flight Trajectory

FuseMix-BEAM: A Stage-Enhanced Feature Fusion Framework for Breast Ultrasound Image

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Abstract

Breast cancer remains a dominant factor in female mortality globally, making early detection an essential factor for enhancing patient survival rates. While breast ultrasound is a key diagnostic modality due to its safe and non-invasive properties, automatically segmenting lesions is a highly challenging task, given issues of low contrast, noise, and diverse lesion morphology. To overcome these difficulties, we introduce FuseMix-BEAM, our stage-enhanced multi-level feature fusion framework created for robust breast ultrasound image segmentation. Our architecture utilizes a MiT-B3 transformer backbone to derive hierarchical multi-stage features, which are then enhanced by specialized modules like Stage Attention Blocks (SAB), Channel Attention Blocks (CAB), dilated convolutions, and deep convolutional stages. An innovative multi-level fusion strategy consisting of Stage Enhancer, Lateral Reduce, Fuse Mix, and Unify Channel modules guarantees the efficient integration of minute details and intricate specifics with broader contextual information. Finally, a decoder with skip connections reconstructs segmentation masks with enhanced boundary precision. Comprehensive experiments conducted on three benchmark datasets for breast ultrasound, BUS-BRA, BUSI, and BrEaST, show that FuseMix-BEAM consistently achieves superior performance, recording an accuracy of up to 0.9851, a Dice score of 0.9168, and an IoU of 0.8449, thereby surpassing multiple state-of-the-art approaches. These results highlight the potential of the framework put forward as a reliable and efficient tool for automated breast cancer image segmentation, offering valuable support in clinical decision making.

Index Terms—Breast ultrasound image, Medical image segmentation, Deep learning, Multi-level feature fusion.

A Multi-Modal Quantification of Parkinson's Medication Response Using Kinematic Rigidity Profiling and Acoustic Feature Regression: A Proof-of-Concept Study

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Abstract

PD affects over 60% of people above 50, and its UPDRS-based monitoring demands clinical visits and lengthy evaluations, making monitoring costly and inconvenient. This pa- per presents a first integrated multi-modal telemonitoring system for Parkinson's disease, combining kinematic rigidity profiling with speech-based regression modelling to estimate medication response severity in Parkinson. Wrist rigidity is quantified using synchronized Inertial Measurement Units (IMUs), while acoustic features extracted from sustained phonation are used to predict UPDRS scores via an XGBoost regression model. Both modalities are fused to generate a unified Medication Response Score (MRS), providing a continuous estimation of patient state rather than categorical ON/OFF detection. This multi-modal fusion will be performed using an application-based system responsible for all data processing and user interaction. For the speech part, we used the largest known PD speech database, comprising nearly 6,000 recordings from 42 patients, gathered over a six-month, multi-centre trial. Preliminary prototyping, hardware validation and algorithm of our regression model achieved R^2 0.887 and MSE 11.49, demonstrating strong alignment with clinician- rated UPDRS. A Bland–Altman analysis confirmed minimal bias acceptable agreement limits. These results highlight the feasibility of a non-invasive, low-cost, portable system for remote UPDRS tracking in Parkinson's telemonitoring. Future work will integrate full sensor–speech processing on-device with clinical- grade validation.

Index Terms—Parkinson's Disease (PD), Inertial Measurement Unit (IMU), Telemonitoring, Rigidity, Speech Analysis, Machine Learning, Multi-Modal Fusion.

Paper ID : 796

Comparative Study of Time-Series Transformation Methods for Diagnosis of Bearing Faults in Three-Phase Induction Motor

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Abstract

The study proposes a qualitative comparison among different methods of time-series to image conversion deployed for detecting fault at its early stage or minor fault (such as faults in bearing, inter turn faults etc.) in a three-phase squirrel cage induction motor. A Convolutional Neural Network called 'RPNet' has been involved here to get conclusive outcome from each of the methods in order to assess their accuracy and capability in detecting faults through non-invasive analysis. RPNet is trained based on modified time-series to image conversion results, which are obtained by capturing stator line currents signature from the induction motor and then preprocessing it through extraction of Park's Vector Alternating Current (PVAC) signal under each operating condition of the motor. High-performance of the overall method demonstrates strong potential for integration into real-world industrial machinery, where it can serve as a core component of nonintrusive and expert fault monitoring systems. By continuously analyzing operational data, the proposed method can detect anomalies and deviations that indicate potential abnormalities in the motor bearing before they escalate into serious failures. This capability supports the implementation of predictive maintenance strategies, which significantly reduce unexpected downtime, enhance equipment reliability, and lower maintenance costs.

Keywords— Bearing faults, Convolutional Neural Network (CNN), RPNet, Predictive maintenance, time-series conversion image, Park's Vector Alternating Current (PVAC), Stator line currents.

Experience with RF Energy Harvesting-Driven Self-Powered RIS

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Abstract

In this paper, we present the design and implementation of a self-powered Energy Harvesting (EH) mechanism for Reconfigurable Intelligent Surfaces (RIS). The EH circuit captures incident Radio-Frequency (RF) energy and converts it into regulated Direct Current (DC) power to drive RIS switching, eliminating the need for external power sources. We evaluate the energy harvesting circuit on two different RIS unit cells—one fabricated for 3.4 GHz and another for 5.5 GHz—and provide profiling results. Large-scale RIS emulator experiments are further conducted to systematically analyze randomized configurations and their impact on overall system performance. The results validate that combining energy harvesting with autonomous RIS reconfiguration provides a practical pathway toward scalable, battery-less, and sustainable RIS-assisted wireless networks.

Index Terms—Emulator, Energy Harvesting, Quartz Clock Crystal Oscillator, Random Configuration, RIS

Phylo-Spatial Graph Neural Networks for Autism: Integrating Evolutionary, Genetic, and Functional Connectivity

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Abstract

Autism Spectrum Disorder (ASD) involves complex disruptions in large-scale brain connectivity, which vary across individuals and are rooted in both neurodevelopmental and genetic factors. To better model this variability, we introduce a biologically informed Graph Neural Network (GNN) framework that integrates insights from evolutionary biology, gene expression, spatial neuroanatomy, and functional brain dynamics. By embedding these priors into brain graph representations derived from resting-state fMRI, our framework captures both individualized connectivity patterns and biologically conserved relationships. A dual-stage GNN is then trained for ASD classification and emotional state decoding. Experimental results demonstrate improved performance (87% Accuracy) and interpretability, highlighting the promise of biologically enriched graph learning in advancing precision modeling of neurodevelopmental conditions.

Keywords—Autism Spectrum Disorder (ASD), Phylo-spatial modeling, Graph Neural Networks (GNN), Cortical expansion, Gene coexpression, Functional connectivity, fMRI, Brain network modelling.

Paper ID : 812

AI-Driven Classification of Encryption Techniques in Medical Image ROIs for Secure Transmission

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Abstract

The secure transmission of sensitive medical images is critical in modern healthcare. This paper presented an AIdriven approach for metadata-agnostic classification of encryption techniques applied to Regions of Interest (ROIs). Deep learning models were trained to identify the specific cipher used on encrypted medical image ROIs, enabling automated decryption routing without reliance on metadata. ROIs were encrypted with three chaotic map–based methods: (i) AES with Logistic Map permutation, (ii) Arnold Cat Map with Sine Map scrambling, and (iii) Sine Map with Logistic Map modification. The resulting dataset of encrypted ROIs was then used to train multiple Convolutional Neural Networks (CNNs), including ResNet18, VGG11, and EfficientNet-B0. Experimental results demonstrated high accuracy in distinguishing encryption techniques, validating the feasibility of AI-assisted cipher classification. The proposed framework enhanced privacy-preserving medical image communication in scenarios where metadata was unavailable or unreliable, bridging AI, cybersecurity, and healthcare.

Index Terms—Medical image security, Region of Interest (ROI), Chaotic maps, Convolutional Neural Networks (CNNs), Encryption classification, Cybersecurity.

Paper ID : 817

Uniform Manifold Approximation and Projection- Based Classification Analysis on Leakage Currents of Artificially Contaminated Insulator

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Abstract

Overhead line insulators are critical components of electric power distribution systems, but their insulation performance degrades under harsh environmental conditions. In this proposed work, surface leakage current signals were acquired from an artificially contaminated insulator surface. Statistical features extracted from these currents were analyzed using Uniform Manifold Approximation and Projection (UMAP) for dimensionality reduction and then classified using Support Vector Machine (SVM). The UMAP-SVM method effectively captures nonlinear patterns present in highdimensional current data under varying contamination levels and operating voltages. To select the effective statistical features, the Minimum Redundancy Maximum Relevance (mRMR) and ReliefF algorithms were employed. A combination of these data-driven methods provides predictive health monitoring of the insulator with considerable accuracy.

Keywords—Contamination, mRMR, ReliefF, UMAP, SVM

Automating Knowledge Discovery in Material Science with RAG Framework

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Abstract

The rapid growth of material science research has led to an unprecedented surge in the volume and complexity of scientific data, encompassing experimental results, computational simulations, theoretical models, and industrial applications. Traditional keyword-based search methods, while widely used, are increasingly insufficient for extracting meaningful insights from such heterogeneous and semantically rich datasets. Researchers often face challenges in locating relevant information hidden within vast repositories of publications, patents, and databases, slowing down the discovery of novel materials and the advancement of sustainable technologies. Recent developments in Artificial Intelligence (AI) and Natural Language Processing (NLP) offer promising avenues to overcome these challenges. In particular, Retrieval-Augmented Generation (RAG) frameworks combine the strengths of Large Language Models (LLMs) with powerful information retrieval mechanisms to deliver contextaware, semantically accurate responses. Unlike conventional retrieval systems that rely on surface-level keyword matches, RAGbased approaches leverage embeddings and source information to capture deeper semantic relationships across scientific literature and databases. To support this study, a domain-specific dataset was curated from unstructured PDF documents and preprocessed into structured text segments for training and evaluation. Experimental results show that the proposed RAG pipeline, powered by MatSciBERT embeddings, achieves strong performance with an overall accuracy of 0.784 and an F1-score of 0.858. These results demonstrate the effectiveness of the approach in automating semantic data retrieval in the materials science domain.

Index Terms—RAG, Natural Language Processing, Semantic Search, Material Science, MatSciBERT, FAISS, Data Extraction

DASGAN: Degradation Generation and Adaptive GAN Training for Real-World Image Super-Resolution

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Abstract

Real-world image Super-Resolution (SR) remains a fundamental yet unresolved challenge, primarily due to the unknown and diverse degradations present in Low-Resolution (LR) images captured in practical scenarios. Conventional SR models, trained on synthetically degraded data with fixed blur or noise kernels, often fail to generalize, producing oversmoothed or artifact-prone reconstructions when applied to real images. To address this limitation, we propose DASGAN (Degradation-Adaptive Super-Resolution GAN), an effective two-stage framework that bridges the synthetic–real domain gap. In the first stage, a Degradation Generation Network (DGN) learns realistic degradation patterns directly from High-Resolution (HR) images, enabling the synthesis of diverse and faithful LR counterparts. In the second stage, a Degradation-Adaptive SR Generator (DASRG) is trained jointly on bicubic and realistically degraded LR samples, allowing implicit adaptation without requiring explicit kernel estimation or handcrafted priors. To further balance fidelity and perceptual quality, the training objective integrates adversarial, perceptual, reconstruction, and total variation losses. Comprehensive experiments conducted on both synthetic benchmarks and complex real-world datasets demonstrate that DASGAN consistently surpasses state-of-the-art baselines, producing finer textures and minimizing artifacts.

Index Terms—GAN, super-resolution, image processing, computer vision, image reconstruction.

Bridging the Simulation-to-Real Gap in Automatic Modulation Classification for 5G/6G: A Problem-Driven Critique and a Lightweight CBAM–Transformer Continuation

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Abstract

Fifth- and sixth-generation (5G/6G) wireless systems demand robust spectrum awareness and adaptive waveform control, where Automatic Modulation Classification (AMC) plays a pivotal role in enabling cognitive radio, interference mitigation, and non-cooperative signal identification. However, existing AMC approaches, particularly deep learning-based methods, often rely on synthetic benchmarks that fail to capture realworld complexities such as Orthogonal Frequency Division Multiplexing (OFDM) effects, hardware impairments, and variable framing. This paper identifies these simulation-to-real gaps and proposes a lightweight Convolutional Block Attention Module– Transformer (CBAM–T) architecture that fuses multi-view representations— I/Q with phase pre-correction, amplitude–phase, and short-time spectrum—through attention mechanisms and a compact temporal Transformer. Using a MATLAB-generated dataset with realistic impairments, we achieve an average accuracy of 70.47% for CBAM-T, comparable to CNN-T (70.47%) and MCMBNN-T (71.07%), while maintaining low complexity (500K parameters) for edge deployment. The solution enhances robustness at mid-to-low SNRs and clarifies boundaries among high-order Quadrature Amplitude Modulations (QAMs). We provide a detailed training recipe, deployment guidelines, and actionable inferences.

Index Terms—5G/6G, Automatic modulation classification, attention, Transformer, impairment augmentation, simulation-toreal gap.

Performance Evaluation of Deep Reinforcement Learning Algorithms for Transient Stability Assessment Using Synchrophasor Data

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Abstract

This work explores how Deep Reinforcement Learning (DRL) techniques can be employed to evaluate transient stability in power systems by utilizing synchrophasor measurements as the primary data source. Traditional approaches depend on numerical simulations or machine learning; however, these methods face challenges in real-time deployment and generalization. To overcome these limitations, this work applies DRL for TSA using phasor measurement unit (PMU) data. Specifically, five DRL models like Soft Actor-Critic (SAC), Deep Q-Network (DQN), Advantage Actor-Critic (A2C), Deep Deterministic Policy Gradient (DDPG) and Proximal Policy Optimization (PPO) are applied to a well-known benchmark dataset. The dataset comprises of 3,120 simulation cases with 354 features that are generated from transient stability studies of the IEEE 39-bus New England test system. The models are employed to classify operating conditions as either stable or unstable under a range of fault disturbances. In these five DRL Model results, DQN achieved the highest accuracy by outperforming PPO, SAC, DDPG, and A2C. These findings demonstrate the robustness of the DQN for real-time TSA and highlight its potential for integration into wide-area monitoring systems.

Index Terms—Rotor angle stability, Transient Stability Assessment, PMU, Synchrophasor data, Deep Reinforcement Learning, Power System Stability.

Paper ID : 830

Evaluation of Nested Sequential Feed-Forward Neural Network For Crop Yield Prediction: A Case Study Using Irrigated Paddy Crop Yield

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Abstract

Climate and weather extremes remain a major challenge for crop yield prediction modeling. Accurately capturing the complex interactions between climatic variability and stress conditions such as drought continues to be an active research focus. A cumulative neural network architecture called Nested Sequential Feed-Forward Neural Network (NSFFNet) was recently proposed to model the cumulative effects of climatic factors on crop yield. This approach has demonstrated strong capability in learning long term climate impacts and improving prediction accuracy. However, modern crop production introduces mediating factors, particularly irrigation, that influence stress responses by reducing drought intensity and regulating temperature. To investigate these effects, this study evaluates the performance of NSFFNet using irrigated paddy yield data. The temporal yield analysis revealed substantial variability in responses during drought years, where one drought affected year resulted in very low yield while another drought year produced comparatively high yield. This variability significantly affected the model's generalization ability, particularly when drought-affected samples appeared only in the test set but were underrepresented in the training set. Cross-validation confirmed this limitation, and comparative analysis against benchmark models including RNN, 1D CNN, LSTM, GRU, and Transformer architectures showed the same generalization pattern. These findings indicate that while cumulative modeling approaches are essential for capturing long term climatic impacts, they must also account for mediating factors that modify the impact of climate on crop yield.

Index Terms—Nested sequential feedforward neural network, crop yield prediction.

Uncertainty-Aware Brain Tumor Segmentation using Bayesian U-Net and Modality Dropouts

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Abstract

Accurate brain tumor segmentation from multimodal magnetic resonance imaging (MRI) is marvelous for diagnosis and treatment planning. Conventional U-Net models assume the availability of all modalities and produce deterministic predictions without confidence estimates, limiting clinical reliability. We propose a Bayesian U-Net approach that integrates modality-specific encoders, Hetero-Modal Image Segmentation (HeMIS)-based statistical fusion, and a dual dropout mechanism. Modality Dropout improves robustness to missing or corrupted MRI sequences, while Monte Carlo (MC) Dropout estimates pixel-wise uncertainty. Evaluations on the BraTS 2019 and 2020 datasets show that the proposed model achieves Dice scores of 0.9508 and 0.9623 with Hausdorff Distances of 3.04 and 2.41, respectively, while also producing low mean uncertainty values (0.001302 and 0.001178). These results demonstrate improved segmentation accuracy, precise boundary localization, and interpretable uncertainty maps. The approach thus provides a practical and reliable solution for clinical deployment where data completeness and predictive confidence are equally critical.

Index Terms—Brain Tumor Segmentation, Uncertainty Estimation, Bayesian U-Net, Monte Carlo Dropout, Modality Dropout, HeMIS, MRI.

Paper ID : 839

FPGA-Based Real-Time Vehicle Monitoring System Using Licence Plate Detection

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Abstract

This paper presents an FPGA-based real-time vehicle monitoring system for automatic license-plate recognition, implemented on the Altera DE2-115 development board. A Sony Handy-cam video module captures a live 2592x1944 4:2:2 YCbCr stream, which is ingested via a Video-In Decoder and converted to full-resolution 4:4:4 YCbCr by a custom Chroma Re-sampler. License-plate localization is performed by a dedicated IP core that applies thresholding on Y, Cb, and Cr channels and executes two-pass connected-component labeling followed by a white-pixel-density filter to isolate the plate region. The cropped 320x240 plate image is written to on-chip SRAM through a burst-mode Video DMA, then up sampled to 640x480 RGB for VGA display. Character segmentation and recognition are extracted via secondary thresholding and labeling, normalized to 16x32 frames, and classified through a parallel template-matching engine. All pixel-level processing is offloaded to hardware IP blocks synthesized with Intel Quartus II and Platform Designer under Nios II soft-processor co-ordination. Experimental results demonstrate accurate plate detection and recognition at 30 fps with under 40% logic and 50% BRAM utilization, offering a low-power, low-cost solution for embedded intelligent-transportation application.

Keywords—FPGA; Automatic Number Plate Recognition; Connected-component Labeling; YCbCr Thresholding; Nios II; Intel Quartus II; Platform Designer

Intra-Lead ECG Analysis for Deepfake Detection Using Temporal Neural Networks

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Abstract

Recent advancements in Generative Adversarial Networks (GANs) have made it possible to produce very realistic deepfake electrocardiogram (ECG) signals, posing serious threats to data integrity, clinical decision-making, and biometric security. This work presents use of Temporal convolutional networks (TCN) which enables simultaneous capture of local waveform characteristics and global temporal patterns, ensuring comprehensive signal representation for distinguishing deepfake from authentic ECG signals. Our approach emphasizes Intra-lead analysis, where models are trained to learn temporal patterns within individual ECG leads, rather than relying on interlead correlations. This helps the models focus on lead-specific morphological cues that may be subtly distorted in synthetic ECGs, avoiding artifact-based learning. We test the approach on a collection of 10-second ECG records at 500 Hz sampling rate, which is evenly split between authentic and artificially generated signals. With early stopping and learning rate tuning, the proposed TCN model attained accuracy of 98.58% at a learning rate of 0.001. Results reflect the susceptibility of AIbased healthcare systems to adversarial-generated physiological signals and the necessity for secure frameworks to guarantee the authenticity of ECG data.

Index Terms—Electrocardiogram (ECG), Deepfake Detection, Intra-Lead Analysis, Generative Adversarial Networks (GANs), Deep Learning, Biomedical Signal Processing, Healthcare AI

Paper ID : 852

Intelligent Aquarium Monitoring System Using YOLOv5 and IoT-Based Environmental

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Abstract

Active supervision of aquariums is central to the maintenance and welfare of aquatic life. In this paper, we describe an integrated biological and environmental parameters monitoring for an aquarium based on deep learning and realtime monitoring sensors. We have integrated an object detection system using YOLOv5 deep learning model to detect and track ornamental goldfish (Carassius auratus) and aquarium decors in real-time.To offer continuous monitoring, the detection system is paired with an ESP32 microcontroller and a 4-in-1 multifunctional sensor that can measure pH, water temperature, ambient light, and water level.The trained YOLOv5 model achieved a mean Average Precision (mAP@0.5) of 0.991 on a 1,308-image dataset, with real-time performance at 21 FPS, demonstrating both accuracy and speed in biological detection. All collected biological and environmental data is transmitted to a custom web-based platform for visualization, providing continuous and remote observation. This system offers an intelligent, economical, and effective aquarium system with adjustable parameters for future improvement that can be used in laboratory research, aquaculture, and fish keeping enthusiasts.

Index Terms—YOLOv5 • Aquarium Monitoring • Carassius auratus • Water Quality Sensors • Real-Time Object Detection

Improved Object Detection Framework with Thermal Imaging

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Abstract

The increasing prevalence of automated driving has led to a heightened demand for robust advanced driver assistance systems (ADAS), making it a critical area of research. Several studies have focused on integrating deep learning models into these systems, leveraging artificial intelligence to detect objects in real-time. However, variations in illumination, weather, geographical location, and pose bring challenges to the detection performance of these models. To address this, infrared imaging offers a reliable and robust alternative. This paper presents a thermal dataset that spans nine object classes critical to ADAS. Then, an optimized YOLOv11-based detection model is proposed, enhancing feature extraction for low-contrast infrared targets. Furthermore, the optimized model is deployed on a Jetson Nano to perform object detection in real-time. For assessing the model's reliability, a comparative analysis of state-of-the-art (SOTA) convolutional neural networks (CNNs) is conducted using mean average precision (mAP) as the main evaluation metric. The experimental findings reveal that YOLOv11n achieves enhanced performance on the ITDAV-25 with an mAP of 97.2%. The results validate the use of domain-specific thermal dataset with optimized deep learning architectures can overcome the limitations posed by adverse weather and illumination in ADAS.

Index Terms—CNN, deep learning, ITDAV-25, Jetson Nano, object detection, thermal images, thermal image dataset, YOLOv11.

Paper ID : 866

MediAid: Automated Healthcare and Smart Medicine Dispenser

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Abstract

Elderly individuals often experience serious health issues that need ongoing monitoring of their health and prompt administration of medication to avoid complications. This work introduces an IoT-based Elderly Health Monitoring and Robust Care System which combines biomedical sensors such as an MAX30102 sensor for heart rate and SpO2 monitoring, an ECG sensor to analyze cardiac activity, and an NTC thermistor to measure body temperature with an ESP32 microcontroller, coupled with a servo motor-controlled automatic medicine dispenser for precise administration of drugs. The system transmits collected health data to the cloud for real-time storage, visualization, and anomaly detection, while incorporating an intelligent alert mechanism to immediately notify caregivers or medical professionals when abnormalities are detected. Additionally, a mobile application has been developed to provide an intuitive interface for doctors, caregivers, and patients to view health records and manage prescriptions. The solution presented provides a low-cost, scalable, and secure method of remote care for the elderly through the integration of real-time health tracking with autonomous medication management, hence enhancing early abnormality detection, drug compliance, and healthcare accessibility for the elderly population.

Index Terms—IoT, elderly health monitoring, ESP32, MAX30102, ECG sensor, ThingSpeak, real-time data, remote healthcare, medicine dispenser.

Paper ID : 867

Flexible and Biodegradable Gas/ Humidity Sensor for Industrial and Health Monitoring Systems

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Abstract

This work reports the fabrication and characterization of a biodegradable and flexible humidity and NO_2 gas sensor based on crystalline nanocellulose (CNC) films derived from banana trunk biomass. The response of the fabricated sensor to mouth breathing was observed under inhalation and exhalation at ambient conditions. The CNC sensor exhibited excellent humidity responsiveness, attributed to its hydrophilic nature and porous microstructure, making it suitable for non-invasive breath monitoring. Furthermore, under static flow conditions at 5 ppm NO_2, the sensor demonstrated a remarkable sensitivity of 500%, with response and recovery times of 475 s and 300 s, respectively. The observed sensing mechanism is governed by reversible physisorption processes, ensuring stable performance. Compared to conventional inorganic sensors, the developed CNC platform offers distinct advantages of biodegradability, flexibility, and environmental safety, positioning it as a promising candidate for next-generation sustainable sensing devices in healthcare and environmental monitoring.

Keywords—crystalline nanocellulose, biodegradable, gas sensor, breath monitoring

Paper ID : 870

Deepfake Image Detection with Vision Backbones vs. SoTA Detectors: The Role of Frequency Representations

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Abstract

The rapid progress of diffusion-based generative models in the recent years has made detecting deepfakes more challenging. This paper presents a systematic comparison of state-of-the-art computer vision backbones (Swin Transformer, ConvNeXt, EfficientNetV2) and specialized deepfake detectors for diffusion-based fake images. We evaluate models with and without frequency-domain cues, incorporating Power Spectral Density (PSD) and Discrete Fourier Transform (DFT). Our experiments demonstrate that hybrid spatial-frequency methods substantially improve detection accuracy. In particular, ConvNeXt with PSD achieves 99.99% accuracy, surpassing existing baselines and establishing a strong benchmark for future diffusion deepfake detection research.

Index Terms—deepfake detection, Diffusion models, Vision Transformers, Frequency analysis, Transfer learning

Paper ID : 872

CLIPQ-Count: A Query-Guided Vision-Language Framework for Few-Shot Object Counting

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Abstract

Few-shot object counting aims to enumerate instances of novel object categories using minimal labeled examples, essential for autonomous navigation, ecological monitoring, and retail inventory management. Traditional counting methods require extensive labeled datasets and struggle with unseen object classes. We propose CLIPQ, The framework employing Contrastive Language-Image Pretraining (CLIP) architecture for robust few-shot object counting with only 1–5 exemplar images . Our approach integrates a Vision Transformer (ViTB/ 32) backbone with point-guided spatial attention, self-adaptive feature enhancement (SAFE), and query-guided exemplar matching. The framework employs contrastive learning to align visual and textual representations, enabling effective transfer learning from pre-trained models. Key contributions include a lightweight counting head processing multi-modal features and attention mechanisms focusing on object-relevant regions while suppressing background clutter. Comprehensive evaluation on the FSC-147 dataset demonstrates that CLIPQ achieves a Mean Absolute Error (MAE) of 22.70, representing a substantial 37.95% improvement over the baseline CLIP model (MAE: 36.60). Our ablation study reveals that each component contributes progressively to performance gains, with the ViT integration providing the largest improvement (16.67%), followed by SAFE (21.31%) and attention mechanisms achieving the final 37.95% improvement. While challenges remain in handling high-density scenes and small objects, the framework demonstrates strong generalization capabilities across diverse object categories.The proposed CLIPQ offers a practical solution for few-shot object counting, making it suitable for real-world deployment scenarios where labeled training data is limited.

Index Terms—few-shot object counting, vision-language models, CLIP, deep learning, transformers, transfer learning, metalearning

AgriLeaf: Attention guided CNNs for Disease Detection in Cotton for Edge-Aware Platforms

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Abstract

Cotton is a closely related agricultural crop that can face production setbacks from diseases that appear on the leaf which are notoriously difficult to identify through visual inspection at scale. Manual inspection of large fields is not only labor intensive, but most importantly, also poorly reliable at a large scale. Current deep learning solutions can also present challenges with robustness based on UAV conditions in real-world situations. Conditions with variability in lighting and occlusion can considerably reduce model generalizability by masking critical features and backgrounds with high degree of complexity. The proposed system consists of a lightweight convolutional neural architecture augmented with channel and spatial attention, to allow multi-class disease detection via fine-grained classification through aerial imagery captured from UAVs. The model attends to important regions while suppressing background fields by utilizing a dual attention mechanism, which allows our model to have better performance and guaranteed accuracy without being bogged down by excess computational worry. The system was built for edge aware deployment so it will allow for effective onboard real-time inference directly on a UAV without loosing accuracy in detection or classification. Overall, through realworld evaluations across six major alternative categories, our detection system was actuation with over 98% AUC with high feature separability and negligible misclassification. Our system will provide real-time, early diagnosis of diseases would limit chemical utilization and provide farmers with solutions to enhance yield through actions and applications in precision agriculture.

Index Terms—Aerial image processing, crop health monitoring, disease detection, attention mechanism, cotton leaf disease, precision agriculture.

Design of Read Timing Control Circuit Using Replica Bitline and Chain Delay Techniques for 64MB Dual-Rail Memory Architecture in 65nm LSTP

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Abstract

This paper describes the read timing control circuit using Replica Bitline and Chain Delay Techniques for generating the Sense Enable (SAEN) signal delay in low-power dual rail Static Random Access Memory(SRAM) operating at a periphery voltage of 0.6V and an array voltage of 1.1V. Simulations conducted in a 65nm CMOS process across various Process, Voltage, and Temperature (PVT) conditions evaluate delay performance, reliability, and temperature inversion behavior. The Replica Bitline Technique, utilizing a replica column to track bitcell discharge with a 25mV offset, achieves delays ranging from 46ps to 171ps with no failures across PVT conditions. In contrast, the Chain Delay Technique, employing a chain of inverters, produces delays from 0.34ns to 1.63ns but exhibits variability and failures in certain configurations. Both techniques show temperature inversion due to subthreshold operation, complicating timing closure. The Replica Bitline Technique is found to be superior for high-speed, reliable SRAM designs, while the Chain Delay Technique offers simplicity for less critical applications. Also chain delay technique can give a significant advantage for a large bitline height OR a large memory instance.

Index Terms—SRAM, Replica Bitcell, Chain Delay, Low- Power, Dual-Rail, Temperature Inversion, Timing Control.

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Paper ID : 877

Few-Shot Bird Sound Classification with Advanced Inference Methods and Enhanced PANN

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Abstract

Self-supervised learning (SSL) has emerged as a powerful approach for learning representations from unlabeled audio data, particularly in domains like bioacoustics where labeled data is scarce. While recent work has demonstrated the effectiveness of SSL for bird sound classification in few-shot learning scenarios, most approaches rely on simple nearest prototype classifiers for inference. In this paper, we extend the state-of-the-art SSL framework for bird sound classification by implementing and evaluating three advanced few-shot inference methods combined with enhanced pre-trained audio neural network (PANN) selection strategies. Using extended training (300 epochs), enhanced data augmentation, and multi-stage PANN filtering on the BirdCLEF 2020 dataset with 10,000 evaluation tasks, we achieve adequate performance improvements over previous work. Our enhancement to Barlow Twins model with smart segment selection achieves 62.72% accuracy in 5-way 1-shot classification, representing a 10.77% improvement over baseline methods and approaching the base paper's performance of 64.19%. With the implementation of enhanced PANN selection, we achieve 65.18% accuracy, exceeding the original benchmark. We demonstrate that the combination of extended SSL training, enhanced PANN selection, and advanced inference methods can substantially bridge and exceed the performance gap in few-shot bioacoustics classification.

Paper ID : 885

Performance Analysis of UAV Communication Using Scaled Selection Combining

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Abstract

Unmanned Aerial Vehicles (UAVs), being deployed as aerial relays are gaining momentum in communication, to enhance coverage, handle sudden surges in connectivity demand, and improve reliability in wireless communication systems. This makes them a promising component of next-generation networks. In this work, we study a cooperative communication model where a base station transmits M-ary Phase-Shift Keying symbols to a destination, both directly and via a UAV aerial relay. At the user end in the destination, the received signals are combined using a low-complexity scaled selection combining (SSC) scheme. A closed-form expression of Symbol Error Probability (SEP) has been analytically derived, for the considered system assuming Rayleigh fading channel conditions. The simulation results demonstrate that UAV-assisted relay communication with SSC outperforms both conventional selection combining and direct transmission.

Index Terms—M-ary phase-shift keying (M-PSK), Scaled Selection Combining (SSC), Symbol Error Probability (SEP), UAV aerial relay.

Real Time Transit Tracking for Public Transportation

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Abstract

Urban public transportation systems in developing nations, particularly in India, are grappling with a systemic crisis characterized by chronic overcrowding, fleet insufficiency, and operational unpredictability. This paper presents a novel system designed to address these issues. The Real Time Transit Tracking (RTTT) framework comprises two key components. First, an affordable, privacy-preserving Internet of Things (IoT) device that utilizes a fusion of a pressure mat and infrared (IR) sensors to achieve high-accuracy passenger counting. Experimental validation of the hardware prototype demonstrates an overall counting accuracy of 90.4% with robust performance across real-world scenarios. Second, we architect a hybrid SARIMA–LSTM forecasting model to leverage seasonal structure and non-linear exogenous effects (weather, holidays, events). Implementation and empirical evaluation of the forecasting model are reserved for future work. The developed hardware and proposed framework offer a viable and powerful tool for transit authorities to optimize fleet deployment, mitigate overcrowding, and enhance service reliability.

Keywords— Automated Passenger Counting (APC), Internet of Things (IoT), Sensor Fusion, Privacy-Preserving, Time Series Forecasting, Hybrid SARIMA-LSTM, Public Transportation.

Paper ID : 894

Efficient Stochastic FP32 to INT4 Quantization in lightweight 32-bit RISC-V Processors

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Abstract

Edge machine learning demands lightweight representations to balance accuracy with computational efficiency on resource-constrained devices. Quantization from 32-bit floatingpoint (FP32) to 4-bit integer (INT4) is key, but stochastic rounding (SR), which introduces randomness to reduce error accumulation, remains computationally expensive without dedicated hardware. This work introduces a compact RISC-V custom instruction extension for hardware-accelerated FP32→INT4 conversion with SR. Integrated into the PicoRV32 core via the PCPI coprocessor interface, it uses a lightweight Linear Feedback Shift Register (LFSR) for randomness, avoiding the overhead of a full floating-point unit. Evaluated on cycle counts, hardware area, and rounding-error distributions, the extension achieves 4.2× speedup over an optimized software routine (54 cycles baseline) and 24× over full software FP emulation (316 cycles). Compared to deterministic rounding, SR improves error variance by up to 30% in simulated ML workloads. This low-overhead extension enables practical stochastic quantization on edge processors, facilitating accurate ML inference with negligible added cost. It demonstrates how targeted ISA enhancements can enable advanced ML techniques for IoT and embedded systems. Index Terms —RISC-V, custom instruction set, stochastic rounding, quantization, edge AI, low-bit inference, PicoRV32, linear feedback shift register (LFSR), low-power computing.

Machine Learning-based Detection and Localization of Communication Delay Attack in IoT

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Abstract

The reliability and timeliness of Constrained Application Protocol (CoAP) based Internet of Things (IoT) applications are critically threatened by communication delay attacks, where adversaries intentionally introduce packet delays keeping it limited by the maximum allowed delay, making detection challenging. Such stealthy delay attacks undermine the responsiveness of time-sensitive applications such as healthcare monitoring, industrial control, and emergency alert systems. Unlike other attacks, delay attack maintains packet delivery ratio and thus often goes undetected by traditional methods. The situation is further complicated by the resource-constrained nature of IoT nodes, which limits the feasibility of complex, resourceintensive security solution. This creates a need for intelligent solutions capable of detecting such timing-based anomalies efficiently. Therefore, this paper presents a machine learning-based framework for Detecting and Localizing Communication delay attacks, namely DeLoC, in CoAP-based IoT networks. Delay anomalies are identified by analyzing packet timestamps using models like Linear Regression and Random Forest Regression, while node-level features such as CPU utilization, queue length, and retransmissions counts are used to localize malicious nodes via classification models. Simulations in the Cooja Contiki- NG environment show high accuracy, precision, and recall. Comparative analysis further shows a significant reduction in induced packet delays, making DeLoC suitable for resource constrained IoT systems.

Index Terms—Internet of Things (IoT), CoAP, Communication delay attack, Anomaly detection, Machine learning based detection.

Paper ID : 907

Robust Multi-loop PI Control Design for Time Delay System : A Disturbance Decoupling Approach

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Abstract

In this paper, a model-based multi-loop decentralized PI controller is proposed based on an analytical solution. Basically, this proposed approach provides a method that offers an appropriate trade-off between good servo and regulatory response. In this work, to implement the controller, a decoupler is first developed using the dynamics of the multi-variable system. Nyquist plots with gershgorin circles are presented to illustrate the effects of decoupling performance. Moreover, to demonstrate the efficacy of the proposed model-based disturbance rejection controller, two industrial complex case studies have been considered. The simulation results are compared with other well-known model-based multi-loop PI controller.

Index Terms—Process Control, Decoupling, MIMO, Internal Model Control

Machine Learning and Deep Learning Approaches for Stroke Classification Using Multi-Muscle Upper Limb EMG Features Across Functional Reaching Tasks

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Abstract

Stroke often results in upper limb motor impairments, necessitating reliable diagnostic tools for clinical and rehabilitation applications. This study presents a comprehensive framework for classifying stroke and healthy individuals using surface electromyography (sEMG) signals recorded from eight upper arm muscles during nine reaching tasks. A total of thirty seven features spanning time, frequency, statistical, and non-linear domains were extracted and ranked using statistical significance testing. Nine machine learning classifiers,including SVM, Random Forest, kNN, Logistic Regression, LDA, AdaBoost, RUSBoost, and Na¨ıve Bayes were evaluated. Along with machine learning classifiers, a deep learning LSTM model was also assessed. Results showed that ensemble and non-linear classifiers outperformed linear models, with ensemble methods achieving 80% accuracy and AUC 0.88. Notably, the LSTM model achieved the highest performance with 90% accuracy, demonstrating its ability to capture temporal dependencies and inter-muscle coordination. These findings highlight the potential of sEMGbased classification, particularly deep learning, for objective stroke assessment and its integration into clinical decision support and rehabilitation systems.

Index Terms—Electromyography (EMG), Stroke, Feature Selection, Machine Learning, Multiclass Classification, Upper Limb, Reaching Task

An Investigation of Star-Shaped Split Ring Resonator For Narrowband Filtering Application

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Abstract

This paper presents a novel star-shaped Split Ring Resonator (SRR) with a thin microstrip wire for narrowband metamaterial application and investigates its double negative properties when combined with thin wire. The proposed geometry introduces sharp corners and extended arms in the SRR unit cell, resulting in enhanced localization of surface currents and a narrower notch. The unit cell star-SRR structure is modeled and analyzed using Ansys HFSS on a Rogers 5880 substrate of 1.575 mm thickness with a dielectric constant of 2.2 and having loss tangent of 0.0009. The S-parameter retrieval technique is employed to obtain the effective material parameters, including permittivity, permeability, wave impedance and refractive index. Simulation results indicate that the star-shaped SRR exhibits double negative behavior in a narrow frequency band around 3.4725 GHz with 10 MHz BW (3.47-3.48 GHz), making it suitable for high-selectivity filters and sensing applications.

Index Terms—Double Negative material, Metamaterial, Narrowband Notch, S-parameter retrieval, Star-Shaped SRR

Paper ID : 918

HDPCA-PNet: A Hybrid Encoder with Dual-Pool Coordinate Attention for Polyp Segmentation

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Abstract

Early detection of colorectal polyps can prevent colorectal cancer (CRC), one of the life-threatening diseases. The removal of a polyp requires precise segmentation of the polyp from the wall of the colon and rectum. Current computeraided diagnosis (CAD) systems, which are based on deep learning algorithms, struggle with long-range dependency and performance accuracy. Even the attention-based mechanism addresses these issues by focusing on the informative region. However, most existing attention mechanisms focus on smooth feature responses and may suppress local variation, which may not perform well on small, flat polyps. The proposed HDPCA-PNet is a U-shaped network with a hybrid pre-trained encoder for better feature and contextual information representation, along with improved dual-pooling coordinate attention to overcome the loss of positional, global contextual information, and dominant features. The variation in polyp shape and size is addressed by employing a residual efficient atrous spatial pyramid pooling (ASPP) method, which captures feature values at different scales effectively. The proposed architecture outperforms other stateof- the-art (SoTA) models with a mean IoU of 94.8% and 88.6% on the CVC-ClinicDB and Kvasir-SEG datasets, respectively.

Index Terms—Deep Learning, Colorectal Polyps, Segmentation, ASPP, Coordinate Attention

Paper ID : 926

SEE-FuseNet: A Stage-Enhanced Multi-Level Feature Fusion Framework for Eye Disease Classification

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Abstract

Eye diseases remain a leading cause of preventable, blindness worldwide, where early and accurate diagnosis is essential for effective treatment. Automated classification of fundus images, however, is challenging due to heterogeneous disease patterns, class imbalance, and limited availability of annotated datasets. To address these issues, we propose SEEFuseNet, a Stage-Enhanced Multi-Level Feature Fusion framework for robust eye disease classification. The architecture employs EfficientNet-B4 as the backbone for hierarchical feature extraction, while a novel Multi-Level Feature Fusion (MLFF) module—comprising Stage Enhancers, Lateral Reduce, Fuse Mix, and Unify Channel operations—refines and harmonizes multi-scale representations. The fused features are further enhanced using a Transformer encoder and an MLP classifier to capture global dependencies and improve discriminative power across ten eye disease categories. Extensive experiments were conducted on both original and augmented datasets to compare SEEFuseNet against several baseline backbones. Among the baselines, EfficientNet-B4 consistently demonstrated superior performance, validating its effectiveness as the backbone choice. SEE-FuseNet further improved upon this, achieving 0.9003 accuracy, 0.9015 F1 Score, and 0.8897 MCC on the augmented dataset, and 0.8091 accuracy on the original dataset. These results confirm that SEEFuseNet effectively integrates spatial and semantic features with global contextual information, achieving superior robustness and generalization for automated eye disease classification.

Index Terms—Eye disease classification, Fundus imaging, Deep learning, Multi-level feature fusion, Transformers, Medical image analysis.

Paper ID : 929

Adaptive Cross-View Attention with Interpretable Bidirectional Lightweight Sequencing for Chest Radiography

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Abstract

Accurate interpretation of dual-view chest radiographs for cardiothoracic and cardiovascular findings is central to patient management, yet most learning systems either ignore the lateral view or fuse it late, limiting cross-view reasoning and clinical trust. Computed tomography can predict cardiovascular risk but entails substantially higher radiation; chest X-ray offers a safer, ubiquitous alternative, motivating multi-view methods that are both efficient and explainable. We propose Adaptive Multi-View Fusion with Interpretable Bidirectional Lightweight Sequencing, which shares a ResNet-50 encoder across projections, tokenizes each feature map with two-dimensional positional encodings, and applies a two-layer bidirectional GRU to capture long-range spatial dependencies without the quadratic cost of generic transformers. Bidirectional cross-view attention transfers evidence between frontal and lateral tokens, per-view tokenattention pooling yields compact descriptors, and a two-weight view gate produces study-specific reliabilities; Grad-CAM and
cross-view saliency provide spatial and inter-view attributions. With 25.8M parameters and 8.3G MACs at 224×224, the model is deployable in real time on commodity GPUs. On a held-out dual-view set, attaining macro ROC-AUC 0.8685 (micro 0.8327), including cardiomegaly AUC 0.922 with AP 0.566 and F1 0.610, while the mean view gate (0.80 frontal, 0.20 lateral) quantitatively reflects clinical reliance on the frontal projection.

Index Terms—Cardiovascular Disease Detection, Sequence Model, Biomedical, Deep Learning, Explainable AI.

Approx-Ch: An Approximate Chameleon Clustering for Large-Scale and High-Dimensional Data

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Abstract

Hierarchical clustering remains a fundamental challenge in data mining, particularly when dealing with real-world datasets. Here, traditional approaches fail to scale effectively when the datasets are large-scale and high-dimensional. Recent Chameleon clustering algorithms – Chameleon2, M-Chameleon, and INNGS-Chameleon – have proposed advanced strategies that try to address this challenge. However, they still suffer from O(n2) computational complexity. We address this challenge here by introducing Approximate-Chameleon (Approx-Ch) that has O(n log n) complexity. Our algorithm has three parts. First, Graph Generation — here we use approximate k-NN search instead of an exact one, as used by earlier three algorithms. This results in fast nearest-neighbor computation, significantly reducing the graph generation time. Second, Graph Partitioning — here we use a multi-level partitioning approach as compared to a singlelevel one, mostly used by the prior three works. This change ensures that graph partitioning is robust to the errors introduced by approximate graph generation. This also facilitates minimal configuration requirements. Third, Merging — here we follow Chameleon2 by retaining its flood-fill heuristic and its merging criteria since it is the cheapest among the earlier three algorithms. On real-world benchmark datasets used in former three works, Approx-Ch delivers an average improvement of 5% in clustering quality and reduces total run-time by 86%. This demonstrates that algorithmic efficiency and clustering quality can co-exist in large-scale hierarchical clustering.

Index Terms—Hierarchical clustering, Approximate nearest neighbors, Multilevel graph partitioning, Computational complexity, Scalability.

A Lightweight CNN for Outdoor Sound Classification on Edge Devices

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Abstract

This paper introduces a lightweight convolutionalneural network (CNN) inspired by ResNet design, for outdoor scene sound classification, targeting ten distinct sound categories: helicopter, electric saw, siren, car horn, engine, train, church bell, airplane, fireworks, and handsaw. The raw sound signals recorded in WAV format using a microphone were transformed into time-frequency images via the continuous wavelet transform (CWT). The proposed CNN is optimized for low memory consumption, making it ideal for deployment on an edge-computing device, the Raspberry Pi. The model's performance was compared against popular pre-trained architectures, including DenseNet, EfficientNet, InceptionNet, MobileNet, NASNet, ResNet, VGGNet, and Xception. Experimental results demonstrate that the proposed lightweight CNN outperforms pre-trained models, achieving a 91.73% testing accuracy with a compact model size of just 3.1 MB. Additionally, it achieves a tenfold cross-validation accuracy of 92.21% and operates efficiently on the Raspberry Pi, with a runtime of 56 milliseconds per inference. The high accuracy, low memory usage, and fast performance make this proposed CNN a promising solution for realtime applications such as environmental monitoring, public safety systems, autonomous vehicles, and smart city infrastructure.

Index Terms—lightweight CNN, time-frequency images, outdoor sound classification, edge computing devices, and pretrained CNN

Multi-Channel 1D-CNN Architecture for Drone vs Bird Classification Using mmWave Radar ADC Data

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Abstract

Reliable discrimination between drones and birds is essential for secure airspace monitoring. Traditionally, imagebased approaches struggle under poor lighting or weather conditions. However, radar-based classification has emerged as a promising alternative by observing drone and bird RCS and Doppler signatures. In this work, we explore raw 60 GHz millimeter-wave radar analog-to-digital converter (ADC) signals for binary aerial target classification using multi-input onedimensional convolutional neural networks (1D-CNNs). In this
paper, three architectures are designed and evaluated on the ADC data: a 2-input CNN (amplitude + phase), a 3-input CNN (amplitude + real + imaginary), and a 4-input CNN (amplitude + phase + real + imaginary). Each proposed model employs parallel convolutional streams for feature extraction and then feature-level fusion to capture complementary signal characteristics. Experimental results show that the 3-input 1DCNN achieves the best performance with an accuracy of 96% when trained on longer sequences. Moreover, the 2-input 1DCNN provides stable and computationally efficient performance. Finally, the 4-input 1D-CNN suffers from reduced generalization due to redundancy despite incorporating richer modalities. These findings demonstrate the potential of raw radar signal learning for robust drone-versus-bird classification and provide practical insights for developing accurate and efficient real-time airspace surveillance systems.

Index Terms—Millimeter-wave Radar, Drone Detection, Bird Detection, Drone vs Bird, 1D Convolutional Neural Networks, Multi-input 1D-CNN, Micro-Doppler.

Paper ID : 942

QUIBC: A Quantum-Inspired Image Binarization Compressor for Resource-Constrained Edge Device

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Abstract

Quantum-inspired neural networks are computationally intensive, and traditional codecs such as JPEG are not well-suited for low-bit-rate perceptual quality, making image compression in resource-limited edge devices a serious problem. To address this, we introduce the Quantum-Inspired Image Binarization Compressor (QUIBC), a deep network structure borrowing quantum computing concepts. With unitary transformations for lossless feature fusion and quantum-inspired binarization of the latent space, QUIBC learns optimal rate-distortion tradeoff with an adaptive Lagrange multiplier (lambda) dynamically learned. QUIBC was trained on a single T4 GPU, achieving validation PSNR of 26.58 dB and MS-SSIM of 0.914 at 0.454 bpp on the CLIC dataset under simulated IoT conditions. To ensure robust generalization, we validated across five diverse datasets spanning medical imaging (Pneumonia MNIST: 32.98 dB), satellite imagery (EuroSAT: 31.02 dB), and natural images (Oxford Flowers 102: 24.69 dB, Food-101: 25.93 dB, DIV2K: 22.72 dB). Ablation studies validate critical components: removing unitary transformations degrades PSNR by 1.71 dB, eliminating STE causes training collapse (NaN), and adaptive lambda achieves
8.6 percent bitrate reduction. Edge device deployment simulation demonstrates practical viability: Coral TPU achieving 26.19 FPS (38ms, 2W), Jetson Xavier NX 7.2 FPS (139ms), Jetson Nano 3.09
FPS (323ms), with memory footprint of 5.38-20.52 MB (INT8- FP32). XAI analyses (Grad-CAM, LRP, t-SNE) comprehensively justify design choices and interpretability. These results establish
QUIBC as a computationally efficient solution for next-generation edge applications with excellent perceptual quality-compression efficiency tradeoff.

Index Terms—Quantum ML, Image Compression, Binarization, Rate-Distortion, Edge Devices

Median Frequency Inflation Rate (MFIR): A Novel Time-Frequency Method for Rapid P and S-Wave Detection in EEW Systems

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Abstract

Earthquake Early Warning (EEW) systems are vital for reducing the damage caused by earthquakes by providing seconds of warning before strong shaking begins. A key challenge in EEW is the rapid and accurate detection of seismic waves, particularly the initial P-wave, along with precise identification of P and S-wave arrival times. This study presents a novel timefrequency based signal processing method termed the Median Frequency Inflation Rate (MFIR) technique for improved realtime seismic event detection and phase picking. Utilising a large, strong-motion accelerogram dataset from Japan's K-NET seismic network and non-earthquake data from NCR, India, the MFIR approach examines spectral density changes across multiple frequency bins in earthquake accelerograms. MFIR effectively detects sudden changes in median frequency that correspond closely with P and S wave arrivals. By tuning detection thresholds, the method achieves a high true positive rate (TPR) of approximately 98% for P-wave events with a threshold of 0.7, while maintaining a low false alarm rate of 5% on nonearthquake data. Additionally, the S-wave detection TPR exceeds 90%. Additionally, MFIR offers low latency, with median phase arrival detection delays under one second for both P and S-waves, demonstrating its capability for real-time applications.

Index Terms—Earthquake early warning, Frequency inflation rate, P-wave, S-wave, Seismic event detection, Seismic phase picking, Spectral binning.

Statistical Validation of Metaheuristic-Guided Multi-Backbone Fusion: A Comprehensive Analysis for Rice Leaf Disease Detection

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Abstract

Rice leaf diseases are a persistent challenge to crop productivity, and early detection is vital for preventing severe yield losses. Manual diagnosis by experts, although effective, is time-consuming, subjective, and difficult to scale in field conditions. This work introduces a Harmony Search-guided multi-backbone ensemble framework for automated rice disease recognition. The framework combines three complementary deep networks - ResNet50V2, ConvNeXt-Small, and Xception, through a two-stage fusion strategy. At the intra-architecture level, predictions from different optimizers are aggregated to stabilize backbone performance, while at the inter-architecture level, Harmony Search adaptively determines fusion weights, leading to more reliable ensembles than simple averaging. The method was evaluated on three standard rice disease datasets covering diverse disease categories and imaging conditions. Using 10-fold crossvalidation, rigorous statistical tests including Friedman, Nemenyi post-hoc, Wilcoxon signed-rank, and Cliff's delta confirmed the significance and stability of the observed improvements. These results demonstrate that adaptive fusion can enhance both accuracy and consistency, offering a robust approach for practical deployment in precision agriculture.

Index Terms—Rice leaf disease detection, Statistical validation, Multi-backbone ensemble, Harmony Search optimization, Wilcoxon signed-rank test, Friedman test with Nemenyi posthoc, Cliff's delta effect size, Precision agriculture.

Paper ID : 949

Practical Evaluation of AI-Assisted Adaptive Solutions and Strategies for Removal of Electromagnetic Interference in X-ray Imaging

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Abstract

Electromagnetic (EM) interference is a longstanding issue in X-ray imaging systems, often seen as grating-like artifacts that compromise image quality and mask diagnostically important information. Standard fixed-frequency filtering methods are unable to cope in dynamic applications where interference parameters like frequency and bandwidth shift randomly. This case study is a comparative assessment of adaptive filtering and artifact removal techniques optimized for real-time use. The studied approaches are autoencoders, inpainting of images, line detection algorithms, physics-informed neural networks (PINNs), and a neural-assisted adaptive filter. This study is significant in that it models grating artifacts as sinusoidal signals based on earlier work. This facilitates a common framework for unsupervised artifact removal and provides an alternative perspective for the incorporation of state-of-the-art supervised neural network methods to enhance image quality in realtime processing. The potential of combining sinusoidal modeling with these methods is investigated to improve robustness and accuracy. Initial experimental data show the relative efficiency of each method in suppressing interference without compromising image quality. This work does not propose one solution, but instead provides an explanation of the benefits, restrictions, and integration possibilities of each, with the goal of informing the creation of scalable, real-time filters for next-generation X-ray imaging systems.

Index Terms—Image Inpainting Techniques, Physics Informed Neural Network, Adaptive Filter, Auto Encoders, Hough Transform, external factors in the removal of horizontal or vertical grating noise types.

Paper ID : 952

A Multimodal Explainable AI Framework for Classification of Indian Medicinal Leaves Using Transformer and CNN-Based Architectures

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Abstract

Existing automated plant identification systems have achieved significant success with deep learning; however, challenges remain due to the complex leaf morphology and variability across datasets. Ensuring the accurate identification of medicinal leaves is vital for applications in healthcare, botany, and conservation. This paper introduces a new multimodal deep learning framework to automatically classify Indian medicinal leaves, using a curated dataset of Indian Medicinal Leaf images and morphological metadata. The proposed method employs deep CNNs and a vision transformer (BEiT) to extract detailed visual features from leaf images, with BEiT demonstrating a superior classification accuracy of 99.52%. The accompanying metadata are modelled independently with a Naive Bayes classifier. By applying a late-fusion approach, features from both image and metadata modalities are combined at the final stage to improve predictive performance. For model interpretability, the framework uses explainable AI techniques to visualise the spatial focus of image-based models and to identify the importance of metadata features. Experimental results show that the integrated multimodal approach outperforms unimodal baselines, resulting in enhanced precision and broader applicability in species classification. The study highlights the potential of multimodal deep learning and explainable AI to advance identification systems and proposes scalable solutions for accurate recognition.

Index Terms—Multimodal Deep Learning, Indian Medicinal Leaves, BEiT, ResNet, DenseNet, ConvNeXt, Metadata Fusion, Grad-CAM, LIME, Explainable AI, CNN

Paper ID : 964

Neural Embedding Bandit - A Novel Contextual Bandit for Intelligent Payment Gateway Routing

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Abstract

Contextual linear bandits have been widely adopted for payment gateway orchestration due to their simplicity and ability to make sequential decisions under uncertainty. However, advancements in contextual bandits with neural networks have led to neural contextual bandits, which outperform their linear counterparts in many scenarios. In this work, we propose the use of neural contextual bandits for intelligent payment routing and benchmark their performance against linear approaches. We introduce a novel Neural Embedding Bandit (NEB) architecture that combines deep representation learning with efficient inference for low latency applications. To enable realistic evaluation, we develop a synthetic dataset generation pipeline using a large language model and define nonstationary reward functions that capture diverse merchant preferences. Our experiments show that neural bandits, particularly NEBs, achieve the lowest cumulative regret while offering faster inference than other neural bandit variants, making them well suited for real time payment orchestration.

Index Terms—Contextual Bandits, Reinforcement Learning, Payment Gateway Orchestration, Online learning

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