FMLDS 2025

2025 IEEE International Conference on Future Machine Learning and Data Science (FMLDS2025)

02-05 November, 2025 Los Angeles, CA, USA

Holiday Inn La Mirada, 14299 Firestone Blvd La Mirada, California 90638, United States

FMLDS

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Welcome to the 2025 IEEE International Conference on Future Machine Learning and Data Science (FMLDS 2025)

Professor Haiyan Qiao
University of California, USA

On behalf of the entire Organizing Committee, it is my great pleasure and distinct honor to extend the warmest of welcomes to you all - researchers, scholars, students, and industry professional, as we gather for the **2025 IEEE International Conference on Future Machine Learning and Data Science (FMLDS 2025)**.

We look forward to hosting you in the vibrant Los Angeles area of Southern California, at the Holiday Inn La Mirada - Buena Park, for four days of intensive learning and collaboration, from November 2nd through the 5th, 2025.

FMLDS continues its tradition as a gathering point for a vibrant global community dedicated to pushing the boundaries of machine learning and data science. This event is a critical opportunity to share cutting-edge breakthroughs, exchange innovative ideas, and foster the interdisciplinary collaborations that will fundamentally shape the future of intelligent systems.

This year, the global response has been truly remarkable. We received 268 full-paper submissions from 16 countries and regions. Following a rigorous peer-review process designed to uphold the highest standards of research quality, we are proud to have accepted 125 papers for presentation. These high-caliber contributions will be published in the IEEE Xplore Digital Library, ensuring they reach and influence a worldwide audience.

The Organizing Committee has curated an inspiring program designed to spark new ways of thinking and facilitate deep technical exchange. The FMLDS2025 features thought-provoking Plenary and Keynote talks from five leading experts in our field. Our program also includes four dedicated Special Sessions spanning a wide and critical spectrum of topics—from AI-driven data science and machine learning advances in biomedical and bioinformatics applications, transportation systems to the latest developments in Industry 5.0.

While the technical presentations are the backbone of this event, we emphasize that FMLDS is a vital platform to spark conversations, discover new ideas, and build lasting partnerships. We strongly encourage all attendees to engage fully with the sessions, ask challenging questions, share unique perspectives, and utilize the networking opportunities to connect with potential future collaborators.

FMLDS2025 would not be possible without the incredible dedication of many individuals. We offer our sincere thanks to our committed authors and keynote speakers, the diligent reviewers, our generous sponsors, and the invaluable support of our volunteers and the entire Organizing Committee. Your time, effort, and belief in the vision of FMLDS2025 have transformed this into a truly collaborative success.

We sincerely wish you a fruitful, inspiring, and engaging experience at FMLDS 2025. May this conference bring new insights, meaningful connections, and fresh inspiration for your future work.

The full conference agenda, including details on all events, is available at **www.fmlds.org**.

Thank you for being a part of the FMLDS community. Welcome to FMLDS 2025!

Warm Regards

Professor Haiyan Qiao
Chair
2025 IEEE International Conference on Future Machine Learning and Data Science (FMLDS 2025)

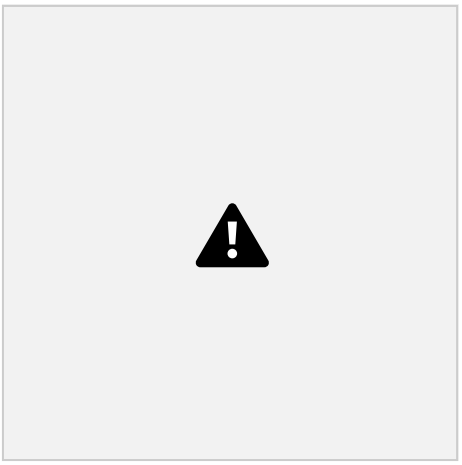
Speakers
FMLDS 2025

Advancing radiology with AI: The rise of vision-language models for report generation

Professor Essam Rashed
University of Hyogo, Japan

Abstract:
The field of radiology is undergoing a transformative shift driven by artificial intelligence, particularly with the emergence of powerful vision-language models (VLMs). As the demand for radiological services continues to rise, coupled with a global shortage of trained radiologists, the pressure to deliver accurate, timely, and consistent diagnostic reports has never been greater. This plenary talk explores how AI, especially transformer-based architectures and large vision-language models, is revolutionizing radiology report generation. By automatically interpreting medical images and generating coherent, clinically relevant text, these models hold the promise of reducing routine workload, accelerating diagnosis, and enhancing decision support for healthcare providers. We will present a comprehensive overview of key developments, showcasing advances in model design, training strategies, and evaluation frameworks. Real-world datasets and benchmarks will be discussed, along with comparative performance analysis of leading systems. The session will conclude with critical reflections on current limitations and offer forward-looking perspectives on how AI can be more deeply integrated into radiological workflows making radiology not only faster but also smarter.

What makes Cognitive Radio Networks Cognitive?



Professor Manish Wadhwa
Salem State University, USA

Abstract:

At the core of cognitive radio networks is the promise of intelligent, flexible spectrum sharing — a shift from static allocation to dynamic, need-based access. But what exactly endows a radio network with cognition? This talk explores how the cognitive aspect lies in the network's ability to observe its surroundings, interpret ongoing spectrum usage, and make independent decisions about when and how to transmit without causing harmful interference. Spectrum sharing becomes the practical expression of cognition, demanding awareness of other users, prediction of availability, and real-time coordination. We will examine how machine learning methods, from predictive modeling to multi-agent reinforcement learning, are enabling radios to negotiate spectrum access intelligently and adapt to shifting conditions. The session will also explore implementation challenges, including fairness, latency, regulatory compliance, and coexistence with legacy systems. Ultimately, this keynote seeks to answer what transforms a traditional radio into a cognitive one, and why spectrum sharing is the most visible manifestation of that transformation.

Machine Learning for Human Interaction

Professor Virginia de Sa
University of California, San Diego,, USA

Abstract:

Robust human interaction requires the ability, at least in part, to infer the thoughts and desires of others. We will discuss our recent work to improve AI automated reading of human preferences, percepts, and desired communications. We show how state-of-the-art facial expression analysis can be used to infer pain levels and preferences. We also show how we can leverage foundation models to extract realistic estimates of viewed images and decode imagined handwriting.

Publishing Your Machine Learning and Data Science Research with Elsevier

Chris Katsaropoulos
Senior Acquisitions Editor for Computer Science at Elsevier, USA

Abstract:

A brief and informative look at how to have your research on Machine Learning and Data Science published with Elsevier. Learn about new publications and areas of research interest, and how to have your work published in an Elsevier journal, or an Elsevier book. We will discuss the publishing process, along with any questions you may have about getting started.

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FMLDS2025-012

Soccer Team Valuation Using Random Forest Regression

Denilson Zetino, Yalong Wu and Pu Tian

Abstract:

Soccer is the world's most popular sport and creates memories across generations. Nonetheless, competitive imbalance persists among leagues as many teams face financial challenges. Thus, it is important for a financially unsound team to understand its market value and make informed decisions on investment through player acquisitions. In this paper, we develop a market value projection (MVP) scheme to value soccer teams holistically rather than focusing solely on individual player valuations, which may overlook league regulations and lead to penalties. Specifically, MVP utilizes random forest regression to study a team's market value on its performance metrics of goals for (GF), goals against (GA), and points (Pts) alongside transfer balance. Random forest regression can effectively capture complex relationships among variables and provide accurate holistic predictions. We have validated MVP's efficacy using data from Europe's top 5 leagues, and the findings highlight the impact of offensive performance and strategic financial investing on market value. These results provide insights to help teams manage transfer balances and strengthen their financial standing through informed decision-making, ultimately promoting financial stability and competitive balance within the sport.

FMLDS2025-033

N-DoF Teleoperational System for 4-DoF Industrial SCARA Robot Control Using Modular CAN Bus-Based Architecture

Sardar Ali

Abstract:

This research presents the development of a tele-operational system for controlling an industrial SCARA robot via a graphical user interface (GUI). The system allows users to control the robot either in joint space or tool space. The teleoperation system configuration includes a GUI application connected serially with a master controller, where the kinematics of the robot is computed through coordinate transformations. These coordinates are transmitted via a CAN bus protocol to slave controllers, each managing one of the four joints of the SCARA robot. Each joint's position is precisely controlled using a PID algorithm, ensuring synchronous movement. The system is designed to be modular and embedded, facilitating easy replacement of any damaged modules. The system achieved a positioning error of ±1.2 mm and an average response time of 12.5 ms, demonstrating its precision and real-time capability, and showcasing its effectiveness on an industrial SCARA robot.

FMLDS2025-035

PREFIL: Preference-Ranked Imitation Learning from Suboptimal Demonstrations

Ketan Anand

Abstract:

Imitation Learning (IL) techniques often rely on large-scale expert demonstrations to approximate optimal policies. However, in practical settings, collected data is frequently noisy or suboptimal, especially when aggregated from heterogeneous sources such as crowdsourcing. Existing IL approaches typically assume uniform demonstrator quality, failing to account for this heterogeneity

and leading to degraded policy performance. We propose PREFIL (Preference-Ranked Imitation Learning), a framework that leverages pairwise trajectory preferences to infer a latent reward function that ranks demonstrations by estimated quality. PREFIL introduces a task-agnostic preference-based discriminator trained via self-supervised learning to model the relative utility of trajectory segments. The inferred reward scores are then used to weight demonstrations during policy training, improving sample efficiency and robustness. We demonstrate that PREFIL enables learning effective policies from suboptimal demonstrations in both in-domain and out-of-domain settings. Empirical results on continuous control tasks from Robomimic and OpenAI Gym benchmarks show that PREFIL consistently outperforms standard behavior cloning and even achieves better-than-demonstrator performance by prioritizing high-quality trajectories based on learned preferences.

FMLDS2025-037

Evaluating Privacy and Utility of Synthetic Tabular Data with Membership Inference Attacks

Brandon Ismalej, Xiaojun Ruan and Xunfei Jiang

Abstract:

Synthetic data is widely used as a privacy-preserving alternative to real data in machine learning. It is especially important in areas with strict data protection rules, such as healthcare and finance. Among its various forms, synthetic tabular data is one of the most common, particularly for structured datasets in decision-making systems. However, the extent to which synthetic tabular data protects individual privacy while preserving utility remains unclear. In this paper, we introduce an evaluation framework for assessing privacy risks and utility tradeoffs across different synthetic data generators. This framework combines distance-based and model-based Membership Inference Attacks to assess privacy risks. It evaluates utility by training classifiers on synthetic data and testing them on real holdout sets. The framework was evaluated using three commonly used synthetic data generators: CTGAN, TVAE, and GaussianCopula on UCI Adult and Bank Marketing datasets. CTGAN achieves the highest utility among the evaluated generators but also exposes the most significant privacy vulnerabilities. Model-based membership inference attacks yield AUC scores averaging 0.52 and reaching as high as 0.56 in the most vulnerable cases. TVAE provides a balanced trade-off between privacy and utility, while GaussianCopula offers the lowest privacy risk. The findings emphasize the importance of task-specific, context-aware evaluation when selecting synthetic data generators for privacy-sensitive applications.

FMLDS2025-041

On Robustness of Vision-Language Models Under Adversarial Perturbations

Pu Tian, Yalong Wu, Sudheera Balagam, Kaushik Kona, Bhuvanya Sirigineedi, Tanmai Bhashyam, Manideep Nalumachu, Varshini Kotha and Justyn Pibil

Abstract:

Despite their success in image object classification, deep learning–based image classifiers remain vulnerable to adversarial perturbations. Conversely, adversarial training has been proven effective in retaining accuracy but incurs substantial resources for training or training with adversarial examples. Additionally, image transform-based methods have been efficient but unable to recover strong adversarial attacks, such as PGD. In this work, we empirically discover that vision-language models

can significantly improve accuracy with strong adversarial inputs (BIM, MIM, and PGD) to CNNs without retraining and other additional resource consumption. Results show that the accuracy recovers up to 87% of all adversarial images using the online Claude service. This demonstrates that integrating large language models substantially advances the robustness and practicality of semantic classification in adversarial settings, establishing a new direction for effective defense strategies against adversarial examples. To the best of our knowledge, we are the first ones to investigate the CNN adversarial examples and their robustness under vision-language models.

FMLDS2025-043

Interpretable Machine Learning for Wine Quality Prediction

Behnaz Moradijamei and Claire Jones

Abstract:

This paper addresses the inherent subjectivity in traditional wine quality assessment by developing an interpretable machine learning framework for objective quality prediction. Using the UCI Wine Quality dataset containing 6,497 samples with 11 physicochemical properties, we implement and optimize a Random Forest classifier that balances accuracy with practical interpretability. Our baseline model achieves 83.69% accuracy but exhibits limited performance in minority classes. Through Synthetic Minority Oversampling Technique (SMOTE) and hyperparameter optimization, our enhanced model (81.3% accu-racy) demonstrates substantially improved detection of underrepresented quality categories, increasing macro-average F1-score from 0.52 to 0.55. Feature importance analysis identifies alcohol content, volatile acidity, and free sulfur dioxide as the most influential quality predictors—findings consistent with oenological domain knowledge. We emphasize visual interpretability through informative visualizations and establish a reproducible pipeline suitable for real-world deployment. This framework bridges data science and practical enology, offering an objective complement to sensory evaluation that benefits producers, distributors, and
consumers in the $400 billion wine industry.

FMLDS2025-045

Policy-Driven Transfer Learning in Resource-Limited Animal Monitoring

Nisha Pilla, Aditi Virupakshaiah, Harrison W. Smith, Amanda J. Ashworth, Prasanna, Phillip R. Owens, Adam R. Rivers, Bindu Nanduri and Mahalingam Ramkumar

Abstract:

Animal health monitoring and population management are critical aspects of wildlife conservation and livestock management that increasingly rely on automated detection and tracking systems. While Unmanned Aerial Vehicle (UAV) based systems combined with computer vision offer promising solutions for non-invasive animal monitoring across challenging terrains, limited availability of labeled training data remains an obstacle in developing effective deep learning (DL) models for these applications. Transfer learning has emerged as a potential solution, allowing models trained on large datasets to be adapted for resource-limited scenarios such as those with limited data. However, the vast landscape of pre-trained neural network architectures makes it challenging to select optimal

models, particularly for researchers new to the field. In this paper, we propose a reinforcement learning (RL)-based transfer learning framework that employs an upper confidence bound (UCB) algorithm to automatically select the most suitable pre-trained model for animal detection tasks. Our approach systematically evaluates and ranks candidate models based on their performance, streamlining the model selection process. Experimental results demonstrate that our framework achieves a higher detection rate while requiring significantly less computational time compared to traditional methods.

FMLDS2025-046

Context Dropout: A Novel Method to Reduce Contextual Reliance in Object Detection

Lynn Vonderhaar, Timothy Elvira, Tyler Procko, Alexandra Davidoff and Omar Ochoa

Abstract:

Object Detection Models (ODM) commonly use the background context of images to aid in their detection process. This introduces some limitations to ODM, because accuracy peaks in the presence of a certain expected context. Ideally, ODM would rely solely on features of the class that they are detecting. However, the exact features that an ODM learns during training are not guaranteed. While predominant features will likely relate to the object in question, secondary features may relate to its scene context. This paper presents a method to alter the background features that an ODM uses for its decisions. This method, termed context dropout, uses a diffusion model to generate new training instances with contexts that would not occur in real-world datasets, effectively forcing object detectors to learn that certain context cannot be reliably used for detection. These generated samples are not meant to replace real data instances, but to supplement them to challenge the training of the model and increase the model's feature generalization. This paper presents a case study of this method on the Common Objects in COntext (COCO) dataset, where some surfboard images are supplemented with images generated by Stable Diffusion in otherwise unrepresented contexts. The attention and performance of the models trained on COCO and the modified COCO datasets are compared to analyze the success of this proposed method. This paper shows that context dropout can reduce the influence of certain scene level objects on a desired class and can also improve performance of an ODM on that class in nontraditional contexts.

FMLDS2025-051

Gold Price Trend Prediction from Candlestick Chart Images Using Multi-Time Frame Analysis and Machine Learning

Seyed Mojtaba Naghibzadeh, Mohammad Hassanzadeh, Majid Ahmadi and George P Pappas

Abstract:

Candlestick chart patterns are a cornerstone of technical analysis, offering visual cues for trend identification in financial markets. This paper introduces a novel image-based classification framework for detecting daily gold (XAU/USD) trends using a multi-time frame candlestick encoding. Specifically,

each sample comprises a 24-hour sequence of hourly candlesticks rendered as a 96×96 RGB image. The corresponding trend label—Uptrend, Downtrend, or Sideways—is determined by analyzing six overlapping 4-hour candles based on directional dominance, average body size, and overall price slope. Using this labeling logic, we generated over 100,000 labeled samples and evaluated three classification models: Random Forest with PCA, a custom 6-layer convolutional neural network (CNN), and MobileNetV2 with transfer learning. All models were trained using stratified 5-fold cross-validation, with CNN-based models enhanced by data augmentation and early stopping. In the binary classification task (Uptrend vs. Downtrend), the custom CNN achieved the highest

performance, with an F1-score of 0.9924, followed closely by MobileNetV2 and Random Forest. To assess model performance under more realistic market conditions, we extended the best CNN architecture to a 3-class setting by adding the Sideways label. While overall accuracy declined due to class
imbalance and visual ambiguity, the model still demonstrated robust trend differentiation. These results confirm that combining multi-timeframe labeling with visual encoding enables effective
and scalable financial trend classification.

FMLDS2025-052

Finding Changes in Transition Probabilities in Reinforcement Learning

Chang-Hwan Lee

Abstract:

Reinforcement learning (RL) agents typically assume stationary environment dynamics, but real-world settings often involve evolving transition probabilities or reward functions—known as model drift. This paper presents a framework for detecting such drift by analyzing distributional changes in agent behavior sequences. We introduce edit operation-based metrics to quantify deviations between trajectories under stationary and perturbed conditions. Our experiments demonstrate that these measures can effectively distinguish drifted from non-drifted scenarios, even under varying levels of noise, providing a practical and interpretable tool for drift detection in non-stationary RL environments.

FMLDS2025-054

Weather Driven Machine Learning Decision Support for Rice Cultivation Suitability in Bangladesh

Jubaer Rahman, Md. Shahjada Sajid, Feroza Naznin, Md. Julfikar Ali Md Alamgir Hossain and Md. Zahidul Islam

Abstract:

Rice (Oryza sativa) underpins food security in Bangladesh, yet its yields are highly vulnerable to daily weather fluctuations. This paper introduces a machine-learning decision-support framework that predicts daily rice-cultivation suitability using four key weather parameters: average daytime temperature (19-40 °C), average nighttime temperature (16–23 °C), daily sunshine hours (0–12 h), and daily rainfall (0–50 mm). We first generated a 10 000-sample synthetic dataset, labeled “suitable” or “unsuitable” according to agronomic thresholds for flowering (22–23 °C), grain filling (20-21 °C), and seasonal water requirements (80-180 cm). Six classifiers—Logistic Regression, SVM, k-NN, Random Forest, XGBoost, and LightGBM—were trained and benchmarked via stratified 5-fold cross-validation, with ensemble methods achieving $F_1 \geq 0.99$ and $AUC \geq 0.99$ on synthetic data. Without retraining, these models were then applied to ten years (2013–2022) of real-world weather records from Data.gov.bd, yielding $F_1 \approx 0.95$ and $AUC \approx 0.96$, which confirms robust generalization. Finally, the framework integrates real-time forecasts from the OpenWeather API to deliver daily suitability assessments and tailored agronomic recommendations—such as optimized irrigation schedules and variety selection—thereby enabling scalable, climate-smart rice farming in data-scarce environments.

FMLDS2025-062

Battery State of Charge Estimation by Machine Learning

Shan Ehsan, Mohammad Hassanzadeh, Majid Ahmadi, Ardian Kelmendi, Nabih Jaber and George Pappas

Abstract:

Accurate estimation of State of Charge (SOC) is essential for managing lithium-ion batteries used in electric vehicles and energy storage systems. This paper presents a comparative study of four different machine learning models: Multivariate Linear Regression (MLR), Random Forest (RF), Multilayer Perceptron (MLP), and Convolutional Neural Networks (CNN) for the prediction of SOC using a data set based on LG 18650HG2 cells. The prepared data set includes voltage, current, temperature and historical moving averages, sampled at 1 Hz and evaluated in a temperature range of -10◦C to 25◦C. SOC values were derived through normalized amp-hour integration accounting for polarity and nominal capacity. Each model was tested using 5-variable and 3-variable (excluding average current and voltage) input configurations. The results show that Random Forest achieved the highest accuracy in all cases, with R2 values exceeding 0.9997 and Mean Absolute Percentage Error (MAPE) below 0.40%. CNN models also performed well, particularly in capturing sequential patterns, while MLP offered a balanced performance between CNN and MLR in most scenarios, with a MAPE of 9.43%. MLR demonstrated the lowest robustness under thermal variation. The findings in this paper highlight that ensemble-based decision tree models may outperform both neural network models and traditional regression techniques for realtime SOC estimation in practical battery management systems, especially on smaller battery datasets.

FMLDS2025-063

Combining Image Transformations to Solve Unseen Time Series Classification Problems

Almiqdad Elzein and Arezoo Emadi

Abstract:

Time Series Classification (TSC) is a key problem in several domains. One of the most popular approaches for TSC is to encode time series as images and use Computer Vision (CV) models for classification. The success of this approach has led to the emergence of several image transformation functions, each offering distinct insights valuable for different classification tasks. However, the significant difference between pre-existing image transformation functions makes it challenging to determine the most suitable transformation for a given TSC task. This work combines insights from various image transformations by concatenating DL-extracted black-box features obtained from several image representations of a given time series. These features are obtained from DL models that are trained on a large family of TSC datasets that have been transformed into one of several image transformations. As a result, each model is specialized in extracting insights from image representations of a specific type. To evaluate the generalizability of these insights, unseen TSC datasets are transformed into feature vector datasets by concatenating the features extracted from several specialized models, transforming a given TSC dataset into a dataset of feature vectors. This feature vector dataset is then learned using an ensemble model, whose initial results are improved using a Genetic Algorithm (GA). The approach is evaluated on the UCR archive and compared to several existing methods. The results show that the insights gained from image representations of time series are both useful and generalizable.

FMLDS2025-064

Player Intention Prediction in Soccer/Football Using Multimodal Fusion of Visual and Pose Data

MOHAMMAD MEHEDI HASSAN

Abstract:

In soccer or football, actions and events occur every second. The problem is the complex visualization of the soccer field and dense player movements, determining a player's intention is challenging. Intentional event recognition is further complicated by unpredictable player behavior. In this research, player's four types of intentions were predicted using multimodal fusion of visual and pose data. The player actions were collected and leveled with 10 frames for each action which is demonstrating physical intention of the player. Additionally, we extracted 512-dimensional visual features per frame to capture appearance-based cues such as jersey, ball, or background, complementing the skeletal pose data. Raw video frames were processed with ResNet for feature extraction, and a BiLSTM model was used for temporal modeling to classify intentions. Pose and visual features were then fused using three multimodal fusion strategies, Early, Late and Attention fusion to improve the robustness of the learning process. The training performance graphs show a steady decrease in training loss to below 0.2 by the 10th epoch, indicating effective learning. Accuracy starts low at 25% but increases dramatically, and finally reaching 95% at the end of the training. Among the three fusion strategies evaluated, Late Fusion and Early Fusion achieved the highest accuracy (60%), while Attention Fusion slightly lagged (55%), with all methods showing challenges in classifying "shoot" and "fouls" events accurately under limited validation data. In future work, additional actions and more refined datasets will be incorporated to improve intention recognition and action prediction.

FMLDS2025-065

A New Stacking Ensemble Learning Method for Semi-supervised Anomaly Detection in Water SCADA Systems

Christopher Montoya, Trevor Smith, Ivan Hinojos, Monju Tanakajima, Patrick Duane and Jun Zheng

Abstract:

Supervisory Control and Data Acquisition (SCADA) systems are essential for the real-time monitoring and control of critical infrastructure, such as water treatment and distribution facilities. However, their reliance on networked sensors and actuators introduces significant cybersecurity risks. A successful cyberattack on SCADA-controlled infrastructure can lead to severe consequences, including service disruptions, equipment failures, environmental damage, and threats to public safety. In this paper, we propose a new semi-supervised stacking ensemble learning method for detecting anomalous events, including cyberattacks, in water SCADA systems. Traditional supervised learning methods require labeled data for both normal and anomalous events, which can be difficult to obtain in critical infrastructure environments due to the rarity and evolving nature of cyber threats. In contrast, semi-supervised anomaly detection leverages only normal data to train the detection model, making it well-suited for identifying previously unseen or unknown attacks. This capability is crucial for securing water SCADA systems, where emerging cyber threats and operational anomalies may not be represented in historical datasets. The proposed method employs a meta-learner to strategically combine the predictions of multiple diverse base learners, enhancing both accuracy and robustness. To validate the effectiveness of our approach, we conducted

evaluations using a real-world water SCADA dataset. Experimental results demonstrate that the proposed method significantly outperforms baseline semi-supervised anomaly detection models, including the individual base learners and the meta-learner used in our ensemble model.

FMLDS2025-066

Spectral Graph Filtering for Long-Term Multivariate Time Series Forecasting

Zongyao Feng and Konstantin Markov

Abstract:

Long-term multivariate time series forecasting requires modeling complex spatiotemporal dependencies, yet existing approaches tend to focus on addressing the problem from the temporal perspective using channel-independent modeling, with few works exploring effective spatial modeling for long-term horizons. While recent methods use attention mechanisms to capture spatial interactions, they suffer from producing diffuse patterns when the number of variables increases. We propose a spectral graph filtering approach that transforms learned attention weights into graph Laplacians, enabling frequency-aware spatial modeling through Chebyshev polynomial approximations. This design treats the multivariate time series as signals over a graph, allowing the model to adaptively learn spatial patterns most critical for long-term forecasting through learnable spectral filters. Our method first projects temporal sequences into a latent space, computes attention-based adjacency matrices, then applies multi-scale spectral filtering to extract predictive spatial patterns. Experiments on three benchmarks, Electricity, Solar and Weather, demonstrate consistent improvements over the representative baselines, validate that frequency-domain spatial modeling offers a principled and scalable alternative to conventional attention mechanisms for long-term multivariate forecasting.

FMLDS2025-067

Adaptive Gradient-Based Weighting in Physics-Informed Neural Networks for Two-Phase Deep-Water Wave Propagation

Peng Shu Ng, Elisa Ang, Peng Cheng Wang and Teng Yong Ng

Abstract:

This study presents an adaptive scheme for dynamically weighting loss components to improve the training of Physics-Informed Neural Networks (PINNs) in modeling two-phase deep-water wave dynamics. The proposed scheme dynamically balances multiple loss terms by evaluating the gradient norm of each term, which reflects its influence on the optimization process. To reduce computational time, two hyperparameters are introduced to control the frequency of weight updates. The performance of the full PINN model is compared against a baseline model without the weighting scheme. Results demonstrate that the adaptive scheme leads to improved convergence and significantly more accurate predictions across all predicted fields with a minimal increase in computational time.

FMLDS2025-068

Machine Learning-Based Aggregation of Contributing Factors Influencing Traffic Safety at Rural Intersections

Senkondo, Erickson, Chimba, Deo, Madalo, Masanja; Blue, Shala

Abstract:

This study investigates injury severity at rural intersections using machine learning-based classification models applied to crash data obtained from Tennessee's Enhanced Roadway Information Management System (ETRIMS). Injury severity was categorized into three levels: Property Damage Only, Possible Injury & Suspected Minor Injury, and Suspected Serious Injury & Fatal. Multiple supervised machine learning models were developed, including Gradient Boosting, Categorical Boost, Decision Tree, Support Vector Machine, and Multi-Layer Perceptron. Class imbalance was addressed using Synthetic Minority Over-sampling Technique (SMOTE). Among all models, gradient Boost demonstrated superior performance, achieving an overall classification accuracy of 66.78% and a macro F1-score of 0.37. SHAP analysis was employed to interpret the contribution of individual features across severity classes. The results consistently identified AADT, DHV, percentage of trucks, manner of collision, weather conditions, and land use as dominant predictors influencing injury severity. Specifically for Class 2 Serious and Fatal injuries, elevated traffic volumes, adverse weather conditions, and head-on or angle collisions were strongly associated with higher severity outcomes. These findings highlight the importance of traffic volume management, truck regulation, intersection geometric improvements, and weather-responsive control strategies in mitigating severe crash consequences at rural intersections. Future work should focus on integrating larger datasets, additional roadway geometric features, hybrid machine learning architectures, and cost-sensitive optimization to improve model sensitivity toward rare but critical injury severity classes.

FMLDS2025-070

LSTM Based Deep Learning for Delay Prediction at Railroad Highway Grade Crossings Using Synthetic Data

Madalo, Masanja, Chimba, Deo; Matongo, Therezia; Blue, Shala

Abstract:

Railroad-highway grade crossings (RHGCs) are critical intersections where rail and road networks converge, frequently causing traffic delays and safety concerns. Accurate real-time prediction of vehicle waiting times at RHGCs is essential for effective traffic management, congestion reduction, and enhanced public safety. This study develops a sequence-aware deep learning framework using Long Short-Term Memory (LSTM) networks to model temporal dependencies in traffic dynamics and signal transitions. To overcome the scarcity of labeled real-world data, we generated comprehensive synthetic datasets using the Simulation of Urban Mobility (SUMO) platform, incorporating key features like vehicle speed, distance to crossing, time, traffic signal state, and vehicle type. Our proposed LSTM architecture features two stacked layers (128 and 64 units) with dropout regularization, optimized using the Adam algorithm with early stopping. When evaluated against XGBoost, Gradient Boosting, and Random Forest models using MAE, MSE, and R^2 metrics, the LSTM demonstrated superior performance (MAE = 4.44 sec, MSE = 31.11, R^2 = 0.9992). SHapley Additive exPlanations (SHAP) analysis revealed time, vehicle identity, and distance to crossing as the most influential predictors in tree-based models. These findings validate LSTM's effectiveness with synthetic data for scalable, interpretable delay prediction at RHGCs. Future research will focus on integrating live sensor data and exploring attention-based architectures to further enhance predictive capabilities.

FMLDS2025-071

Time Optimization for Traffic Signal Control Using Genetic Algorithm with Machine Learning Enhancement

Jeannine Mbabazi, Deo Chimba, Erickson Senkondo and Afia Yeboah

Abstract:

This study presents an integrated framework for optimizing urban traffic signal control using a hybrid Genetic Algorithm (GA) and Machine Learning (ML) approach. The methodology involves modeling existing traffic conditions using VISSIM microsimulation software and evaluating key performance metrics such as travel time, vehicle delay, queue length, emissions, and fuel consumption. Initial optimization using GA significantly reduced congestion and environmental impacts by adjusting signal timings. To enhance adaptability, K-means clustering was employed on historical turning movement data to capture temporal traffic patterns based on time-of-day, day-of-week, and vehicle composition. Customized GA-based signal plans were generated for each cluster, resulting in further performance improvements. Comparative analysis demonstrated that the ML-enhanced GA approach outperformed both existing fixed-time control and traditional GA only optimization. Beyond mobility, this study frames signal control as an AI-assisted safety and sustainability problem by incorporating emissions measures and crash-context variables during modeling. The ML module (K-means) detects time-of-day traffic regimes and assigns a customized GA plan per regime. The results support the potential of combining data-driven ML techniques with evolutionary algorithms to achieve intelligent and context-aware traffic signal management in metropolitan settings.

FMLDS2025-072

Last-Mile Route Optimization Using Genetic Algorithm, Integer Programming, and Machine Learning-Based Clustering and Cost Estimation Models

Yeboah, Afia; Chimba, Deo; Mbabazi, Jeannine; Bist, Sandeep

Abstract:

This study proposes a hybrid framework for optimizing last-mile delivery routes that combines Genetic Algorithm (GA), Integer Programming (IP), and machine learning (ML)-based clustering and cost estimation. Real-world delivery data from Nashville was clustered using K-Means to form spatially coherent zones, enabling localized optimization. GA had higher scalability, although IP consistently delivered more accurate and shorter routes. A Random Forest regression model was used to estimate travel time, minimizing the need for external APIs and increasing operational flexibility. The results highlight the complementary strengths of GA and IP and validate the role of ML in route planning. This framework provides a scalable, data-driven approach that logistics operations in similar urban contexts may use.

FMLDS2025-073

Deep Learning for Taxol Exposure Analysis: A New Cell Image Dataset and Attention-Based Baseline Model

Sean Fletcher, Gabby Scott, Douglas Currie, Xin Zhang, Yuqi Song and Bruce MacLeod

Abstract:

Monitoring the effects of the chemotherapeutic agent Taxol at the cellular level is critical for both clinical evaluation and biomedical research. However, existing detection methods require specialized

equipment, skilled personnel, and extensive sample preparation, making them expensive, labor-intensive, and unsuitable for high-throughput or real-time analysis. Deep learning approaches have shown great promise in medical and biological image analysis, enabling automated, high-throughput assessment of cellular morphology. Yet, no publicly available dataset currently exists for automated morphological analysis of cellular responses to Taxol exposure. To address this gap, we introduce a new microscopy image dataset capturing C6 glioma cells treated with varying concentrations of Taxol. To provide an effective solution for Taxol concentration classification and establish a benchmark for future studies on this dataset, we propose a baseline model named ResAttention-KNN, which combines a ResNet-50 with Convolutional Block Attention Modules and uses a k-Nearest Neighbors classifier in the learned embedding space. This model integrates attention-based refinement and non-parametric classification to enhance robustness and interoperability. Both the dataset and implementation are publicly released to support reproducibility and facilitate future research in vision-based biomedical analysis.

FMLDS2025-074

Towards a Universal Model for Denoising Computed Tomography via Iterative Fine-Tuning

Austin Yunker, Peter Kenesei, Andrew Chuang, Hemant Sharma, Jun-Sang Park, Antonino Miceli and Rajkumar Kettimuthu

Abstract:

Computed tomography (CT) is an essential imaging technique that utilizes x-ray measurements taken from different angles of the object allowing for detailed investigations into the internal structure of the material. During the experimental setup, factors can arise that corrupt the produced images with varying levels of background noise. Methods for denoising have been extensively studied with recent approaches favoring deep learning-based methods due to their superior performance. However, a limitation of these methods is their poor generalizability. At synchrotron based light source facilities, researchers regularly bring distinct samples to perform specific investigations. Therefore, models unable to generalize to new samples must be trained from scratch for each use case potentially slowing down the CT workflow. In this work, we take the first step towards developing a universal model for denoising CT data by iteratively fine-tuning models on new samples. To ensure models don't suffer from catastrophic forgetting, we incorporate knowledge distillation using a student-teacher framework. We evaluate our approach on a simulated CT dataset showing an improvement of 24.64\% and 62.56\% in the SSIM and PSNR, respectively, on past data when using knowledge distillation. When applied to real-world experimental datasets, our method shows a substantial improvement in recovered visual features.

FMLDS2025-075

RBD-Net: Enhancing Binocular Depth Accuracy with Robust Multi-Scale Neural Networks

Xin Zhang and Yuqi Song

Abstract:

Depth estimation is critical for applications such as autonomous driving and robotics, enabling these systems to perceive and interact with their environments effectively. Binocular depth estimation, which utilizes stereo image pairs to derive depth information, is a popular approach due to its potential for accuracy. However, the performance of existing methods is highly dependent on ideal conditions, focusing predominantly on scenarios involving perfectly aligned devices and optimal imaging conditions. These methods often fail to address real-world challenges like variable lighting, camera misalignments, and environmental noise, limiting their practical utility in non-ideal or dynamic settings. To address these limitations, this paper introduces RBD-Net (Robust Binocular

Depth-Net), a sophisticated convolutional neural network designed to robustly estimate depth from stereo images under diverse and challenging conditions. RBD-Net integrates a noise-reduction module that proactively mitigates the impact of noise and disturbances, thereby enhancing the reliability of depth predictions. The model employs a multi-scale approach to capture detailed depth features across various resolutions and incorporates a novel loss function tailored to improve precision and robustness in varying environments. Extensive testing on the KITTI 2015 and KITTI 2012 datasets demonstrates that RBD-Net not only maintains but also significantly enhances the robustness and accuracy of depth estimations compared to existing methods. Our findings confirm RBD-Net's superior performance, establishing it as a formidable tool for achieving high-fidelity depth perception across a broad range of operational scenarios, making it highly suitable for advanced computer vision applications where environmental adaptability and accuracy are paramount.

FMLDS2025-077

From Naive to Advanced: Enhancing Question Answering with Retrieval-Augmented Generation

Junaid Syed

Abstract:

Natural Language Processing (NLP) has been transformed by the advent of Large Language Models (LLMs), yet they continue to face challenges such as factual inaccuracies and "hallucinations." Retrieval-Augmented Generation (RAG) has emerged as a powerful paradigm to mitigate these issues by grounding LLMs in external knowledge. However, standard or "Naive" RAG implementations often suffer from limitations in retrieval precision and contextual coherence. This paper presents a systematic analysis of RAG systems by designing, implementing, and empirically comparing two primary frameworks: a baseline Naive RAG and an enhanced Advanced RAG. Our Advanced RAG incorporates sophisticated pre-retrieval (query rewriting) and post-retrieval (reranking) stages to enhance performance. To evaluate these frameworks in a practical, domain-specific context, we constructed a novel knowledge base from the Georgia Institute of Technology's public web data and benchmarked them using the RAGAS framework for a multi-faceted evaluation. Our results demonstrate that the Advanced RAG model significantly outperforms the Naive RAG, achieving an \textbf{18.07\% improvement in Answer Correctness} and an \textbf{11.43\% increase in Context Recall}. This study underscores the critical role of refined retrieval and reranking pipelines in developing robust, accurate, and context-aware RAG systems for real-world applications.

FMLDS2025-078

Ease and Equity of Point of Interest Accessibility via Public Transit in the U.S.

Junaid Syed

Abstract:

Equitable access to essential Points of Interest (POIs) such as healthcare facilities and grocery stores via public transit is a critical urban planning challenge. This paper introduces an interactive tool that analyzes the ease and equity of such access in major U.S. cities. Using a 2-step floating catchment area (2SFCA) approach, we calculate granular accessibility indices and present them on an interactive, web-based platform. A key contribution of this work is a scenario analysis feature that allows users to simulate the impact of adding or removing POIs and visualize the resulting changes in accessibility equity. Our analysis reveals significant disparities across demographic groups, and we further utilize machine learning models to demonstrate a strong, quantifiable link between accessibility scores and neighborhood racial composition, highlighting systemic inequities. The tool

provides a practical framework for policymakers to make more informed and equitable infrastructure decisions.

FMLDS2025-079

An Enhanced Lightweight Model for Real-time Pavement Condition Index Prediction

Anthony Dontoh, Armstrong Aboah, Logan Sirbaugh, Andrews Danyo, Stephanie Ivey, Blessing Agyei Kyem and Jude Dontoh

Abstract:

This study proposes a lightweight, attention-enhanced deep learning framework for real-time Pavement Condition Index (PCI) prediction from pavement imagery. The model integrates a Convolutional Block Attention Module (CBAM) into an EfficientNet-B0 backbone to enhance feature representation without significantly increasing computational cost. Extensive experiments conducted on a publicly available urban pavement dataset demonstrate that the proposed EfficientNet-B0 + CBAM architecture outperforms seven standard CNN baselines, achieving a test MAE of 9.102 and an R^2 of 0.738. Statistical analysis confirms that these improvements are significant. The model maintains a compact size and inference efficiency, making it suitable for deployment on edge devices and UAVs. Future work will assess the model's reliability at PCI class boundaries and reframe PCI prediction as a classification task to better align with transportation agency decision-making practices.

FMLDS2025-081

Predicting Music Origin with Deep Learning

Fruzsina Ladanyi and Haiyan Qiao

Abstract:

This study explores the use of deep learning to predict the geographic origin of music based on audio features. Mel-frequency cepstral coefficients (MFCCs) were extracted to capture acoustic information, while language was identified using OpenAI's Whisper model to provide additional contextual signals. A late fusion neural network architecture combining Long Short-Term Memory (LSTM) layers for sequential MFCC input and dense layers for non-sequential language features were employed to support both classification and regression tasks. The classification model achieved an accuracy of 33.03% across 56 countries and territories, substantially outperforming the random baseline (1.79%). The regression model produced a Mean Great-Circle Error (MGCE) of 2,754.83 km. While regression offers more flexibility for geographic estimation, classification demonstrated a more promising performance with the current dataset. This work highlights the potential of multimodal learning in music-origin prediction.

FMLDS2025-083

IMPLEMENTATION OF DEEP REINFORCEMENT LEARNING BASED AUTONOMOUS DRIVING AGENTS

Radhakrishnan Nagaratnam, Rathnakannan K and Aashique K S M

Abstract:

Road safety is a global concern impacting millions of individuals. Governments, industry leaders, and researchers are actively collaborating to enhance same through various techniques, and

technologies. Among them Advanced Driver Assistance Systems (ADAS), Autonomous Driving Systems (ADSs), and Connected Vehicle Technologies (CVT) are promising candidates with the potential to mitigate accident risks and improve overall road safety. Autonomous driving is still emerging and needs to address potential challenges which includes maneuvering over the curves. This paper describes the process of design and implementation of an autonomous driving agent based on deep reinforcement learning techniques to boost safety within the realm of autonomous driving. The agent is developed and tested in CARLA simulator, aiming to address the challenges associated with reliability of ADSs. The results show a clear improvement over the average deviation from the centre of the road and distance covered. Maneuvering over the curves is effectively handled by the proposed system and keeps the car to stay on the road rather than going off-road.

FMLDS2025-084

Bayesian Belief Networks for Predicting Ecosystem Collapse Using Climate and Satellite Data

Hrithvi Salian

Abstract:

The rapid expansion of Internet of Things (IoT) devices in modern microgrids presents both a transformative opportunity and a complex energy management challenge. This paper proposes a novel AI-driven energy optimization framework utilizing Federated Reinforcement Learning (FRL) to enhance energy efficiency while preserving data privacy. Unlike traditional centralized learning models, the federated approach allows distributed IoT nodes to collaboratively learn optimal energy policies without sharing raw data, addressing critical privacy and communication bottlenecks. We design a reward-driven multi-agent FRL architecture capable of real-time energy forecasting, adaptive load balancing, and renewable integration across diverse microgrid environments. Simulations conducted on standard microgrid datasets demonstrate significant improvements in convergence speed, energy savings, and fault resilience. This decentralized, privacy-preserving method opens new avenues for secure, intelligent, and scalable microgrid operations. The proposed approach is particularly relevant for smart city infrastructure, remote energy systems, and sustainable urban planning.

FMLDS2025-085

Low-Cost Sensor Fusion Framework for Organic Substance Classification and Quality Control Using Classification Methods

Borhan Uddin Chowdhury, Damian Valles and MD Raf E Ul Shougat

Abstract:

We present a sensor-fusion framework for rapid, non-destructive classification and quality control of organic substances, built on a standard Arduino Mega 2560 microcontroller platform equipped with three commercial environmental and gas sensors. All data used in this study were generated in-house: sensor outputs for ten distinct classes—including fresh and expired samples of apple juice, onion, garlic, and ginger, as well as cinnamon and cardamom—were systematically collected and labeled using this hardware setup, resulting in a unique, application-specific dataset. Correlation analysis was employed as part of the preprocessing pipeline for feature selection. After preprocessing and dimensionality reduction (PCA/LDA), multiple supervised learning models—including Support Vector Machine (SVM), Decision Tree (DT), and Random Forest (RF), each with hyperparameter tuning, as well as an Artificial Neural Network (ANN) and an ensemble voting classifier—were trained and cross-validated on the collected dataset. The best-performing models, including tuned Random Forest, ensemble, and ANN, achieved test accuracies in the 93–94% range.

These results demonstrate that low-cost, multisensory platforms based on the Arduino Mega 2560, combined with advanced machine learning and correlation-driven feature engineering, enable reliable identification and quality control of organic compounds.

FMLDS2025-087

An Integrated Transformer Learning Based Framework for Multi-Stage Feature Optimization in Naval Intention Detection

Md Azizul Hakim, Monica Nicolescu and Mircea Nicolescu

Abstract:

To enhance naval security systems, accurate detection of intentions in naval domain plays a vital role. A set of important predictive features can strengthen the strategy of decision making and reduce the likelihood of possible incidents. In this paper, we present a transformer learning based multi- stage feature optimization framework that enables multi-class classification of seven different behaviors in the naval environment to minimize potential threats. Our framework involves several key steps: first, important features are identified based on a machine learning technique; second we introduce a multi-headed transformer learning based deep neural network to extract the optimal subset of features; and finally the intentions are predicted by using a fully connected multi-class feedforward network. The experimental results demonstrate that our proposed model can effectively classify the seven different naval intentions with an overall accuracy of 96%, which outperforms baseline deep learning models such as fully connected deep neural network and LSTM

FMLDS2025-088

Emotion Recognition in Children Using Lightweight Deep Learning Model for Mobile Applications

Hafiz Arslan Ramzan

Abstract:

This study presents a lightweight deep learning framework for real-time facial emotion recognition (FER) in children aged 4 to 12, targeting mobile health and AI-assisted e-therapy applications. Traditional FER systems are often trained on adult datasets and require high computational resources, making them unsuitable for real-time mobile applications or for accurately interpreting children's nuanced emotional expressions. To address this gap, a custom child-specific dataset was curated by filtering and aggregating images from FER-2013, CK+, JAFFE, and AffectNet. The dataset focuses on four primary emotions, Happy, Sad, Neutral, and Angry, and is pre-processed using augmentation and grayscale normalization to improve robustness. A compact Convolutional Neural Network
(CNN) was designed and trained on this dataset, achieving 94.90% training and 88.12% validation accuracy. The model was then integrated into a mobile application with a FastAPI backend and Firebase storage for real-time image capture, classification, and reporting. This system enables psychologists and caregivers to remotely monitor children's emotional states in natural environments, offering a significant step forward in AI-driven, context-aware emotional health monitoring.

FMLDS2025-092

Deep Learning Models for Speech Dereverberation: Dual-Label LSTMs Compared with Transformers

Hao Zhang

Abstract:

In this paper, we present a reverberation removal approach for speaker verification, utilizing dual-label deep neural networks (DNNs). The networks perform feature mapping between the spectral features of reverberant and clean speech. Long short term memory recurrent neural networks (LSTMs) are trained to map corrupted Mel Filterbank (MFB) features to two sets of labels: i) the clean MFB features, and ii) one-hot vector representing speaker ID, estimated clean pitch tracks, or the fast Fourier transform (FFT) clean spectrogram. The performance of reverberation removal is evaluated by equal error rates (EERs) of speaker verification experiments. To contextualize our approach's performance, we also conducted preliminary comparison with SepFormer, a transformer model for speech reverberation removal, using the pre-trained model on WHAMR! dataset made available by its original authors.

FMLDS2025-093

Online Class Incremental Learning of Acoustic Events Using Acoustic Pre-trained Models

Yao Houkpati and Darsana Josyula

Abstract:

Performance of machine learning models trained in static settings degrades when they are confronted with unseen classes. In real-word scenarios, data is most often non-stationary and unavailable at once, prompting the development of Machine Learning (ML) algorithms - mostly DNN-based - that can learn incrementally and adapt to new data as it becomes available. However, many still suffer from catastrophic forgetting while learning new classes. To mitigate this, various Class-Incremental Learning (CIL) techniques have emerged, particularly in computer vision. Recently, Pre-Trained models (PTMs), known for their transfer learning capabilities, are increasingly used in CIL. In the acoustic domain, vision-based PTMs are commonly adapted, while acoustic PTMs remain underused despite their strong performance in acoustic classification tasks. Additionally, online versions of many of the traditional ML algorithms have been developed, yet their role in CIL is less explored. This study evaluates seven acoustic PTMs with four online ML algorithms on ESC-10, ESC-50, and UrbanSound8K datasets. Results show that, with strong PTMs, even simple classifiers like online Naive Bayes can outperform state-of-the-art methods in acoustic CIL.

FMLDS2025-097

Towards Fair User Modeling with Survey Guided Learning

Aman Shukla, Daniel Scantlebury and Rishabh Kumar

Abstract:

User behavior modeling critically relies on diverse data, yet direct survey responses, despite their semantic clarity, often suffer from sparsity and incomplete coverage. Integrating external contextual signals, while improving predictive performance, introduces complexities regarding data quality, distribution biases, and fairness. This paper presents LANTERN (Late-Attentive Network for Enriched Response Modeling), a novel neural architecture designed for multilabel user behavior prediction in survey-centric applications. LANTERN employs late gated cross-attention mechanisms to selectively fuse sparse survey embeddings with heterogeneous contextual features, aiming to enrich predictions while anchoring the model's primary signal in interpretable survey data. Empirical evaluation demonstrates that LANTERN outperforms strong survey-only and context-only baselines in predicting multilabel survey responses, achieving significant recall improvements. A key practical component is a postprocessing threshold calibration pipeline that ensures logical consistency of predictions across different survey response types, dramatically reducing illogical outputs with minimal impact on predictive metrics. Critically, we conduct a rigorous audit-style fairness evaluation using both loss-based diagnostics and outcome-based classification metrics. Our analysis reveals that disparities are primarily correlated with data representation imbalances and label coverage within subgroups

rather than architectural bias, underscoring the systemic nature of fairness challenges in behavioral modeling. This work offers a practical framework for integrating diverse user signals and highlights the essential role of comprehensive fairness diagnostics in the development of responsible behavior prediction systems.

FMLDS2025-100

Mitigating Congestion with Physics-Informed Neural Networks and Adaptive Traffic Signal Control

Ntemi Masanja, Abdul Ngereza, Tumaini Sakaza, Philip Balyagati and Emmanuel Kidando

Abstract:

Traffic congestion and delays at signalized intersections remain a challenge in urban mobility. To minimize congestion, adaptive traffic signal control systems have been adopted across the United States. However, for these systems to function at their best, systems require an accurate estimation of traffic states, such as traffic density and queue length. This paper implements a relatively novel method, Physics-Informed Neural Networks (PINNs), for real-time traffic density estimation to enhance adaptive intersection signal control. The methodology leverages PINNs, which integrate both data-driven learning and physical constraints imposed by the Lighthill-Whitham-Richards (LWR) macroscopic traffic flow model. A simulation of a four-way intersection was used to generate realistic spatio-temporal traffic

data to evaluate the performance of the model. Separate PINNs models, one trained for each incoming approach using simulation-based spatio-temporal density data, provide segment-level density predictions. These real-time density estimates are then employed within an adaptive traffic signal control algorithm designed to adjust green light phasing based on detected demand. The propos *PINNs control strategy was evaluated through simulation, comparing its performance against the* Webster traffic timing method using key metrics such as average vehicle delay at the intersection and average vehicle travel time. The findings show an approximate 18% decrease in average vehicle delay and more than a 6% reduction in average travel time when utilizing adaptive traffic control based on the PINNs method for determining density values. These findings highlight the potential of leveraging PINNs for accurate, real-time traffic state estimation, which can effectively inform and improve the performance of adaptive traffic signal control systems, leading to reduced congestion and enhanced mobility at intersections.

FMLDS2025-102

Predicting Likelihood of Multiple Secondary Crashes Using Ordinal Neural Networks

Ngereza, Abdul; Kidando, Emmanuel; Bikuba, Caroline; Kitali, Angela ; Kutela, Boniphace*

Abstract:

A secondary crash involves a crash that is a result of a primary crash and plays a great role in injury severity and traffic operations on the roadways. It is estimated that secondary crashes are likely to be 3 to 3.5 times more severe than primary crashes and take more time to clear. While previous studies have focused on single secondary crashes or did not distinguish between single and multiple secondary crashes, the impact of multiple secondary crashes is hypothesized to be severe, thus understanding and distinguishing between the two would benefit traffic operators. Therefore, this study introduces the use of Ordinal Neural Networks (ONN) in predicting multiple secondary crash occurrences which accounts for the ordinal nature of the severity of the crashes and compares its accuracy with the traditional multiclass neural network (MNN). The MNN and ONN models were fitted with similar architecture (i.e., number of neurons and hidden layers) to facilitate accurate comparison performance measures such as balanced accuracy, and confusion matrix were used in

the analysis. The ONN model has demonstrated high performance in predicting multiple secondary incidents compared to MNN, and this can be used for proactive measures to minimize the occurrence and impact of secondary crashes.

FMLDS2025-104

Minimizing Toponym Ambiguity in Geocoding Tweets by Predicting Common Ground

Sunshin Lee, Mohamed Farag, Yingyuan Yang and Goutham Alavalapati

Abstract:

Over 11 billion tweets about disasters and emergencies have been collected using more than 500 keywords, phrases, mentions, and hashtags. Yet most tweets lack precise geolocation, which is critical for situational awareness and emergency response. Tweets are often brief, omit geospatial named entities (geonames), or include ambiguous ones (e.g., “Washington” can denote over 90 U.S. places). This problem is compounded by the absence of shared knowledge or “common ground,” such as country or state context, that is typically unstated in casual communication.

We propose an approach that infers this missing context by combining geonames with location-indicative words (LIWs). Using Stanford NER and regular expressions, we extract candidate geonames and LIWs, then apply machine learning models to predict implicit state-level common ground.

To evaluate, we created two types of datasets from five collections of roadside emergency tweets (water main breaks, sinkholes, potholes, car crashes, and accidents). The first dataset was automatically geocoded with the Google Geocoding API to identify effective LIWs as features. The second was manually annotated to test classifiers trained on geonames and LIWs together.

Performance was measured with ROC and AUROC metrics. In the first experiment, person names used alongside geonames produced the largest gains, with AUROC improvements up to +0.1939 for Texas car accident tweets, while only 3.3 of cases declined slightly. In the second, classifiers using both geonames and LIWs significantly outperformed geonames alone, achieving AUROC up to 0.9090 ($p = 0.00001$), demonstrating statistically significant improvements in reducing location ambiguity.

FMLDS2025-105

Machine Learning Using Interpretable Indicators of Trust for Industrial Internet of Things Security

Jeffrey Yu

Abstract:

This paper introduces a machine learning-based security architecture that applies interpretable digital trust concepts to guide feature selection for threat detection (binary classification) and threat family identification (multiclass classification). The proposed approach selects two reduced dimension classification model feature sets (core and focused) from NetFlow network traffic metadata that already exist within an enterprise. A comparative study using the core trust feature set demonstrates high cyberattack intrusion detection rates of over 99% using multiple types of tree-based, gradient descent boosted tree, and deep machine learning classifier models, when evaluated against a large scale public dataset of heterogenous information technology, operational technology, and Industrial Internet of Things network traffic. The focused trust feature set shows comparably strong performance with a smaller computational footprint that is suitable for low resource environments.

FMLDS2025-107

An Aperture-Based Spatiotemporal Metric for Mobility Intelligence

Mahdi Zarif, Jan Eric Martins-Simonsen and Jason O. Hallstrom

Abstract:

In this recently initiated research, we introduce an aperture-based spatiotemporal metric that uncovers pedestrian mobility patterns at varying spatial scales by tuning a decay parameter σ. Applied to Wi-Fi sensor data from downtown West Palm Beach, Florida, our method reveals both localized and city-scale behavioral linkages. At narrow apertures (e.g., σ = 25), the metric emphasizes block-level correlations, suitable for targeted safety and infrastructure improvements. As σ increases (e.g., σ = 400), the metric exposes broad, synchronous pedestrian trends across functionally similar but geographically distant areas. This capability enables planners to identify latent mobility corridors, coordinate cross-district policies, and inform congestion mitigation strategies. Our analysis demonstrates how temporal similarity, when disentangled from strict spatial proximity, can serve as a powerful lens for mobility intelligence in dense urban environments.

FMLDS2025-108

Leveraging LLMs for Recipe Generation: Knowledge Distillation with GPT-2, BART, T5, and LoRA Fine-Tuning

Nazmus Sakib, Mohammad Anwar Hosen and Nirjhar Gope

Automatic recipe generation transforms ingredient lists into coherent and logically sequenced cooking instructions—a task that challenges even state-of-the-art language models due to redundancy, inconsistency, and fluency issues. This study proposes an efficient and scalable recipe generation framework using fine-tuned large language models (T5-base, BART, GPT-2) combined with Low-Rank Adaptation (LoRA) and knowledge distillation. To mitigate data scarcity and enhance diversity, a clustering-based downsampling approach was applied to extract 1,000 high-quality samples from a large-scale recipe dataset, followed by systematic preprocessing and refinement using a teacher model. Experimental results demonstrate that BART outperforms in ROUGE metrics, reflecting superior structure and fidelity, while T5 achieves the highest BLEU score, indicating more fluent and semantically rich instructions. The integration of LoRA allowed for parameter-efficient fine-tuning, enabling high performance under limited computational resources. Compared to baseline models, the proposed framework yields significantly more coherent, diverse, and instructionally relevant recipes, establishing a robust foundation for scalable, real-world AI-driven culinary applications.

FMLDS2025-111

TIOLI-GAN with Wasserstein-1 Distance and Adaptive Gradient Penalty

Tetsuya Saito

Abstract:

Generative Adversarial Networks (GANs) are widely used for distribution learning but often suffer from instability, mode collapse, and poor convergence. Wasserstein GANs (WGANs) address these issues by employing the Wasserstein-1 distance as a smoother alternative to the Jensen–Shannon divergence. However, enforcing the 1-Lipschitz condition required for theoretical guarantees remains a challenge, typically managed through fixed-gradient penalties that may limit flexibility. TIOLI-GAN, based on a take-it-or-leave-it bargaining mechanism, introduces structured adversarial interactions grounded in game-theoretic principles and social welfare maximization. This paper extends TIOLI-GAN to the Wasserstein setting, formulating TIOLI-WGAN and introducing a novel adaptive gradient penalty derived from constrained optimization. The penalty adjusts dynamically according to learning dynamics, enforcing Lipschitz conditions without over-regularization. This leads to

improved training stability and support coverage. The proposed model is evaluated on Gaussian mixtures and 2D/3D Swiss-roll distributions, where it outperforms baseline methods in convergence speed and distributional accuracy. Furthermore, a 4D Klein bottle is used as a benchmark to test the method's ability to capture nontrivial topological structure. Both visual and quantitative analyses demonstrate that TIOLI-WGAN preserves geometric fidelity and topological correctness more effectively than standard alternatives. These results highlight the potential of game-theoretic adversarial training with adaptive regulation for the advancement of generative modeling. The proposed framework provides a principled approach for learning complex distributions and offers a foundation for future extensions to high-dimensional topological manifold learning.

FMLDS2025-112

Identifying Proposers' Behavioral Patterns in Human-AI Economic Interactions

Debanjan Borthakur, Hamdaan Ahmad and Jason Plaks

Abstract:
Understanding how humans adapt their decision-making in economic interactions with artificial intelligence (AI) is essential for building socially attuned AI agents. In this study, we analyzed human proposers' behavior in the Ultimatum Game (UG) using interpretable behavioral features and supervised machine learning models to classify strategic proposer types (Fair, Selfish, Learner, Tit-for-Tat). Using data from human–human and human–AI interactions in a UG experiment, we uncover context-sensitive patterns in proposer behavior. The analyses revealed that machine learning models—especially Random Forest (RF) and Neural Network (NN) can reliably identify behavioral strategy types with high accuracy across both interaction contexts. Classification was slightly more stable in the human condition, though the strongest models also generalized well to AI interactions. In contrast, simpler models such as Logistic Regression (LR) and Support Vector Machine (SVM) showed reduced performance in the AI condition, suggesting greater variability in human behavior when interacting with artificial agents. These findings suggest that while strategic behavior remains recognizable, collaboration with AI partners introduces greater variability, potentially due to expectancy violations or ambiguous fairness norms. Outcomes in human–AI interactions appear to depend on whether the context is cooperative (e.g., fair or tit-for-tat strategies) or competitive (e.g., exploitative or self-maximizing behavior). These insights can inform AI design, particularly when it comes to developing systems that interact more equitably and ethically with humans.

FMLDS2025-113

Evaluating LLM Reasoning for Suicide Screening with the Columbia-Suicide Severity Rating Scale

Avinash Patil

Abstract:
Suicide prevention remains a critical public health challenge. While online platforms such as Reddit's r/SuicideWatch have historically provided spaces for individuals to express suicidal thoughts and seek community support, the advent of large language models (LLMs) introduces a new
paradigm—where individuals may begin disclosing ideation to AI systems instead of humans. This study evaluates the capability of LLMs to perform automated suicide risk assessment using the Columbia-Suicide Severity Rating Scale (C-SSRS). We assess the zero-shot performance of six models—including Claude, GPT, Mistral, and LLaMA—in classifying posts across a 7- point severity scale (Levels 0–6). Results indicate that Claude and GPT closely align with human annotations, while Mistral
achieves the lowest ordinal prediction error. Most models exhibit ordinal sensitivity, with misclassifications typically occurring between adjacent severity levels. We further analyze confusion
patterns, misclassification sources, and ethical considerations, underscoring the importance of

human oversight, transparency, and cautious deployment. Full code and supplementary materials are available at https://github.com/av9ash/llm cssrs code. Index Terms—Suicide risk assessment, Large Language Models, C-SSRS, mental health, zero-shot learning, natural language processing, ethical AI, Reddit, digital triage, ordinal classification.

FMLDS2025-114

Balancing Interpretability and Performance in Credit Card Fraud Detection Using Machine Learning Techniques with SMOTE and Logistic Regression

Hasan Ahammad and Modina Jahan Priya

Abstract:
Credit card fraud detection is a critical issue in modern financial systems, with challenges arising from the imbalanced nature of transaction datasets, where fraudulent activities account for only a small fraction. This thesis proposes an enhanced fraud detection system by combining Logistic Regression with Synthetic Minority Oversampling Technique (SMOTE) to address class imbalance, improve model performance, and detect fraudulent transactions more effectively. SMOTE which generates synthetic samples from minority class helps to improve the recall and precision of Logistic Regression model. The results are evaluated using standard metrics - accuracy, precision, recall and AUC. As you can see there is a significant improvement in detecting fraud transactions. Similar works like those of IEEE have also shown the benefits of SMOTE in fraud detection, thus providing further justification for the use of this technique. The results show that the combination of logistic regression and SMOTE makes it possible to successfully detect fraud in imbalanced datasets, thus providing a solution to the requirements needed in the monetary organizations in the real world.

FMLDS2025-115

Comparative Analysis of Machine Learning Algorithms for Spam SMS Classification Using TF-IDF Vectorization

Hasan Ahammad, Md Samsuzzaman, Md Harunur Rashid and Md Abdul Masud

Abstract:
The rapid increase in unsolicited SMS messages necessitates the development of efficient spam detection systems. This study compares three widely used machine learning algorithms — Naive Bayes, Logistic Regression, and Support Vector Machine (SVM) — for classifying spam and legitimate SMS messages. Using Term Frequency-Inverse Document Frequency (TF-IDF) vectorization, the textual data is transformed into a format suitable for machine learning models. Each model's performance is assessed through accuracy, precision, recall, and F1-score, with confusion matrices highlighting misclassifications. The findings indicate that while each algorithm has its strengths, SVM demonstrated superior performance in accurately classifying SMS messages. These results have practical implications for enhancing real-world spam detection systems, especially in mobile applications and messaging platforms, where efficient filtering can improve user experience and security. The study suggests potential for integrating machine learning models into existing anti-spam frameworks for more reliable SMS filtering.

FMLDS2025-118

X-TinyBERT: An Explainable and Lightweight BERT Framework for Intrusion Detection in IoT

Shahid Latif, Qurat-Ul-Ain Mastoi, Djamel Djenouri, Mohammed S. Alshehri and Jawad Ahmad

Abstract:
The rapid expansion of Internet of Things (IoT) has increased vulnerabilities to advanced cyberattacks, requiring robust yet efficient Intrusion Detection Systems (IDS). Traditional machine learning-based IDSs struggle with high-dimensional, imbalanced IoT traffic patterns, while deep learning (DL) models face challenges from computational complexity and lack of interpretability. To address these challenges, this paper introduces X-TinyBERT, an explainable and lightweight IDS framework that utilizes a compressed TinyBERT architecture optimized for IoT limitations. The proposed approach adapts transformer layers to tabular data via multi-head self-attention and GELU activations, combined with SHapley Additive exPlanations (SHAP) for post-hoc interpretability. The model uses feature standardization, label encoding, and a streamlined 4-layer transformer backbone to lower computational costs while preserving contextual feature relationships. Experimental results demonstrate that the proposed X-TinyBERT model achieves a superior attack detection accuracy of 98.56% while surpassing the standard BERT model in terms of efficiency, with a significantly smaller model size of 5.33 MB compared to 11.76 MB and a 28% reduction in inference latency. Moreover, integrating SHAP enhances the model's interpretability by providing actionable insights into feature attribution, thereby helping security analysts validate threat classifications.

FMLDS2025-122

Comparative Analysis of Machine Learning Algorithms with Feature Selection for Predicting AADT

Chimba, Deo; Gupta, Subash; Matongo, Therezia; Lee, David*

Abstract:
Accurate prediction of Annual Average Daily Traffic (AADT) is crucial for effective transportation management, infrastructure planning, and policymaking. This study investigates the application of machine learning models to enhance AADT prediction by selecting the most influential features. Three feature selection methods—Filter, Wrapper, and Embedded—to identify key features and evaluate their impact on model performance were employed. This comprehensive analysis demonstrated that the filter method significantly improved prediction accuracy, with the Random Forest model exhibiting the best performance among the evaluated models. Specifically, the filter method with RF achieved the lowest Mean Absolute Error and Mean Squared Error of 0.4883 and 0.4253, respectively. Along with the highest R-squared and Explained Variance Score of 0.7537 and 0.7538, respectively, indicating a superior fit and predictive power. Key features identified as crucial for AADT prediction include the number of lanes, speed limit, percent of grade, and degree of curve.

FMLDS2025-127

Machine Learning-Based Load Forecasting for Vehicle-to-Grid Scheduling: A Case Study on the Italian Power System

Zahid Ullah, Michele De Santis and Luigi Rubino

Abstract:
Electric vehicles (EVs) are emerging not only as a sustainable mode of transportation but also as a promising source of flexibility in modern power systems using vehicle-to-grid (V2G) technology. This study investigated the integration of short-term load forecasting with V2G scheduling using open-access hourly data from the Italian grid. Multiple forecasting models, including linear regression, Random Forest, XGBoost, and a hybrid ARIMA + XGBoost model, were evaluated for their accuracy using standard metrics. The hybrid model demonstrated superior performance, with an

RMSE of 376.91 MW and an R^2 of 0.9969. This model was then used to simulate two V2G discharging strategies, forecast-driven discharging during the top-5 peak hours and fixed-window strategy. The fixed-window strategy resulted in 2320 MWh of energy discharge over the month and contributed to improved load curve flattening. These results demonstrate the potential of coupling accurate forecasting with well-timed V2G operations to support peak-load management and enhance grid flexibility. This study provides a standardized process for integrating forecasting into V2G planning, supporting smart grid development and policy design.

FMLDS2025-128

An ML-driven Adaptive TGTCT-2SRU-Based Security Framework With Polymorphic Shellcode Analysis For Multi-Layered Cloud Environment

Abhijeet Mukkawar and Ravichandra Kulkarni

Abstract:

Adaptive Security Mechanisms (ASMs) are vital in the era of Cloud Computing (CC) for handling Evolving Threats (ETs). Nevertheless, none of the existing works concentrated on examining the Polymorphic Shellcode (PS) in the multi-layered cloud environment. Hence, in this paper, an adaptive Transferred Gated Trid Colville Triple-State Swish Recurrent Unit (TGTCT-2SRU)-based security framework with PS analysis for multi-layered CC is proposed. The cloud users initially register in the data plane, followed by Message Authentication Code (MAC) creation. Afterward, the registered users are fed into Micro-Segmentation (MS). MAC verification is carried out during the event request initiation. Once the authentication is successful, the PS is investigated, followed by data encryption. Similarly, in the network plane, zero-trust-centric authentication is performed. Then, the data is forwarded to the application plane through the routing hub. Here, to ensure authorized access, the MAC is verified once again. Thereafter, the data is decrypted and further subjected to the proposed intrusion detection framework. Next, the tasks are executed for the benign request. Further, they are stored in the cloud server. The proposed method improves cloud reliability with a significant improvement in security level compared to any of the previous methods.

FMLDS2025-131

Causal Intervention Sequence Analysis for Fault Tracking in Radio Access Networks

Chenhua Shi, Jayanta Choudhury, Joji Philip and Subhadip Bandyopadhyay

Abstract:

To keep modern Radio Access Networks (RAN) running smoothly, operators need to spot the real-world triggers behind Service-Level Agreement (SLA) breaches well before customers feel them. We introduce an AI/ML pipeline that does two things most tools miss: (1) finds the likely root-cause indicators and (2) reveals the exact order in which those events unfold. We start by labeling network data: records linked to past SLA breaches are marked `abnormal', and everything else `normal'. Our model then learns the causal chain that turns normal behavior into a fault. In Monte Carlo tests the approach pinpoints the correct trigger sequence with high precision and scales to millions of data points without loss of speed. These results show that high-resolution, causally ordered insights can move fault management from reactive troubleshooting to proactive prevention.

FMLDS2025-132

LIMA: Leveraging Large Language Models and MCP Servers for Initial Machine Access

Mohammad Ibrahim Saleem, Sohan Simha Prabhakar, Abhinav Harsha, William Arthur Conklin, Kyu In Lee and Tania Banerjee

Abstract:
We present LIMA (Large Language-Model-driven Initial Machine Access), a penetration testing framework that pairs off-the-shelf LLMs with Model Context Protocol (MCP) servers to orchestrate automated initial-access reconnaissance, enumeration, and exploitation. LIMA's modular design allows an LLM to invoke scanners, parse outputs, consult vulnerability databases, and generate exploits while receiving minimal human input. We evaluate Claude 3.5 and GPT-4o on five targets: four HackTheBox machines and a custom VM and compare their performance with that of beginner- and expert-level human testers. Claude finished four boxes in a mean time of 13 minutes which is up to 2x faster than the expert and required help only for CAPTCHAs, achieving autonomous completion otherwise. GPT-4o, with sporadic guidance, completed two boxes in 17.5 minutes. Both models failed on a BurpSuite-dependent target, showing that missing GUI tooling, not model logic, is now the main bottleneck. Token-cost analysis puts a full autonomous run at < $0.06. These results establish the first quantitative baseline for AI-augmented penetration testing at the initial-access phase.

FMLDS2025-133

Investigation of Injection Molding process Parameters in Polymethyl Methacrylate (PMMA) Injection Molding Production: A Simulation and Machine Learning-Based Regression Analysis Approach.

Sonia Pol, Bhushan Tryambak Patil and AMIT J Lopes

Abstract:
Polymethyl Methacrylate (PMMA) is a transparent thermoplastic valued for its optical clarity, UV resistance, and mechanical strength, making it indispensable in applications such as automotive and aerospace. The manufacturing of PMMA sheets through injection moulding offers a cost-effective and efficient alternative to other production methods. However, achieving high-quality, defect-free products requires careful management of process parameters, including mold temperature, melt temperature, injection pressure limit, pressure holding time, pure cooling time, and coolant temperature. These parameters, dictated by the material properties, are critical in minimizing defects like sink marks and volumetric shrinkage. This study explores the relationship between process parameters and the occurrence of sink marks using data derived from hundred simulation experiments. Hypotheses were developed during the simulations, revealing that mold temperature and pure cooling time significantly influence sink mark formation. Furthermore, cooling time is closely related to both sink marks and volumetric shrinkage. To validate these findings, machine learning techniques specifically linear and quadratic regression that were employed to model and predict sink marks. The regression analysis yielded predictive equations, highlighting the significance of process parameters, which were further supported by ANOVA and R^2 values to establish the reliability of the models. This research demonstrates how integrating simulation data with predictive modelling enhances decision-making in injection moulding processes. By identifying optimal process parameter ranges, the study contributes to reducing defects, improving product quality, and promoting sustainable manufacturing practices. The findings also align with global sustainability goals by minimising material waste and increasing production efficiency, reinforcing the value of data-driven methodologies in modern manufacturing.

FMLDS2025-134

Machine Learning-Driven Feasibility Prediction in Manufacturing Design Using Scalar and 3D Geometric Features

Md Mohsin Uddin Fahim and Amit J Lopes

Abstract:

In modern manufacturing design, ensuring the feasibility of 3D mechanical models before prototyping remains a critical challenge. This study presents a hybrid framework that integrates scalar design parameters and geometric information extracted from 3D models to predict feasibility efficiently. The methodology begins with scalar feature preprocessing, where six variables representing design constraints are standardized and cleaned. Simultaneously, 3D geometry data in STL format is processed using Open3D to extract features such as surface area, volume, curvature, aspect ratio, and bounding box dimensions. Multiple machine learning classifiers Logistic Regression, Support Vector Machine, Decision Tree, and Random Forest are trained and evaluated using 5-fold stratified cross-validation. Recursive Feature Elimination is applied to identify the most informative predictors. The best-performing model achieved an accuracy of over 93% with strong F1-score performance, demonstrating its effectiveness in distinguishing between feasible and infeasible designs. Statistical significance testing, including T-tests and F-tests, validates the discriminative power of selected features. Furthermore, the explainability of the model is enhanced using SHAP analysis to interpret feature contributions toward feasibility classification. The integration of 3D geometric information significantly improves prediction accuracy compared to scalar features alone. This approach not only streamlines early-stage design evaluation but also provides engineers with a data-driven tool to anticipate feasibility constraints before investing in physical prototypes. This study highlights the potential of combining machine learning and geometric processing to support intelligent design decision-making in manufacturing. Future work will explore incorporating material properties and simulation-driven features to improve predictive robustness and generalizability across more complex, multi-material models.

FMLDS2025-135

Causal Inference with Uncertainty Quantification for Counterfactual Analysis of Injury Severity in Multi-Vehicle Collisions

Philip Balyagati, Abdul Ngereza, Emmanuel Kidando, Ntemi Masanja and Caroline Bikuba

Abstract:

Traffic crashes continue to pose significant public health concerns, prompting transportation agencies to prioritize strategies for improving roadway safety and mitigating crash impacts. Traditional approaches to modeling highway safety data often rely on regression-based methods to identify significant factors associated with injury severity. However, these methods primarily capture associations rather than causal effects, limiting their ability to evaluate the effectiveness of interventions. This study introduces a Bayesian causal inference framework to advance safety analysis by capturing underlying causal relationships on crash injuries. Using data from Ohio interstates, the framework assesses the effects of roadway, environmental, and behavioral factors on injury severity, with crash type modeled as a mediating variable. The average causal impacts and their associated uncertainties are estimated using the highest density interval (HDI). The study findings reveal that alcohol involvement and multi-vehicle crashes are key contributors to the increased risk of injuries and fatalities. Road geometry and vehicle speed exhibit both direct and mediated effects through crash type, while lighting conditions and the presence of work zones show uncertain impacts based on HDI. The results offer valuable insights for transportation safety policy, emphasizing the importance of targeting both direct and indirect pathways in crash injury prevention strategies.

FMLDS2025-136

Shape Prior Fusion for Efficient 3D Reconstruction

Kamanuru, Vamsidhar Reddy; Tawade, Hrishikesh Gopal; Dekkata, Sai Charan; Bheri, Sam Prakash*

Abstract:
Creating accurate 3D models from images is a challenging problem in computer vision, especially for appli- cations like autonomous driving, virtual reality, and mobile computing. Multi-View Stereo (MVS) methods rely on geometry to reconstruct shapes but often struggle with missing details due to occlusions or textureless surfaces. In this work, we introduce a learning-based approach that enhances MVS by fusing deep priors, allowing for more complete and accurate 3D reconstructions with fewer input images. Our deep prior prediction network is trained using masked silhouette and texture
losses, ensuring better shape recovery. Tested on the ShapeNet dataset, our model achieves a Chamfer Distance of 0.18 and an IoU of 0.80, outperforming MVS based only methods while also improving surface coverage to 91.1% and density score to 85.7%. By integrating learning-based priors with geometry-based methods, our approach improves the reliability and efficiency of 3D reconstruction for practical applications.

FMLDS2025-142

A Jetson TX2-Based License Plate Recognition and GPS Tracking System for Vehicular Surveillance

Jared Jan Abayan, Leonard Ambata, Argel Bandala, Rae Elise Dalangin, Ivan Alexis Duaqui, Joshua Vincent Saavedra, Mikaylo Junell Veloria and Ronnel Agulto

Abstract:
Real-time License Plate Recognition (LPR) systems play a critical role in intelligent transportation, offering automated solutions for vehicle monitoring, law enforcement, and traffic data collection. Most existing systems rely on fixed-position cameras, limiting their applicability in dynamic or wide-area deployments. This study proposes a mobile, embedded LPR framework that integrates image-based license plate detection, optical character recognition (OCR), GPS-based geolocation, and distance estimation. The system is implemented using the NVIDIA Jetson TX2 platform for onboard processing, leveraging a USB camera for video acquisition and OpenCV for real-time image preprocessing. Character recognition is performed using Tesseract OCR, while vehicle distance is estimated through a contour area–based regression model calibrated via empirical data. An Arduino-based GPS module provides geospatial tagging of detected vehicles. Additionally, a mobile application is developed to visualize recognized license plates and their corresponding trajectories on a map. Field evaluations demonstrate a recognition accuracy of 93.15% at a 1-meter distance and sustained performance up to 3 meters under optimal conditions. Distance estimation achieved a maximum absolute error of 0.07 meters after correction. The system supports offline data storage and mobile visualization, enabling contactless and portable deployment for traffic monitoring and enforcement. Results indicate the feasibility of deploying the proposed platform in real-world, dynamic traffic scenarios, offering a scalable alternative to stationary LPR systems.

FMLDS2025-145

Hybrid Vision–Inertial Fusion for End-to-End UAV Control in Simulation

Chen, Wenhui

Abstract:
Autonomous unmanned aerial vehicles (UAVs) require robust perception and control to navigate complex environments.Traditional end-to-end learning methods often rely on single-modality inputs, such as RGB images, which limits performance under sensor noise or changing conditions. To address this, we propose a multimodal control framework that fuses visual and inertial data. The system integrates a Hybrid Vision Transformer (Hybrid-ViT), combining MobileNet for local feature extraction and a Vision Transformer for global representation, and an LSTM network for modeling IMU timeseries data. Early feature-level fusion of RGB and IMU modalities improves perception robustness and control accuracy. The framework was implemented and evaluated in the Flightmare simulation platform with 95,000 RGB–IMU pairs collected across diverse scenarios. Experiments demonstrate improved obstacle avoidance (92% success rate), greater control stability, and reduced trajectory deviation compared to CNN- and ViT-based baselines. These results highlight the potential effectiveness of hybrid visual–inertial fusion for enhancing UAV autonomy in simulated environments, with real-world validation left for future work.

FMLDS2025-146

TigerGPT: A Theory-Driven AI Chatbot for Adaptive Campus Climate Surveys

Jinwen Tang, Songxi Chen and Yi Shang

Abstract:
Campus climate surveys play a pivotal role in capturing how students, faculty, and staff experience university life, yet traditional methods frequently suffer from low participation and minimal follow-up. We present TigerGPT, a new AI chatbot that generates adaptive, context-aware dialogues enriched with visual elements. Through real-time follow-up prompts, empathetic messaging, and flexible topic selection, TigerGPT elicits more in-depth feedback compared to traditional static survey forms. Based on established principles of conversational design and cognitive theories, the chatbot employs empathetic cues, bolded questions, and user-driven topic selection. It retains some role-based efficiency (e.g., collecting user role through quick clicks) but goes beyond static scripts by employing GenAI adaptiveness. In a pilot study with students, we collected both quantitative metrics (e.g., satisfaction ratings) and qualitative insights (e.g., written comments). Most participants described TigerGPT as engaging and user-friendly; about half preferred it over conventional surveys, attributing this preference to its personalized conversation flow and supportive tone. The findings indicate that our TigerGPT is promising in gaining deeper insight into campus climate.

FMLDS2025-147

Advanced Machine Learning with Feature Aggregation based Detection and Classification of Cardiac Arrhythmia on Electrocardiograms

Majed Balkheer, Ashis Kumer Biswas, Reda Salama and Mahmoud Ragab

Abstract:
As we age, our blood vessels deteriorate, often leading to cardiovascular diseases. Arrhythmia is a common early symptom, and its timely detection is vital for reducing mortality. Automatic arrhythmia detection, heavily reliant on machine learning (ML), has gained significant attention. Using sensors, it captures real-time electrocardiogram (ECG) data, which ML models analyze to classify arrhythmias. However, body movements and environmental factors often disturb ECG signals,

introducing noise, missing samples, and unbalanced data distributions that hinder detection. This study introduces a novel Classification of Cardiac Arrhythmia Using Multi-Technique Feature Fusion and Deep Hybrid Neural Networks (CCAMFF-DHNN) approach for ECG-based clinical diagnosis. The main objective is to establish the CCAMFF-DHNN system as a reliable tool for real-time cardiac arrhythmia analysis in clinical settings. Initially, the CCAMFF-DHNN method applies comprehensive preprocessing, including interpolation for signal regularization, noise removal, standardization for consistent scaling, and data oversampling. Subsequently, it employs a fusion of feature selection techniques—principal component analysis (PCA), recursive feature elimination (RFE), chi-square test, and mutual information (MI)—to extract the most informative features from the high-dimensional ECG data. Finally, a hybrid deep neural network combining a convolutional neural network with a long short-term memory (LSTM)-driven denoising autoencoder (CL-DAE) performs arrhythmia classification. The proposed system undergoes extensive experimental evaluation, with outcomes assessed under various performance metrics. Simulation results highlight the superiority of the CCAMFF-DHNN approach compared to state-of-the-art methods.

FMLDS2025-149

Classifying Scientific Peer Reviews: Distinguishing Authentic, Generic, and AI-Generated Feedback

Muhammad Aashir Aftab, Jannat Ara Ferdouse Raya, JUNAID SHUJA, Mohammad Ali Humayun and Khalid Mahmood Malik

Abstract:

The quality, and more importantly, the integrity of academic research heavily rely on the peer review process. However, the increasing sophistication and accessibility of Large Language Models (LLMs) pose a potential threat, as they can be utilized to generate generic and ineffective peer reviews, thereby undermining the rigor of scholarly publications. "Pal-reviews'' providing generic comments with no critical feedback, are another pressing subject in scientific publications. This research investigates the feasibility of automatically auditing and categorizing peer reviews using fine-tuned transformer-based language models. We explored five prominent architectures, i.e., BERT, XLNet, DistilBERT, RoBERTa and OpenAI GPT-4o-nano, while training them on a very specifically curated dataset of authentic, AI-generated, and generic reviews. We generated the authentic reviews from journals that publish open reviews with articles. ChatGPT was used to generate AI-generated reviews, while sentence concatenation was used to generate generic reviews. Our methodology involved combining paper titles, abstracts, and review text with special tokens, employing robust text encoding techniques, and utilizing a rigorous training routine incorporating cross-validation, focal loss for class imbalance, and early stopping. The models were evaluated using accuracy, F1-score, precision, and recall. Our findings indicate the promising potential of this approach, with GPT-4o-nano substantially surpassing all other models, achieving a held-out test accuracy of 80.7% and macro-F1 of 80.6%. RoBERTa, DistilBERT and XLNet followed with moderate performance, while BERT lagged behind. To encourage reproducibility, the fine-tuned the BERT based models have been published on the Hugging Face Model Hub with open access.

FMLDS2025-150

Automated Synthetic Dataset Creation for Vehicle Classification and Counting

Ambata, Leonard; Dadios, Elmer*

Abstract:

Abstract—This paper presents a method for vehicle detection, classification, and counting in traffic video streams by leveraging a custom-generated training dataset and a state-of-the-art object

detection model. The study focuses on processing CCTV footage from major thoroughfares in Metro Manila, Philippines, to distinguish between private vehicles (motorcycles, sedans, pickup trucks, SUVs, vans) and public transport (jeepneys, buses, tricycles) and count them. An automated synthetic dataset generation approach was used to create an initial training set of 10,000 images by superimposing labeled vehicle images onto road backgrounds, reducing the need for manual annotation. A YOLOv12 one-stage detector was trained on this dataset and integrated with a multi-object tracking algorithm (BoT-SORT) to track vehicles across frames and count them when they cross designated lines. The system was iteratively refined by fine-tuning the model with real CCTV footage, achieving improved accuracy with each iteration. Results show that the proposed approach can accurately detect and classify vehicles by class (with ~90% average accuracy for per-class classification after fine-tuning) and by type (public vs. private, ~97% accuracy), and count them with over 96% accuracy. The final model outperforms a baseline Faster R-CNN and the pre-trained YOLO model on comparable data. This work demonstrates an effective solution for traffic monitoring with minimal manual data preparation, suitable for urban traffic management applications.

FMLDS2025-152

Event-based Human Action Recognition: Rehabilitation Monitoring Dataset and Models

Maisha Hafiz, Sahil Hassan, Serhan Gener, Joshua Mack and Ali Akoglu

Abstract:
Human Action Recognition (HAR) enables interactive rehabilitation monitoring for patients and has wide range of use cases in healthcare. Event-based vision sensors have become of interest for such deployment scenarios as they offer high temporal resolution and operate under varying illumination, while inherently preserving patient privacy by capturing only motion-triggered changes in the scene. Although there is growing interest in event-based HAR, current datasets dominantly cover general activities and lack focus on movements specific to the rehabilitation. In this work, we introduce the first open-source event-driven dataset tailored for rehabilitation exercises, study three models with distinct features covering ResNeXt-50, a CNN-LSTM based and a Fully CNN based model, and investigate their ability to learn from this dataset. Our results provide key insights into the applicability of event-based sensing for privacy-preserving and real-time rehabilitation monitoring.

FMLDS2025-155

Interpretable Lung Cancer Prediction Using Selected Clinical Features and Machine Learning with XAI (SHAP and LIME)

Md. Nasir Uddin, Al- Amain, Nusrat Jahan, Rajon Bardhan and Shifat Ahmed

Abstract:
Early and accurate prediction of lung cancer plays a vital role in improving clinical outcomes and reducing mortality. Using clinical data, we present a strong machine
learning-based diagnostic approach in this study that may detect possible cases of lung cancer early on. To guarantee optimal performance, a total of eight machine learning algorithms were used, each of which was hyperparameter tuned using RandomizedSearchCV. Strict sampling and preprocessing methods were used to improve data quality and address class imbalance. The most relevant attributes were retained through feature selection using the ANOVA F-test with SelectKBest, which greatly increased model efficiency. With the highest accuracy of 99.26% among all models, the

Support
Vector Machine (SVM) showed exceptional predictive power. Model decisions were interpreted using SHAP and LIME, which provide both global and local explanations, to increase openness.
The suggested approach provides an interpretable and dependable solution that can be incorporated into processes for clinical diagnostics.

FMLDS2025-157

Flatten Wisely: How Patch Order Shapes Mamba-Powered Vision for MRI Segmentation

Osama Hardan, Omar Elshenhabi, Tamer Khattab and Mohamed Mabrok

Abstract:
Vision Mamba models promise transformer-level performance at linear computational cost, but their reliance on serializing 2D images into 1D sequences introduces a critical, yet overlooked, design choice: the patch scan order. In medical imaging, where modalities like brain MRI contain strong anatomical priors, this choice is non-trivial. This paper presents the first systematic study of how scan order impacts MRI segmentation. We introduce Multi-Scan 2D (MS2D), a parameter-free module for Mamba-based architectures that facilitates exploring diverse scan paths without additional computational cost. We conduct a large-scale benchmark of 21 scan strategies on three public datasets (BraTS 2020, ISLES 2022, LGG), covering over 70,000 slices. Our analysis shows conclusively that scan order is a statistically significant factor (Friedman test: $\chi 2 = 43.9$, $p = 0.0016$), with performance varying by as much as 27 Dice points. Spatially contiguous paths—simple horizontal and vertical rasters—consistently outperform disjointed diagonal scans. We conclude that scan order is a powerful, cost-free hyperparameter, and provide an evidence-based shortlist of optimal paths to maximize the performance of Mamba models in medical imaging.

FMLDS2025-158

Towards Trustworthy Flight State Identification Using Explainable Supervised Learning

Iqbal, Anam; wild, Graham; Iqbal, Kanwal*

Abstract:
Flight state identification of an aircraft focuses on improving aviation safety and operational efficiency, and various Artificial intelligence (AI) models have been adopted in this regard. However, this adoption is still restricted due to concerns about the interpretability of AI models, which frequently operate as opaque decision-making black box systems. This study aims to improve the identification of flying states by integrating Explainable AI (XAI) with supervised classification models. Multiple classification models are employed to simulated flight data for classifying the different flying states of an aircraft. Random Forest (RF) model shows superior performance than its counterparts with the highest values of accuracy, precision, recall and F1 score. Also, the RF model has strong alignment with actual states and clearly defines transition points. Shapley Additive Explanations (SHAP) technique is then employed to improve explainability by locating the key features that impact the model's outcomes. Moreover, Delta SHAP analysis is performed for state transition explainability of the model. The findings demonstrate that XAI has the potential to enhance the transparency and interpretability of AI models in the aviation sector.

FMLDS2025-161

Discriminative Sequence Features for DNA-Binding Protein Detection Using ML and DL Techniques

NADEEM IQBAL, Islam Uddin and Syed ahmad Chan Bukhari

Abstract:
DNA binding proteins (DBPs) play an important role in various cellular processes, including transcription, replication, and DNA repair. Identifying DBPs accurately from protein sequences is important for understanding gene regulation mechanisms and guiding biomedical research. However, traditional computational models often suffer from limited accuracy, heavy dependence on manual feature engineering, and poor generalization across diverse datasets. To overcome these limitations, this study proposed a unified *evaluation framework that systematically compares machine learning (ML) and deep learning (DL)* approaches for DBP prediction. Firstly, the procedure initiates with the extraction of discriminative features using kmer frequency, amino acid composition (AAC), and Bidirectional Encoder Representations from Transformers (BERT). Secondly, we utilize ML algorithms, such as Random Forest (RF), Support Vector Machine (SVM), decision tree (DT), and XGBoost, to train on these feature sets. Thirdly, DL models, such as Long Short Term Memory (LSTM), Convolutional Neural Networks (CNN), and Deep Neural Networks architecture, are developed to capture hierarchical and sequential patterns in protein sequences. Finally, models are evaluated using standard metrics, including accuracy, precision, recall, F1 Score, ROC AUC, and MCC. Experimental results show that DL models, particularly CNN-LSTM, outperform classical ML methods. A comparative analysis reveals that the proposed framework offers enhanced accuracy, robustness,
and biological relevance in DBPs prediction.

FMLDS2025-162

Multifaceted Fusion of Glove and Additive Attention Models for Scalable Fake News Detection

NADEEM IQBAL, Ashfaq Ur Rahman, Islam Uddin and Syed Ahmad Chan Bukhari

Abstract:
The rapid spread of fake news across social media and digital platforms poses a significant challenge to the credibility of public information. To address this issue, we proposed a framework that integrates GloVe-based semantic embeddings with additive attention mechanisms to enhance fake news detection (FND). The proposed approach integrates multiple components to capture both semantic and contextual features from news articles. Specifically, we employ pre-trained GloVe embeddings to transform raw textual data into meaningful vector representations that preserve word relationships. A Bidirectional LSTM network is used to learn sequential dependencies, while a scaled additive attention mechanism selectively emphasizes critical information within the text, enhancing model interpretability and accuracy. This multifaceted fusion allows the system to focus on linguistically significant patterns that distinguish real from fake content. We evaluate the proposed model on benchmark datasets validated by Politifact and Reuters, and the results demonstrate that the approach significantly outperforms existing state-of-the-art methods in terms of precision, recall, and overall classification accuracy. The proposed model provides a scalable solution for real-time fake news detection and can be extended to other domains of misinformation.

FMLDS2025-163

VerseAge: A phenotypic age predictor based on a shallow random network architecture

Brandon Warner, Elliot Farmer Garcia, Edward Ratner, Christopher Douglas, Anirban Datta and Amaury Lendasse

Abstract:
Aging is the leading cause of disease and deterioration in humans. To better understand the aging process, it is essential to develop accurate biological aging measurement techniques. Phenotypic clocks are one of the most powerful biological age (BA) predictors and rely on easily measurable clinical and physiological measurements to predict “true” biological age. In this study, we developed a phenotypic clock based on artificial neural networks (ANNs) to predict chronological age using only routinely collected blood and physiological measurements. We developed a novel Modified Matching Pursuit (MMP) algorithm that creates a stable and orthogonal basis set from the measurement variables. To build our ANN, we trained an ensemble of shallow random networks samples from the publicly available NHANES year 2017-2020 data set that represents broad US population demographics. Our proposed approach outperforms state-of-the-art methods with a Pearson correlation of r = 0.9197 with the output (chronological age) using only 5 biomarkers available from standard blood and urine tests.

FMLDS2025-167

Robust Multimodal Learning Using Low-Rank Approximation and Context-Aware Representations in Medical Imaging

Jiblal Upadhya, Khem Poudel and Jaishree Ranganathan

Abstract:
Multimodal learning systems have shown great promise in healthcare by integrating image and text modalities, yet they often struggle with missing data, high dimensionality, and limited generalization in data-scarce environments. This work introduces a mathematically grounded and theoretically justified framework for robust multimodal learning that simul- taneously addresses data incompleteness, interpretability, and few-shot generalization. Unlike prior empirical fusion methods, our approach is built upon low-rank modeling principles, includ- ing Robust Principal Component Analysis (RPCA), semantic-regularized matrix completion, and tensor factorization, which allow us to denoise, complete, and compress high-dimensional multimodal representations into meaningful low-dimensional latent spaces. The proposed HyperFusion module uniquely combines bilinear, low-rank, and tensor fusion strategies to learn comprehensive cross-modal interactions while maintaining computational efficiency. Additionally, semantic priors from pre- trained language models are leveraged during matrix completion to ensure clinically relevant imputations. For generalization under limited supervision, we adopt a prototype-based few-shot learning scheme, further enabled by the robustness of our latent embeddings. Our framework is validated on the MIMIC-CXR dataset, achieving competitive classification accuracy (94.9%), outperforming baseline CNN, BioBERT, and early fusion models. It also demonstrates high semantic alignment and robustness to up to 70% missing modalities, confirming its effectiveness in real-world clinical scenarios.

FMLDS2025-168

Entropy based Intuitionistic Fuzzy Weighted Least Square Twin Support Vector Machine

Q.M. Danish Lohani, Niher Ranjan Das and Nauman Ansary

Abstract:
Imbalanced datasets are difficult to handle in classification problems, where some classes have significantly fewer samples than others. Support Vector Machines (SVMs) are known for their strong performance in many areas, but they struggle with imbalanced and noisy data as they treat all training samples equally, which causes the model to favour the majority class when forming the decision boundary. Although fuzzy SVM variants like entropy based fuzzy SVM (EFSVM) and

intuitionistic fuzzy twin SVM (IFTSVM) reduce the impact of noise and outliers by assigning fuzzy membership values, they rely heavily on distance-based assumptions and assume uniform uncertainty across the data. These methods compute membership and non-membership values based on the centres of the data. In this paper, we propose a new entropy based IFW-LSTSVM (EIFW-LSTSVM) that combines intuitionistic fuzzy theory with local entropy to handle class imbalance better. It assigns full membership to minority class samples and reduces it for the uncertain majority class. This dual approach enhances the model performance by focusing more on the minority class while reducing the influence of noisy majority samples, leading to a more balanced and reliable decision boundary. Moreover, to validate the performance of the proposed method, experiments were conducted on 14 imbalanced datasets from the KEEL repository, comparing it with several recent and widely recognized SVM variants. For statistical validation of these findings, the Friedman test followed by the Dunn-Bonferroni post-hoc test was applied at a 95$\%$ confidence level. The results indicate that the proposed method exhibits significantly superior performance compared to existing state-of-the-art methods.

FMLDS2025-170

Time-Resolved Monitoring of Ethanol and VOC Emissions in Strawberry Spoilage Using Low-Cost Gas Sensors

Nana Amankwatia Tuffour-KWarteng

Abstract:
Strawberries are among the most consumed fruits globally but suffer from rapid postharvest spoilage. This study presents a time-resolved analysis of ethanol and volatile organic compound (VOC) emissions using low-cost gas sensors (MQ3 and BME680) across three storage regimes: room temperature, cold storage, and greenhouse-like conditions. Over 4–5 days and 30 experimental batches, sensor signals were continuously recorded and segmented into spoilage phases: Fresh, Spoiling, and Late Spoilage. The results reveal regime-specific emission patterns, with early VOC changes preceding ethanol surges, highlighting microbial and enzymatic activity. Labeled temporal features enable future application of machine learning models for spoilage prediction. This work offers a scalable, affordable framework for real-time, IoT-enabled postharvest monitoring.

FMLDS2025-171

Novel Intuitionistic Fuzzy Hierarchical Clustering Technique Emphasizing the Fuzzy Variant

Q.M. Danish Lohani, Niher Ranjan Das and Nauman Ansary

Abstract:
In the paper, a novel intuitionistic fuzzy hierarchical clustering (NIFHC) technique is proposed such that the membership values of the intuitionistic fuzzy set (IFS) dominate in the clustering. Here, two benchmark datasets analysing car markets and flood disasters are considered to study the proposed NIFHC algorithm. The performance of some well-known IFS based hierarchical clustering techniques is compared with our technique on given datasets. The efficacy of the proposed technique is adjudged in terms of benchmark indexes, namely correlation coefficient, Silhouette score, Dunn index, Davies-Bouldin index, and Calinski-Harabasz index. The proposed technique outperforms the other IFS based clustering counterparts.

FMLDS2025-172

MNIST-Gen: A Modular MNIST-Style Dataset Generation Using Hierarchical Semantics, Reinforcement Learning, and Category Theory

Pouya Shaeri, Arash Karimi and Ariane Middel

Abstract:

Neural networks are often benchmarked using standard datasets such as MNIST, FashionMNIST, or other variants of MNIST, which, while accessible, are limited to generic classes such as digits or clothing items. For researchers working on domain-specific tasks, such as classifying trees, food items, or other real-world objects, these data sets are insufficient and irrelevant. Additionally, creating and publishing a custom dataset can be time consuming, legally constrained, or beyond the scope of individual projects. We present MNIST-Gen, an automated, modular, and adaptive framework for generating MNIST-style image datasets tailored to user-specified categories using hierarchical semantic categorization. The system combines CLIP-based semantic understanding with reinforcement learning and human feedback to achieve intelligent categorization with minimal manual intervention. Our hierarchical approach supports complex category structures with semantic characteristics, enabling fine-grained subcategorization and multiple processing modes: individual review for maximum control, smart batch processing for large datasets, and fast batch processing for rapid creation. Inspired by category theory, MNIST-Gen models each data transformation stage as a composable morphism, enhancing clarity, modularity, and extensibility. As proof of concept, we generate and benchmark two novel datasets—\textit{Tree-MNIST} and \textit{Food-MNIST}—demonstrating MNIST-Gen's utility for producing task-specific evaluation data while achieving 85\% automatic categorization accuracy and 80\% time savings compared to manual approaches.

FMLDS2025-173

A Late-Fusion Multimodal AI Framework for Privacy-Preserving Deduplication in National Healthcare Data Environments

Mohammed Omer Shakeel Ahmed

Abstract:

Duplicate records pose significant challenges in customer relationship management (CRM), healthcare, and financial systems, often leading to inaccuracies in analytics, impaired user experiences, and compliance risks. Traditional deduplication methods rely heavily on direct identifiers such as names, emails, or Social Security Numbers (SSNs), making them ineffective under strict privacy regulations like GDPR and HIPAA, where such personally identifiable information (PII) is restricted or masked. In this research, I propose a novel, scalable, multimodal AI framework for detecting duplicates without depending on sensitive information. This system leverages three distinct modalities: semantic embeddings derived from textual fields (names, cities) using pre-trained DistilBERT models, behavioral patterns extracted from user login timestamps, and device metadata encoded through categorical embeddings. These heterogeneous modalities are combined using a late fusion approach and clustered via DBSCAN, an unsupervised density-based algorithm. I evaluated this proposed model against a traditional string-matching baseline on a synthetic CRM dataset specifically designed to reflect privacy-preserving constraints. The multimodal framework demonstrated good performance, achieving a good F1-score by effectively identifying duplicates despite variations and noise inherent in the data. By enabling accurate deduplication without

reliance on PII, the framework supports secure digital infrastructure, enhances the reliability of public health analytics, and promotes ethical AI adoption across government and enterprise settings. The system's modular architecture makes it well-suited for integration into national health data modernization efforts, aligning with broader goals of privacy-first innovation, resilience, and operational efficiency.

FMLDS2025-174

Feature-Aware Deep Learning for Maritime Intent Recognition

Md Abu Sayed, Md. Azizul Hakim, Ayesh Meepaganithage, Monica Nicolescu and Mircea Nicolescu

Abstract:
Maritime safety depends on early recognition of nearby vessels' intent, especially in dynamic environments. This paper presents a feature-aware deep learning framework for real-time maritime intent recognition using own ship sensor data. The system integrates two neural architectures: a Long Short-Term Memory (LSTM) network for temporal behavior modeling and a lightweight Fully Connected Deep Learning (FCDL) model for efficient onboard inference. To address the challenge of high-dimensional and imbalanced data, we introduce a Categorical Permutation Feature Importance (CPFI) method that fairly ranks categorical and constant features, overcoming biases in traditional techniques. Additionally, we leverage Transformer-based attention to compute a Feature Importance Score (TFIS), capturing inter-feature dependencies for improved feature selection. By training models on top-ranked features from CPFI and TFIS, we achieve high classification accuracy (up to 98%) across seven behaviors. The proposed approach improves robustness, reduces input complexity, and demonstrates strong potential for deployment in real-time maritime decision systems.

FMLDS2025-175

Robust Access Point Localization Using RSSI Fingerprinting and Pattern Similarity Filtering

Eyiara Oladipo, Ethan Scheys, Osama Najeeb and Mina Maleki

Abstract:
Indoor access point (AP) localization remains a significant challenge in indoor positioning systems and wireless network management due to signal noise, environmental interference, and variability in RSSI measurements. This study introduces a novel approach to AP localization using Wi-Fi fingerprint scans. The proposed method integrates dynamic pattern similarity filtering (PSF), z-score filtering, and RSSI-weighted clustering to enhance estimation accuracy in noisy indoor environments. PSF adaptively applies binary pattern similarity for strong-signal clusters and Euclidean distance–based filtering for weaker ones, allowing the method to preserve high-quality signal patterns while discarding inconsistent fingerprints. Experimental results from fingerprints collected on all three floors of the Engineering Building at the University of Detroit Mercy demonstrate consistent improvements in localization accuracy, reducing the average localization error from 1.20 meters (baseline) to 0.80 meters, with the lowest RMSE observed at an RSSI threshold of –60 dBm. Visual inspection further confirms PSF's ability to discard contextually mismatched fingerprints and mitigate the limitations of RSSI in multipath-prone environments. These results highlight the effectiveness of signal-aware filtering strategies in improving the precision and reliability of indoor AP localization.

FMLDS2025-177

A Machine Learning Framework for Pathway-Driven Therapeutic Target Discovery in Metabolic Disorders

Iram Wajahat, Amritpal Singh, Fazel Keshtkar and Syed Ahmad Chan Bukhari

Abstract:
Metabolic disorders, such as type 2 diabetes mellitus (T2DM), pose substantial global health challenges, particularly affecting genetically predisposed populations like the Pima Indians. This study proposes a novel machine learning (ML) framework that integrates predictive modeling with gene-agnostic pathway mapping to identify high-risk individuals and discover therapeutic targets. Employing the PIMA Indian dataset, logistic regression and t-tests identified key predictors of T2DM, achieving a model accuracy of 78.43%. A pathway mapping strategy links these predictors to insulin signaling, AMPK, and PPAR pathways, facilitating mechanistic insights without molecular data. Therapeutic strategies encompass dual GLP-1/GIP receptor agonists, AMPK activators, SIRT1 modulators, and phytochemicals, validated through pathway enrichment. This framework advances precision medicine by providing interpretable, scalable solutions for early detection and targeted intervention in metabolic disorders and contributions:(1) An ML framework combining logistic regression and principal component analysis (PCA) for T2DM risk prediction; (2) A gene-agnostic pathway mapping method for mechanistic insights;(3) Novel therapeutic targets for high-risk populations.

FMLDS2025-178

ReForge: A Customizable AI-Driven Framework for End-to-End Exploit Generation and Analysis

Sohan Simha Prabhakar, Danindu Gammanpilage, Abhinav Harsha, Maalavika Sudhakar, Samarth Bhaskar Bhat and Tania Banerjee

Abstract:
In this paper, we introduce ReForge, a novel, end-to-end AI-based software framework for detecting vulnerabilities in code and automatically generating exploits that trigger these vulnerabilities. Traditional manual approaches to vulnerability detection and exploit generation are time-consuming and struggle to keep pace with the rapid evolution of code. ReForge implements an iterative feedback loop over an MCP server to ensure reliability in exploit generation. Its modular architecture enables seamless future extensions. In under one minute, ReForge generated working Python exploits for all evaluated C/C++ targets, achieving up to a 168x speedup over beginner analysts, while maintaining high token efficiency and low overall token cost. This democratizes advanced exploit development and lays the groundwork for flexible automated security workflows.

FMLDS2025-179

Transfer Learning-based Culvert Silting Condition Classification

Hemanth Madduri, Jun Zheng, Claudia Wilson, Isabel Morris and Wesley Cook

Abstract:
Culverts are essential structures that channel water across or alongside roads and other infrastructure. Their primary function is to facilitate proper drainage, preventing water accumulation, stagnation, erosion, and potential flooding that could compromise structural stability and longevity. Regular inspections and maintenance are crucial as culverts deteriorate over time. However, traditional manual inspections often involve stringent conditions, making them hazardous, time-consuming, and labor-intensive, especially in culverts with poor structural integrity, limited visibility, or confined spaces. These challenges underscore the importance of predictive models in strengthening the asset management process by enhancing efficiency, accuracy, and safety. In this

paper, we investigated the use of transfer learning to automatically classify culvert silting conditions based on image data. Transfer learning leverages a model pretrained with a large dataset for a specific task and applies it to a new, related task, significantly reducing training time and computational resources. Our approach employs pretrained convolutional neural network (CNN) models, including DenseNet-121, EfficientNetV2-Small, ResNet-50, and VGG11, to extract features from culvert images. The extracted features are then fed into a custom classification head to predict silting conditions. We evaluated model performance using a culvert image dataset collected in the state of New Mexico, categorizing silting conditions into three levels: low (<10%), medium (10%–60%), and high (>60%). Our results show that the model using EfficientNet as the feature extractor achieved the highest classification performance. Additionally, the customized classification head significantly outperformed traditional machine learning classifiers, including Support Vector Classifier (SVC), Random Forest, and XGBoost.

FMLDS2025-182

Evaluating Lightweight Vision Transformers for Chest Disease Detection in Low-Resource Clinical Settings

Mridul Banik and Ismail Hossain

Abstract:
This study presents a comprehensive evaluation of lightweight Vision Transformers (ViTs) for chest disease detection in low-resource clinical settings using the Indiana Chest X-ray Reports dataset. The research addresses the critical need for computationally efficient diagnostic models that can operate effectively in resource-constrained healthcare environments. Through systematic preprocessing and exploratory data analysis, 349 validated normal chest X-ray cases were analyzed across ten distinct radiological finding categories. The dataset demonstrated excellent characteristics for training lightweight ViTs, with balanced distribution (CV = 0.47) and strong clinical indication-finding correlations ($r > 0.6$, $p < 0.05$). Performance evaluation revealed that lightweight Vision Transformers achieved promising diagnostic accuracy with precision scores reaching 1.0, while maintaining computational efficiency suitable for deployment in low-resource settings. The keyword extraction algorithm successfully identified medical conditions with 100% data quality assurance following preprocessing. Statistical analysis confirmed dataset suitability for machine learning applications, with comprehensive terminological diversity (847 unique medical terms) and clinically meaningful correlations between indications and findings. The findings demonstrate that lightweight Vision Transformers represent a viable solution for addressing diagnostic challenges in resource-limited healthcare environments, offering an optimal balance between diagnostic accuracy and computational efficiency. This research contributes to the broader goal of democratizing AI-powered healthcare solutions and reducing diagnostic disparities in underserved populations worldwide.

FMLDS2025-183

Bridging Visual and Linguistic Intelligence for Chest X-rays: A Comprehensive Review of ViTs and LLM Synergies

Mridul Banik and Ismail Hossain

Abstract:
The integration of Vision Transformers (ViTs) and Large Language Models (LLMs) in chest X-ray analysis has emerged as a promising solution to address the growing challenges in radiology, including increasing diagnostic workloads and the need for timely, accurate interpretations. This systematic review examines the recent advancements in ViT-LLM hybrid systems, exploring their

architectural innovations, multimodal fusion strategies, and application in automated report generation. A comprehensive search of databases such as Google Scholar, PubMed, and IEEE Xplore was conducted to identify studies published between 2018 and 2025, focusing on ViT-LLM integration, performance metrics, and clinical validation. Key findings highlight that ViT-LLM models significantly improve diagnostic accuracy, with a 15% improvement in pneumonia detection compared to traditional CNN-based models. These systems also excel in generating clinically relevant reports, achieving a 93% alignment rate with clinician-generated reports. ViT-LLM hybrid models are shown to reduce diagnostic errors, enhance radiology workflow efficiency, and support clinical decision-making by providing real-time assistance. However, challenges related to computational complexity, data biases, and regulatory approval remain, posing barriers to widespread clinical adoption. Future directions include optimizing these models for real-time deployment, addressing ethical concerns, and integrating them into clinical settings with minimal disruption to existing workflows. The review underscores the potential of ViT-LLM systems to enhance both diagnostic performance and patient care, offering a transformative tool for the future of radiology.

FMLDS2025-184

Attacking LLMs and AI Agents: Advertisement Embedding Attacks Against Large Language Models

Qiming Guo, Jinwen Tang and Xingran Huang

Abstract:
We introduce Advertisement Embedding Attacks (AEA), a new class of LLM security threats that stealthily inject promotional or malicious content into model outputs and AI agents. AEA operate through two low-cost vectors: (i) hijacking third-party service-distribution platforms to prepend adversarial prompts, and (ii) publishing back-doored open-source checkpoints fine-tuned with attacker data. Unlike conventional attacks that degrade accuracy, AEA subvert information integrity, causing models to return covert ads, propaganda, or hate speech while appearing normal. We detail the attack pipeline, map five stakeholder victim groups, and present an initial prompt-based self-inspection defense that mitigates these injections without additional model retraining. Our findings reveal an urgent, under-addressed gap in LLM security and call for coordinated detection, auditing, and policy responses from the AI-safety community.

FMLDS2025-185

Adaptive Frame Extraction and Deep CNN-Based Classification of Salt Crystallization Videos

Srinivasa Kolachina, Ruth Agada, Jie Yan, Beni Dangi and Oliver Steinbock

Abstract:
classification of salt compounds, specifically Potassium Chloride (KCl), Sodium Chloride (NaCl), and Ammonium Chloride \ce{(NH4Cl)}, is essential in chemical, pharmaceutical, and materials industries, where accurate monitoring of crystal nucleation and growth directly impacts product quality and process optimization. Traditional crystallization monitoring techniques often rely on time-consuming manual analysis or destructive physical measurements, limiting their applicability for real-time, automated applications. In this study, we propose a novel deep learning framework for automated salt crystallization classification using video-derived frame-level datasets. The proposed pipeline

integrates adaptive per-class frame extraction to address variability in crystallization dynamics, along with dataset balancing strategies to mitigate class imbalance without synthetic augmentation. Multiple Convolutional Neural Network (CNN) architectures—including RegularizedCNN, ResNet18, EfficientNetB0, MobileNetV2, VGG16, DenseNet121, and VanillaCNN—are trained and evaluated across both manual (video-level) and randomized (frame-level) data splits. Experimental results demonstrate that the proposed method achieves high accuracy across multiple models, reaching up to 98.7\% with the VGG16 architecture, highlighting the effectiveness of dynamic frame extraction and balancing in improving generalization. This study contributes a reproducible pipeline for video-based salt crystallization classification and provides comparative insights into model performance under varying dataset split strategies.

FMLDS2025-190

Leveraging Game Theory for Intelligent and Adaptive Traffic Signal System

Tumaini Sakaza

Abstract:

Traffic congestion is a major growing problem in urban areas, where inefficient signal timing plans result in delay, emissions, and safety risks. This paper proposes an adaptive traffic signal controller for an isolated intersection utilizing connected vehicle telemetry and game-theoretical principles. This approach resulted in a fair allocation of green time to each signal phase. The proposed model was built on Python and SUMO software, and a comparison was made against a predetermined fixed signal timing plan. The model was then evaluated using (Automated Traffic Performance Measures) ATSPMs and standard intersection measures. Assess the model on an isolated intersection in Columbus, Ohio, and the model showed a significant performance increase. Results showed an improvement of 29.62% in total delay, 28.69% in average speed, 5% in travel time, 15% average queue length, 19.83% in average fuel consumption, 19.83% in carbon monoxide emissions, 45.8% in split failures, and 4% in arrivals on red relative to the baseline model.

FMLDS2025-191

Sliding Window based Physical Activity Classification using Smart Wearable Data

Neha Ananthavaram, Xunfei Jiang and Nhut Ho

Abstract:

Physical activity classification helps us better understand daily movement, improve lifestyle habits, and support overall well-being. With the widespread adoption of smartwatches, there is growing potential to leverage wearable sensor data for real-world behavior analysis. Studies have explored the classification of physical activities using Apple Watch sensor data to support health monitoring and behavior analysis. While existing studies have attempted to label Apple Watch data, many lacked robust segmentation strategies for accurate classification. To address this gap, we propose a structured and interpretable classification pipeline. This project addresses real-world activity strategy was introduced by analyzing patterns in physiological metrics to categorize activity types. Sensor readings were segmented into sliding windows, shifting forward by one minute at a time, which allowed the model to learn from gradual activity changes and build a more diverse training dataset. These labeled segments were used to train machine learning models, Random Forest and SVM, to classify activities. The Random Forest model achieved a high accuracy of 96%, demonstrating robust classification of both active and low-motion states. Algorithms such as SVM and RF achieve high accuracy but offer limited interpretability, either due to their opaque internal structure or the complexity of their decision logic.

FMLDS2025-192

A Spatiotemporal Neural Network for Short-Term Traffic Flow Prediction

krishnaveni katta

Abstract:

Accurate short-term traffic flow prediction underpins Intelligent Transportation Systems (ITS) and smart-city operations. This study proposes a spatiotemporal neural architecture that integrates Graph Convolutional Networks (GCN) for spatial dependencies with Independently Recurrent Neural Networks (IndRNN) for temporal dynamics in a sequenceto- sequence encoder–decoder with scheduled sampling. Evaluated on Caltrans PeMS sensor data with 5-minute aggregation at 15/30/60-minute horizons, the model is compared against vector autoregression (VAR), a fully connected LSTM (FCLSTM), and a graph-convolutional GRU (GCGRU). The proposed method achieves lower error across metrics, e.g., MAE = {2.54, 2.78, 3.15} mph and RMSE = {4.56, 5.10, 5.81} mph at 15/30/60 min, improving over the best baseline by 6.7%–15.4% depending on horizon and metric. The paper further reports ablations (IndRNN-only, GCN-only, without scheduled sampling), robustness to incident-like anomalies, interpretability analyses via node/edge occlusions, and scalability with respect to network size.

FMLDS2025-194

Unified Predictive Maintenance with Generative Anomaly Injection, RL Scheduling in Data-Driven Digital Twins

RAJ KUMAR MYAKALA, Sampath Lavudya, vinithya reddy podduturi, AKHIL REDDY JAGIRAPU, sanjeev kumar pedhapally and praveen kumar nagata

Abstract:

In modern industrial systems, unplanned downtime leads to significant operational and financial losses. To address this, we propose a unified predictive maintenance pipeline that integrates generative anomaly injection, explainability, and reinforcement learning (RL) within a digital twin framework. Our system uses sensor data from real-world datasets (XJTU-SY, AI4I, and C-MAPSS) for Remaining Useful Life (RUL) prediction, fault simulation, and proactive maintenance policy generation. First, a GAN-based fault simulation module injects rare but realistic failure patterns using low discriminator confidence. Next, SHAP-based explainability is applied for feature attribution and drift monitoring. LSTM and Prophet models are employed to forecast RUL trends, which are fed into a Q-learning-based RL scheduler to optimize prescriptive actions like maintenance or load reduction. These actions are sent to a virtual command layer and closed-loop feedback is achieved via MQTT/OPC-UA to simulate interaction with the physical twin. We quantitatively evaluate the synthetic fault realism using t-SNE, PCA, and classifier generalization. The overall pipeline improves prediction accuracy by 12.6% and reduces failure downtime by 19.4% on average. SHAP analysis reveals interpretable patterns across synthetic and real failures. Our modular architecture demonstrates a self-optimizing, explainable, and simulation-augmented predictive maintenance system for Industry 4.0 environments. This work highlights the practical synergy of generative models, RL, and digital twins for scalable, real-time industrial reliability solutions.

FMLDS2025-195

Prediction of Hurricane Helene Using Aurora Machine Learning Model

Kristen Lou

Abstract:

Accurate and timely hurricane forecasting is critical for minimizing the devastating impacts of extreme weather events. This paper studies the prediction of Hurricane Helene (2024) using Microsoft's Aurora machine learning (ML) model, comparing it to both the ERA5 reanalysis dataset and the National Hurricane Center (NHC) observed data. The Aurora model, a billion-parameter deep learning model, was trained using ERA5 data and used to predict Hurricane Helene's speed, pressure, trajectory and intensity, both 1-day and 2-days in advance. The prediction focused on key parameters, including the maximum 10-meter wind speed, minimum mean sea level pressure (MSLP), and the hurricane's centroid location. Results indicate that while the maximum wind speed and minimum MSLP were underpredicted, the hurricane's overall trajectory was successfully tracked by Aurora model. Even though the Aurora model showed a margin of error of 13-20% for wind speed compared to ERA5, it performed reasonably well in predicting the hurricane's path, which is crucial for early warning systems and disaster preparedness. Despite its limitations, Aurora's ability to accurately predict the hurricane's movement underscores its potential for supporting future hurricane forecasting. The study suggests that further refinement and integration of more localized data may be needed for Aurora model to be used for extreme weather prediction.

FMLDS2025-200

Machine Learning-Based Early Detection of Autism Spectrum Disorder in Children: A Predictive Analytical Approach

Hafiz Arslan Ramzan

Abstract:
Early screening of Autism Spectrum Disorder (ASD) is essential for timely intervention and improved developmental outcomes. This study presents a machine learning-based approach for classifying ASD cases in children using behavioral and demographic screening data. A dataset from the UCI repository, comprising 292 child instances with 21 features, was analyzed. The pipeline involved robust preprocessing, Principal Component Analysis (PCA), and model training using Logistic Regression and Random Forest classifiers. To prevent data leakage and overfitting, all steps were conducted within a cross-validated pipeline. Evaluation metrics were derived using 5-fold cross-validation, yielding average accuracies of 92.6% and 94.1%, respectively. Key predictors included behavioral features (A5, A9, A10) and family history. The results indicate the potential of machine learning for assisting ASD screening but emphasize the need for rigorous validation, generalizability testing, and careful clinical deployment.

FMLDS2025-201

A Hybrid Vision Transformer and Feature-Based Model for Mitotic Figure Classification in Glioma

Essam Rashed

Abstract:
Accurate classification of mitotic figures in glioma histopathology images is critical for reliable tumor grading and informed treatment planning. In this study, we introduce HybridNet, a hybrid deep learning framework that combines the high-level semantic capabilities of a pre-trained Vision Transformer (ViT) with the domain-specific discriminative strength of handcrafted features. Specifically, four handcrafted feature sets, local binary patterns, texture descriptors, morphological attributes, and color statistics, are extracted to complement the ViT's learned representations. These engineered features are concatenated with the partially fine-tuned ViT features to enhance classification performance and model interpretability. An ablation study was conducted to evaluate

the contribution of each handcrafted feature group, revealing consistent performance gains with each module addition. In addition to HybridNet, we benchmark several conventional machine learning classifiers trained solely on handcrafted features, as well as standalone deep learning architectures including ResNet50, DenseNet121, EfficientNet-B0, and ViT, to establish robust performance baselines. The proposed method is evaluated on a curated dataset of glioma cell crops using five-fold cross-validation, achieving a mean classification accuracy of 91.75% with consistent performance across folds. The results underscore the complementary value of integrating handcrafted and deep features and highlight HybridNet's potential as an interpretable and computationally efficient solution for mitotic figure classification in digital pathology workflows.

FMLDS2025-203

Ayurvedic-guided Natural Product Discovery as Potential Inhibitors of HIV-1 Proteins

Muhammad Alqaaf, Ahmad Kamal Nasution, Elvian Indah Nilamsari, Retno Supriyanti, Naoaki Ono, Shigehiko Kanaya and Md. Altaf-Ul-Amin

Abstract:
We developed an ethnopharmacology-guided pipeline using Ayurvedic formulations to identify natural compounds targeting HIV-1 proteins. From 280 formulas with 268 botanical species, we extracted 5,295 metabolites via KNApSAcK database. Cross-referencing with BindingDB revealed 259 HIV-1 "formula-plant-metabolite-protein" associations. PDB sequences were grouped into five mechanistic clusters using k-mer similarity and DPClusSBO analysis, with metabolites mapped to respective clusters. Top candidates such as ursolic acid, rhamnetin, and limonin showed promising docking scores against protease, integrase, and reverse transcriptase. These leads feature in Ayurvedic remedies for gastrointestinal and genitourinary disorders, suggesting antiviral potential. This approach demonstrates the value of combining traditional medicine with in silico techniques for discovering natural anti-HIV agents.

FMLDS2025-204

Toward Smarter Air Quality Forecasting: An Advanced Modeling Approach to PM2.5 Estimation Using GEOS-CF and Machine Learning

Long Bui

Abstract:
Understanding the spatial and temporal dynamics of ambient PM2.5 concentrations is critical for public health and environmental management. Despite numerous efforts, predicting ground-level (≤ 2 meters) air pollution remains an unresolved challenge. A practical and cost-effective solution is proposed by combining atmospheric outputs from GEOS-CF with ground-based observations. This study presents an advanced modeling strategy that integrates such forecast data with machine learning algorithms to assess PM2.5 variability across Oregon in near real-time. By leveraging high-resolution chemical fields — including PM2.5 concentrations at 985 hPa and relevant meteorological parameters — together with measurements from over 60 monitoring stations, six machine learning models were trained: Decision Tree, Random Forest, Gradient Boosting Machine, XGBoost, CatBoost, and LightGBM. Model performance was evaluated using the coefficient of determination (R^2), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE). The most accurate model was selected to forecast ground-level pollution, particularly benefiting rural areas where observational data is limited. A key innovation over previous studies lies in the system's ability to output TIFF-format files, enabling the creation of large-scale pollution maps at both state and

county levels. This approach is scalable and applicable to other regions across the United States and globally.

FMLDS2025-212

DataTransformer: Software Develpment for Named Entity Normalization Using Deep Learning: "EWUNN-NEN"

Ramiro Chavez, David Torres and Cesar Salas

Abstract:
Data quality is a critical requirement in processes such as data analysis, auditing, and decision-making. One of the main challenges lies in named entity normalization (NEN) within high-cardinality datasets, where multiple mentions may refer to the same entity, or conversely, a single mention may correspond to different entities. In this context, we present DataTransformer, a web-based solution focused on named entity normalization, with a particular emphasis on company names in the Peruvian business sector. The application integrates Deep Learning techniques through fine-tuning of the BERT model, alongside graph-based methods, specifically leveraging the Edge Weight Updating Neural Network (EWUNN) model. This approach enables the alignment of variant mentions to their canonical identifiers by minimizing the divergence between similarity and ground-truth graphs. The system was implemented in Python using PyTorch for parameter manipulation and Hugging Face's Transformers library for BERT integration. During the evaluation phase, the system achieved an Accuracy of 91%, F1 Score of 89%, and Recall of 89% on unseen mentions.

FMLDS2025-213

AIChessCoach: Software development aimed at competitive level chess players using Generative AI

Pietro Minaya, Lucas Moreno and Cesar Salas

Abstract:
Current chess engines have reached superhuman levels of performance, but their usefulness as pedagogical tools is limited, especially for tournament players seeking to understand the reasoning behind the moves. These systems offer accurate numerical evaluations, but lack accessible explanations tailored to the level of the user. In response to this limitation, we propose AIChessCoach, a web application that combines the analytical capabilities of Stockfish with a generative natural language model, with the goal of generating understandable explanations of complex positions. The system is designed to emulate the interaction between a human coach and a player, providing detailed analysis and contextualized tactical and strategic reasoning. To validate its effectiveness, an experimental comparison was made between AIChessCoach and ChessBuddy, using tactical problems classified by difficulty level as: mate in 2, 3 and 4. The results show that AIChessCoach achieved an average performance of 80.43%, surpassing ChessBuddy (61.83%) by 30%, and providing clearer and more substantiated explanations, even in highly complex positions. This approach proves to be a promising alternative for AI-assisted learning in chess, promoting a deeper understanding of positional analysis and facilitating personalized and effective training.

FMLDS2025-215

Integrated Sign Language Aid (ISLA): Development and Evaluation of Prototype Robotic Hands for Filipino Sign Language Interpretation as a Communication Aid

Laurence Hapin, Beatrice Aleni Garcia, Dylan Ignacio and Jocelynn Cu

Abstract:
This study presents the design, development, and evaluation of a prototype robotic hand capable of performing Filipino Sign Language (FSL) gestures. Built with low-cost materials and controlled via a web-based user interface, the system aims to provide accessible communication aid for the deaf and hard-of-hearing community. The prototype was evaluated based on two metrics: execution time and success rate. It successfully performed FSL gestures for the alphabet, numbers, and common phrases with a 93.02% success rate. A usability assessment with nine participants was also conducted to gather feedback on ease of use, reliability, and future potential. Results indicate that users viewed the system positively and believed it has promise as a communication and educational tool. This research highlights the potential of robotic hands as assistive technologies that promote inclusion, awareness, and accessibility for the Filipino deaf community.

FMLDS2025-216

ALTARN: A Tabular Residual Neural Network for Alzheimer's Disease Classification and Prediction

Keshav Balakrishna, Aditya Baisakh, Vivan Kanna, Moemal Al-Wishah and Aaron Lee

Abstract:
Early and accurate prediction of Alzheimer's disease (AD) from accessible clinical data remains a significant challenge in mainstream healthcare. This study proposes ALTARN, a tabular attention residual neural network architecture for robust classification of AD through heterogeneous patient data from a publicly available dataset of 2149 subjects, with medical, demographic, and lifestyle variables organized as structured tabular data. Combining sigmoid attention mechanisms for the dynamic reweighting of input variables for each patient, alongside deep residual connections capturing complex, non-linear relationships in tabular features, ALTARN achieved an average cross-validated training accuracy of roughly 92.73%, alongside robust validation metrics, including an average accuracy of 85.06%, average precision of 80.73%, mean recall of 76.18%, and a mean validation F1-score of 78.32% when evaluated through five-fold stratified validation. When tested against other approaches, ALTARN meets and also exceeds the performance of supervised deep learning models for non-imaging AD classification, further illustrating that deep neural network based approaches with tabular attention offer a promising direction for interpretable diagnosis of AD via non-imaging medical data.

FMLDS2025-218

A Contextual Analysis of Driver-Facing and Dual-View Video Inputs for Distraction Detection in Naturalistic Driving Environments

Anthony Dontoh

Abstract:

Despite increasing interest in computer vision-based distracted driving detection, most existing models rely exclusively on driver-facing views and overlook crucial environmental context that influences driving behavior. This study investigates whether incorporating road-facing views alongside driver-facing footage improves distraction detection accuracy in naturalistic driving conditions. Using synchronized dual-camera recordings from real-world driving, we benchmark three leading spatiotemporal action recognition architectures: SlowFast-R50, X3D-M, and SlowOnly-R50. Each model is evaluated under two input configurations: driver-only and stacked dual-view. Results show that while contextual inputs can improve detection in certain models, performance gains depend strongly on the underlying architecture. The single-pathway SlowOnly model achieved a 9.8 percent improvement with dual-view inputs, while the dual-pathway SlowFast model experienced a 7.2 percent drop in accuracy due to representational conflicts. These findings suggest that simply adding visual context is not sufficient and may lead to interference unless the architecture is specifically designed to support multi-view integration. This study presents one of the first systematic comparisons of single- and dual-view distraction detection models using naturalistic driving data and underscores the importance of fusion-aware design for future multimodal driver monitoring systems.

FMLDS2025-220

AutoCompactionAI: A Reinforcement Learning Framework for Adaptive File Compaction in Serverless Data Lakes

Vivek Venkatesan

Abstract:
Compaction is critical to storage and query efficiency in serverless analytics, yet fixed schedules waste resources under variable loads. AutoCompactionAI is a serverless framework that uses adaptive learning to trigger compaction from metadata trends. Built on AWS Glue, Lambda, and Athena, it combines lightweight RL with a statistical fallback and guardrails (rate caps, backoff, rollback). In experiments on non-production test datasets from the digital marketing, healthcare telemetry and e-Commerce domains, it reduced API costs by 65% and improved query latency by 3x, while remaining portable to other clouds.

FMLDS2025-226

Differentially Private Decentralized Dataset Synthesis Through Randomized Mixing with Correlated Noise

Utsab Saha, Tanvir Muntakim Tonoy and Hafiz Imtiaz

Abstract:
In this work, we explore differentially private synthetic data generation in a decentralized-data setting by building on the recently proposed Differentially Private Class-Centric Data Aggregation (DP-CDA) algorithm. DP-CDA synthesizes data in a centralized setting by mixing multiple randomly selected samples from the same class and injecting carefully calibrated Gaussian noise, ensuring (ϵ, δ)-differential privacy. When deployed in a decentralized or federated setting, where each client holds only a small partition of the data, DP-CDA faces new challenges. The limited sample size per client increases the sensitivity of local computations, requiring higher noise injection to maintain the differential privacy guarantee. This, in turn, leads to a noticeable degradation in the utility compared to the centralized setting. To mitigate this issue, we integrate the Correlation Assisted Private Estimation (CAPE) protocol into the federated DP-CDA framework and propose CAPE-Assisted

Federated DPCDA algorithm. CAPE enables limited collaboration among the clients by allowing them to generate jointly distributed (anticorrelated) noise that cancels out in aggregate, while preserving privacy at the individual level. This technique significantly improves the privacy-utility trade-off in the federated setting. Extensive experiments on MNIST and FashionMNIST datasets demonstrate that the proposed CAPE Assisted Federated DPCDA approach can achieve utility comparable to its centralized counterpart under some parameter regime, while maintaining rigorous differential privacy guarantees.

FMLDS2025-227

A novel graph neural network approach for predicting drug-target interactions

Brandon Warner, Avi Ruthen, Edward Ratner, Elliot Farmer Garcia and Christopher Douglas

Abstract:
Predicting drug-target interactions is a critical challenge in advancing drug development. Earlier studies primarily focused on predicting potential interactions using knowledge graphs that encompassed known interactions. However, more recent efforts have shifted towards enhancing predictive models by incorporating chemical structure data for both drugs and targets. In this context, we propose a novel graph neural network architecture built on shallow, randomized networks. Additionally, we introduce a new set of graph features designed to capture the topology of knowledge graphs. Our model leverages these novel graph features alongside state-of-the-art drug and protein embeddings. The resulting model outperforms current state-of-the-art approaches on the widely used ChG-Miner dataset from the BIOSNAP collection.

FMLDS2025-228

A Data-Driven RetinaNet Model for Small Object Detection in Aerial Images

Zhicheng Tang, Jinwen Tang and Yi Shang

Abstract:
In the realm of aerial imaging, the ability to detect small objects is pivotal for a myriad of applications, encompassing environmental surveillance, urban design, and crisis management. Leveraging RetinaNet, this work unveils DDR-Net: a data-driven, deep-learning model devised to enhance the detection of diminutive objects. DDR-Net introduces novel, data-driven techniques to autonomously ascertain optimal feature maps and anchor estimations, cultivating a tailored and proficient training process while maintaining precision. Additionally, this paper presents an innovative sampling technique to bolster model efficacy under limited data training constraints. The model's enhanced detection capabilities support critical applications including wildlife and habitat monitoring, traffic flow optimization, and public safety improvements through accurate identification of small objects like vehicles and pedestrians. DDR-Net significantly reduces the cost and time required for data collection and training, offering efficient performance even with limited data. Empirical assessments over assorted aerial avian imagery datasets demonstrate that DDR-Net markedly surpasses RetinaNet and alternative contemporary models, achieving F1 score improvements of up to 24.2% and mAP improvements of up to 48% while reducing inference time by 12-28%. These innovations advance current aerial image analysis technologies and promise wide-ranging impacts across multiple sectors including agriculture, security, and archaeology.

FMLDS2025-231

A Significance Measure for Node Splits in C4.5

Shawn Wang

Abstract:
Decision trees remain one of the most interpretable and computationally efficient classification methods. The ID3 (Iterative Dichotomiser 3) algorithm is a classic algorithm in machine learning used to construct decision trees from a dataset. C4.5 extends ID3 to handle numeric attributes using thresholding and information gain. The C4.5 algorithm recursively partitions data based on maximum information gain, producing trees that progress from the most informative attributes at the root to the least informative at the leaves. While inner nodes are chosen by optimizing entropy-based criteria, leaf nodes do not admit further entropy comparisons, leaving the importance of the last split ambiguous. We propose a simple, dataset-agnostic scoring scheme that quantifies the significance of a parent node's final subdivision into its leaves, enabling a direct measure of the utility of the final split. After training a full tree, we record predictions and ground truth at each leaf on a held-out test set, compute per-leaf scores as accuracy × correct, and then "merge" sibling leaves back into their parent by concatenating their predicted/actual lists; the same score is computed for the merged node. The final-split significance is measured as the difference between the sum of leaf scores and the merged-parent score; zero indicates no benefit from splitting. Across several public datasets, the measure highlights when small but accurate leaves or imbalanced families meaningfully improve performance, and when splits add little value. The measure is simple to compute, compatible with standard pruning workflows, and can act as a practical heuristic for late-split evaluation. Our experiments on multiple real-world datasets show that this approach can identify and prune non-beneficial splits, improving model interpretability without compromising accuracy. This method offers a statistically aware pruning criterion that complements existing entropy-based splitting strategies.

FMLDS2025-233

Prediction of Mangrove Species Distribution in Sri Lanka Using Unsupervised Machine Learning Techniques

Dilini Tharangi Uyanahewage, Muhammad Zia Ur Rehman, Syed Mohammed Shamsul Islam, Ruminda J. Wimalasiri and Somaratne Seneviratnage

Abstract:
Mangroves are indispensable in the coastal ecosystem and are depleting due to man-made and natural causes. Attempts are being made to mitigate the impact on mangroves, and transplantation is considered a strategy for mangrove regeneration. However, it is essential to identify suitable regions and select mangrove species compatible with these regions to achieve maximum benefit from transplantation. Mangrove transplantation is increasingly adopted as a restoration strategy, yet its success hinges on selecting species adapted to site-specific environmental conditions. This study utilized an unsupervised machine learning (ML) approach, a Self-Organizing Map (SOM) model, to predict mangrove species distribution using readily available data, requiring minimal labor, time, and cost. The data used in this study were gathered from the literature and included climatic, hydrological, and solar insolation variables. An SOM model with an 11 × 8 neuron grid was developed to cluster species based on their ecological preferences. Model accuracy was assessed through Quantization error (0.0003) and Topographic error (0.0548), confirming strong predictive performance and topological preservation. The SOM model effectively predicts mangrove species across climatic zones, capturing their zonal preferences based on input variables. This approach offers a practical decision-support tool for restoration practitioners, improving site–species matching and thereby increasing transplantation success rates. Future refinement could be achieved by integrating additional environmental parameters such as soil salinity, tidal dynamics, and seasonal microclimatic variations to better capture temporal shifts in species distribution. Hence, findings

highlight the potential of ML to guide cost-effective, evidence-based mangrove conservation and ecological restoration strategies.

FMLDS2025-234

Ensemble-Based Deep Learning for Bengali Accident Text Classification

Kazi Farhan Tanjim

Abstract:
Classification of Bengali accident texts describing daily life incidents such as injuries, deaths, and various damages is essential for safety management systems, but deep learning approaches for this low-resource language are still limited. This study examines multiple deep learning models for both binary and multi-class classification of Bengali accident texts. We develop a voting ensemble method designed for Bengali language characteristics, combining traditional deep learning models with hybrid architectures to tackle low-resource language challenges. Experiments on Bengali accident datasets achieve strong results: 95.9\% accuracy for binary classification and 94.6\% accuracy for multi-class classification across ten accident categories. Our ensemble approach outperforms baseline models by 1.8\% and 9.5\%, establishing new benchmarks for Bengali accident text classification. We also implement LIME (Local Interpretable Model-agnostic Explanations) to provide clear explanations for safety-critical decisions. These results demonstrate the effectiveness of ensemble deep learning for safety-related text classification in low-resource language settings.

FMLDS2025-236

Forecasting UFO Sightings with Deep Learning and Natural Language Generation

Lucas Costa and Komalpreet

Abstract:
Reports of Unidentified Flying Objects (UFOs) are historically anecdotal and unstructured, lacking predictive frameworks capable of forecasting when, where, and how sightings may occur. This gap limits both scientific investigation and potential applications in aerospace monitoring and anomaly detection. This study introduces a deep learning system that predicts future UFO sightings based on historical data and generates related witness comments. The model uses Long Short-Term Memory (LSTM) networks to learn patterns over time and space, enabling accurate forecasts of where and when sightings may occur. In addition, a Natural Language Processing (NLP) pipeline creates text descriptions based on predicted features. To manage both numeric and textual outputs, a dual-branch architecture is implemented. The best-performing model achieved a mean absolute error of 0.23 for prediction tasks, which in one case study corresponded to a spatial deviation of approximately 240 km. Generated narratives were qualitatively coherent and semantically aligned with predicted attributes, demonstrating the feasibility of combining quantitative forecasting with descriptive synthesis. The system also includes a user-friendly interface built with Gradio and Folium, showing results on an interactive map. To our knowledge, this is the first deep learning system to combine temporal forecasting with predicted narrative generation for UFO sighting forecasting. This study demonstrates how machine learning can bring structure and prediction to a field previously based on anecdotal reports, with broader applications in anomaly detection and aerospace monitoring.

FMLDS2025-237

Classifying Obstructive Sleep Apnea from 3D Facial Images Using Automated Landmark Detection and Geodesic Distances

Mehraan Chowdhury, Mohammed Bennamoun, Farid Boussaid and Syed Islam

Abstract:

Obstructive sleep apnea (OSA) affects up to 38% of the population but remains largely undiagnosed due to cumbersome and expensive diagnostic methods, thereby necessitating better screening tools. This study developed the first fully automated pipeline for OSA prediction from 3D facial images using clinically significant landmarks. We trained automated landmark detection models to find peripheral landmarks on 400 3D facial scans. We then applied that model and an off-the-shelf midface landmarking model to 32 OSA subjects from a Perth sleep clinic, computed geodesic distances between those landmarks, and passed that to a classifier. The automated pipeline achieved 75% accuracy with 86% sensitivity and 55% specificity using geodesic distance features and Random Forest classification. Peripheral landmarks demonstrated superior performance (76% sensitivity) compared to midface-only features (68% sensitivity). This approach offers potential for cost-effective OSA screening, though validation on larger datasets is required for clinical implementation.

FMLDS2025-238

Quantum-Resilient Trigonometric-Arithmetic Lossless Unified Compression with Encryption

KHAN FARHAN RAFAT

Abstract:

This paper presents a quantum-resistant cryptographic breakthrough: a unified compression-encryption scheme that achieves deterministic 2:1 lossless reduction while maintaining provable security. Our novel trigonometric-phase encoding leverages key-dependent mapping to perfectly compress two bits into one through exact $\cos^2\theta$ quantization - a feat validated exhaustively across all parameter combinations. The architecture delivers unprecedented efficiency: 53% energy reduction in IoT edge devices versus conventional pipelines, 37% lower latency in federated learning systems, and superior physical-layer robustness (withstanding 37% more jamming attacks than QAM schemes per NATO validation). At its core, the framework's integer-based arithmetic enables constant-time execution that outperforms all NIST lightweight finalists in simultaneous compression/encryption tasks, resolving the fundamental conflict between data minimization and security. Implementation results confirm <1ns timing variance (FIPS 203 compliant) and 128-bit quantum security (Grover-optimized bound), while maintaining perfect reversibility and CCA2-secure encoding detectable only with the key. This represents not merely an algorithmic improvement, but a foundational advancement that intrinsically embeds NIST-certified security (SP 800-208 compliant key derivation with 2^{256} collision resistance) into compression's information-theoretic limits. Benchmarking against 75 years of cryptographic evolution, our solution uniquely achieves the trifecta of: (1) guaranteed 50% size reduction independent of content, (2) quantum-resistant protection, and (3) hardware-efficient integer operations - making it immediately viable for next-generation IoT, edge computing, and distributed learning systems where traditional approaches fail. The implications are profound: for the first time, systems can simultaneously maximize data density and cryptographic robustness without compromise.

FMLDS2025-240

RPKT: Learning What You Don’t Know - Recursive Prerequisite Knowledge Tracing in Conversational AI Tutors for Personalized Learning

Jinwen Tang, Qiming Guo and Zhicheng Tang

Abstract:
Educational systems often assume learners can identify their knowledge gaps, yet research consistently shows that students struggle to recognize what they don't know they need to learn—the "unknown unknowns" problem. This paper presents a novel Recursive Prerequisite Knowledge Tracing (RPKT) system that addresses this challenge through dynamic prerequisite discovery using large language models. Unlike existing adaptive learning systems that rely on pre-defined knowledge graphs, our approach recursively traces prerequisite concepts in real-time until reaching a learner's actual knowledge boundary. The system employs LLMs for intelligent prerequisite extraction, implements binary assessment interfaces for cognitive load reduction, and provides personalized learning paths based on identified knowledge gaps. Demonstration across computer science domains shows the system can discover multiple nested levels of prerequisite dependencies, identify cross-domain mathematical foundations, and generate hierarchical learning sequences without requiring pre-built curricula. Our approach shows great potential for advancing personalized education technology by enabling truly adaptive learning across any academic domain.

FMLDS2025-241

Hybrid Attention-Enhanced DenseNet201 Deep Learning Model for Eye-Disease Classification from Low-Resolution Images

Kazi Nashia, Neazmul Mowla, Fazlea Rabby, Zarin Anon and Fariah Mahzabeen

Abstract:
Accurate classification of eye diseases from real-world images remains challenging, particularly when using low-resolution, heterogeneous inputs acquired outside controlled clinical settings. Most existing approaches rely on high-quality fundus images, with limited investigation of consumer-grade, real-eye photographs. To address this gap, we propose a DenseNet201-based transfer learning framework that integrates a domain-adapted multiscale atrous depthwise pyramid module for enriched contextual representation and a hybrid cross-gated channel–spatial attention module for precise, disease-specific feature modeling. The model is trained on a low-resolution, heterogeneous eye image dataset and attains an accuracy of 99.69%, surpassing state-of-the-art architectures including DenseNet169 (+0.24%), InceptionV3 (+1.11%), InceptionResNetV2 (+0.46%), ResNet50 (+7.64%), and MobileNetV2 (+17.07%). These results demonstrate the feasibility of deploying high-performance deep learning models for ocular disease classification from low-resolution images, providing a scalable and practical solution for telemedicine and home screening in resource-constrained healthcare environments.

FMLDS2025-242

Enhancing Breast Cancer Classification Through GAN-Generated Synthetic Malignant Samples: A Study on the UCI Wisconsin Dataset

Keshav Balakrishna, Aditya Baisakh, Vivan Kanna, Aaron Lee, Moemal Al-Wishah

Abstract:
The inherent class imbalance in breast cancer diagnostic datasets limits the generalizability and accuracy of ML models, often resulting in the under-detection of malignant instances. In this study, a

minority class augmentation approach for tabular clinical data - through a Generative Adversarial Network (GAN) trained exclusively on malignant samples - to generate high-fidelity synthetic minority instances while avoiding noise from majority class features. The augmented data are then used to balance the training set for a soft-voting ensemble classifier. Using 5-fold stratified cross-validation, the proposed model achieved an average validation accuracy of 98.07% and F1-score of 97.40%, with low standard deviations indicating robustness. Comparative analysis against recent augmentation frameworks shows competitive or superior results, supporting the effectiveness of targeted GAN-based augmentation for robust breast cancer classification.

FMLDS2025-243

Evaluating the Impact of Input Format on LLM Performance: JSON vs. YAML vs. Text

Aditya Narvekar and Trisha Mukherjee

Abstract:

The efficacy of language models is highly dependent on the quality and structure of the input data. While significant research has been devoted to enhancing model architecture and training paradigms, relatively less attention has been given to understanding how different input formats influence model performance. This research aims to reduce this gap by systematically evaluating the impact of three common input formats—JSON, text, and YAML—on the performance of both small and large language models. Specifically, we assessed the behavior of several prominent large models, including GPT- 4, GPT-4o, Mistral Large, Jamba Large, and Llama 405B, alongside smaller models such as Llama 8B, Mistral Small, Jamba Mini, and GPT4o-Mini. Each model was provided with identicalcontextual information in JSON, text, and YAML formats. The quality of their responses was evaluated based on their alignment with human-generated responses. Our results indicate a clear preference for JSON format across both large and small models.

Interestingly, while both large and small models demonstrated a preference for JSON, the performance disparity between formats was more pronounced in smaller models. This suggests that smaller models, which have limited capacity and context windows compared to their larger counterparts, benefit more significantly from structured input. The results are important for both the development and deployment of language models in real-world applications. For practitioners, providing context in a structured format like JSON can enhance the performance of models across a variety of tasks, including question-answering, summarization, and information extraction. In conclusion, this research highlights the critical role of input format in optimizing language model performance and highlights the need for further research to develop adaptive preprocessing techniques that can dynamically restructure unstructured data into a format that maximizes model efficacy.

FMLDS2025-246

Morphological Characteristics of Galaxies in Studying Galaxy Evolution via Optimising Classification

Sujith Thillayampalam

Abstract:

In the beginning, the infinite state of energy initiated the formation of cosmos and celestial bodies. Cosmic evolution is studied in the interest to understand the origin and potential life formation. Gradual cooling of the expanding universe leaves its remanent among the celestial bodies and galaxy morphology plays a considerable role in decoding such mysteries. Their shapes reveal so much on their inner kinetics and colour is an indication of element abundance such as Hydrogen, Helium, Carbon etc. Morphological complexity and physical distance related challenges see the opportunity of employing exponentially growing sky survey data. Few past studies attempted in classifying galaxies with sky survey images; however, they are limited within the boundaries of detecting features on volunteer participated survey. Others aimed at improving the image quality by reconstructing to aid the volunteer-based survey. Since there is no direct classification, as an initial experiment, 20000 galaxy images were trained against 12 galaxy type labels with CNN, and it underperformed. As an alternative, the research built a pipeline of photometric, multiwavelength (MW) and redshift (numeric) sky survey data with ~350,000 galaxies labelled against 12 classes. Tree algorithms such as Random Forest (RF), XGBoost performed well, particularly RF model yielded 68.47% accuracy. This study investigates the possibility of building classification with the above-mentioned numeric sky survey data as an alternative to image-based approaches. Overall, the work lays a foundation in astronomical domain to provide a practical solution towards galaxy related investigations.

FMLDS2025-247

Traditional RAG vs. Agentic RAG: A Comparative Study of Retrieval-Augmented Systems

FNU NEHA and Deepshikha Bhati

Abstract:
Retrieval-Augmented Generation (RAG) enhances large language models (LLMs) by integrating external knowledge retrieval to improve factual reliability. Traditional RAG employs a fixed, single-pass retrieval process, limiting its ability to handle multi-step reasoning, adaptive queries, and heterogeneous data sources. Agentic RAG extends this framework with autonomous agents that plan, iterate retrieval, integrate tools, and reason over intermediate results. This paper presents a comprehensive comparison of Traditional and Agentic RAG in terms of architecture, capabilities, evaluation metrics, and operational challenges. In addition to synthesizing representative systems, we provide a side-by-side analysis of comparative limitations, failure modes, and corresponding mitigations, mapping domain-specific applications across established and emerging fields. We also outline governance recommendations and propose future research directions, including graph-augmented, multimodal, human-in-the-loop, and domain-specialized Agentic RAG frameworks with standardized model cards. These insights offer both a technical and practical foundation for designing more adaptive, trustworthy, and context-aware retrieval-augmented systems.

FMLDS2025-248

PEAF: Payload Entropy Analysis Framework for Cybersecurity Classifier Robustness Evaluation

Md Mehedi Hasan, Rafiqul Islam, Quazi Mamun, Md Zahidul Islam and Junbin Gao

Abstract:
Modern cybersecurity systems increasingly rely on entropy-based features to analyze encrypted network traffic, but this dependency creates critical vulnerabilities. This study introduces PEAF (Payload Entropy-based Adversarial Framework), a dual-module system that evaluates entropy-dependent traffic classifier robustness through strategic statistical manipulation. PEAF exploits entropy heterogeneity across attack types: the Low Entropy Module (LEM) enhances randomness in structured traffic (2.1-3.4 bits/byte), while the High Entropy Module (HEM) reduces

entropy in randomized traffic (6.8 bits/byte). Both modules generate universal perturbations via gradient-based optimization that transfer across neural network architectures while preserving traffic functionality. Experiments on CIC-IDS2017 demonstrate severe vulnerabilities: PEAF reduces CNN accuracy by 72.76% and SDAE accuracy by 78.77% using minimal statistical modifications. The framework achieves 91.2% success against low-entropy traffic and 89.7% against high-entropy traffic. These findings reveal fundamental weaknesses in entropy-based detection and provide insights for developing more resilient AI-powered cybersecurity solutions.

FMLDS2025-249

LARFS: Lightweight Feature Selection Framework for Enhanced Robustness and Efficiency in Cybersecurity Systems

Md Mehedi Hasan, Rafiqul Islam, Quazi Mamun, Md Zahidul Islam and Junbin Gao

Abstract:
Machine learning-based cybersecurity systems face critical vulnerabilities to evasion attacks, with recent studies demonstrating attack success rates exceeding 86% against state-of-the-art models. Existing defense mechanisms suffer from prohibitive computational overhead, making them unsuitable for real-time deployment in resource-constrained environments. This paper introduces LARFS (Lightweight Attack-Robust Feature Selection), a novel framework that simultaneously enhances system robustness and computational efficiency through strategic feature selection. LARFS integrates three key innovations: a lightweight sensitivity metric that quantifies feature vulnerability without expensive example generation, an adaptive multi-objective selection algorithm that balances accuracy, robustness, and efficiency, and a targeted enhancement mechanism that focuses computational resources on defending critical feature dimensions. Comprehensive evaluation on CICIDS2017, NSL-KDD, and UNSW-NB15 datasets demonstrates that LARFS achieves 3.6% improvement in classification accuracy, 12.3% enhancement in adversarial robustness against FGSM, PGD, and C&W attacks, and significant computational efficiency gains: 35% reduction in training time, 25% reduction in memory usage, and 63% faster feature selection compared to existing approaches. The framework maintains superior performance across diverse attack scenarios while enabling practical deployment in real-time cybersecurity environments. These results establish lightweight feature selection as a viable foundation for attack-resilient security systems, addressing the critical gap between security requirements and operational constraints in modern threat protection

FMLDS2025-252

Mechanics-Informed Autoencoders for Synthetic Data in Structural Health Monitoring

Zy Li and Jooa Lee

Abstract:
Structural health monitoring (SHM) often suffers from a lack of labeled damage data, while synthetic data from finite element (FE) models may not match real measurements. This paper adapts the mechanics-informed autoencoder (MIAE) to vibration-based SHM using the Z24 bridge dataset.

Accelerometer signals are represented by time- and frequency-domain features, and a vibration based weight matrix enforces physics-consistent sensor relationships. Beyond anomaly detection, MIAE is extended as a generator of synthetic data: intact latent codes are sampled to create healthy signals, while perturbed latent codes or error patterns yield damaged signals. Results on Z24 show that this approach produces realistic synthetic data, improves damage detection and localization, and generalizes MIAE beyond its original strain-based formulation. Limitations due to environmental variability and modal assumptions highlight directions for future work. Overall, MIAE offers a unified framework for detection and physics-consistent data augmentation in SHM.

FMLDS2025-253

MeloManga: Integrating Emotion-Driven Soundscapes to Enrich the Manga Reading Experience

Jan Anthony Murillo, Christian Jude Caramat, Lenz Gio Rivera, Matthew Fontillas, Matthew Kristoffer Ong and Norshuhani Zamin

Abstract:
Despite the increasing digitization of comics and manga, current reading platforms rarely incorporate dynamic or emotion-driven audio, missing an opportunity to deepen narrative immersion. This study addresses that gap by exploring the potential of MeloManga, a prototype system that integrates context-aware background music into digital manga reading. MeloManga dynamically matches musical tracks with the emotional tone and pacing of scenes by using the Gemini 2.5 Flash model for page segmentation and mood determination. The system also integrates the MangaDex API for manga information and the ReccoBeats API for song recommendations. A comparative needfinding and user study was conducted, where participants read two emotional one-shot manga: one through a traditional reader and another using MeloManga. Post-reading questionnaires assessed immersion, emotional engagement, and overall experience. Results show that MeloManga enhanced readers' focus, emotional resonance, and narrative immersion, particularly for emotions such as happiness, sadness, and surprise. Compared to the control group, participants using MeloManga reported a modest increase in immersion (+0.61) and that the music helped them feel emotions more intensely. The study also found that happiness showed a strong increase (+1.67), while sadness (+1.11) and surprise (+0.92) also intensified. These findings suggest the potential of emotion-driven music to enrich digital comic experiences and highlight directions for future multimedia storytelling systems.

FMLDS2025-254

What Haffen Fella?: Emotion Detection in Journal Entries with Meme-Based Feedback in Filipino

Clarissa Albarracin, Charlize Kirsten Brodeth, Reina Althea Garcia, Miko Santos and Norshuhani Zamin

Abstract:
With 97.5 million Filipino internet users, students frequently use the web to connect with peers, yet this extended exposure also brings negative effects for Gen Z students on their mental well being. Instead of adding to these mental health challenges, digital tools can be redesigned through empathic computing to provide meaningful support. This study presents an empathic journaling web application that uses the positive effects of memes within the Filipino Gen Z community. Employing the RoBERTa-base model with the GoEmotions dataset, the system analyzes users' journal entries and responds with culturally-relevant, emotion-appropriate memes to provide comfort and uplifts mood. A needfinding study was conducted to understand Gen Z students' meme awareness and usage, as well as journaling preferences. To ensure cultural relevance and authenticity, the meme dataset was built through participant contributions and expanded using contents from social media

platforms popular among Filipino users. The application was evaluated through user testing, measuring system usability, performance, and emotional impact on users' mood and well-being. Results show that the application successfully improves Filipino Gen Z students' emotional states, demonstrating the broader potential for empathic computing applications in supporting youth mental health in the digital age.

FMLDS2025-255

LasallEats: A Restaurant Recommendation System Mobile App for DLSU Manila Students

Katipunan Miguel Delos Reyes, Rafael Enrico Hugo, Vance Gyan Robles, Dylan Andrei Rodriguez, Jan Benjamin Yap and Norshuhani Zamin

Abstract:
University students often struggle to choose where to eat, with decisions influenced not only by preferences but also by emotional state. This is a factor overlooked by most existing restaurant recommendation systems. To address this, we introduce LasallEats, a mobile app designed for De La Salle University (DLSU) Manila students that delivers personalized dining recommendations by incorporating empathic computing. The system enables users to select an image reflecting their current mood, which is classified into one of six basic emotions: anger, disgust, fear, enjoyment, sadness, or surprise. This emotional input is combined with user-defined preferences such as cuisine type, dietary restrictions, and budget constraints. Recommendations are generated using a hybrid engine that fuses content-based filtering with emotion-driven decision logic and utilizes Google Gemini for contextual recommendation. Evaluation results from a user study (n=14) showed that 85.7% of participants felt their emotional state was accurately captured, and the app received an average satisfaction rating of 4.36 out of 5. Feedback highlighted interest in emotion-based filtering and budget prioritization, validating the app's design. By localizing recommendations and incorporating emotional relevance, LasallEats promotes a more empathetic, user-centered dining experience. This study demonstrates that integrating mood into recommender systems enhance user satisfaction and offers new possibilities for emotionally intelligent mobile applications.

FMLDS2025-256

BantayText: Machine Learning-Based Detection of Scam SMS in the Philippines

Peter Parker, Matthew Sanchez, Neil So, Luis Jaime, Andrew Ishikawa and Norshuhani Zamin

Abstract:
The proliferation of SMS-based scams, particularly those using Filipino-English (Taglish) code-switching, poses a significant threat to mobile users in the Philippines. While large language models (LLMs) can effectively identify these scams, their computational size makes them impractical for on-device deployment. This paper presents BantayText, a comparative study to identify an optimal lightweight model for this task. We evaluate four distinct approaches: a fine-tuned mBERT "teacher" model, a "student" neural network trained via knowledge distillation, an identical neural network trained from scratch, and a traditional machine learning pipeline using TF-IDF with Multinomial Naive Bayes. Our findings reveal that while distillation improves the neural network's performance, the traditional TF-IDF and Naive Bayes model achieves a superior balance, reaching a 97% accuracy and a 0.950 F1-score for scam detection. Critically, this traditional model is not only more accurate than the lightweight neural networks but also over 16 times smaller (3.5 MB vs. 58.4 MB), establishing it as the most viable solution for efficient, real-time, on-device protection.

FMLDS2025-257

Wearable HRV Stress Detection and Intervention for Sensory Overload in Children with Autism in the Philippines

Miguel Villanueva, Norshuhani Zamin and Berenice Medina

Abstract:

Children with Autism Spectrum Disorder (ASD) are often highly susceptible to sensory overload, triggered by factors such as excessive noise, unfamiliar environments, or challenges in emotional regulation. Sensory overload can result in intense reactions, including tantrums and meltdowns, which may escalate into heightened anxiety, withdrawal, self-stimulatory behaviors, or even impaired communication. These responses make it difficult for caregivers to manage and comfort the child effectively and can hinder their learning, social interactions, and emotional well-being. Existing assistive technologies, such as wearable devices, have been developed to detect sensory overload and provide real-time information to parents. This study proposes an innovative assistive technology system, designed to enhance the management of sensory overload in children with ASD. The system integrates a wearable device equipped with a DFRobot Gravity photoplethysmography (PPG) heart rate sensor, using Arduino with an ESP32 microcontroller. The wearable continuously measures heart rate and derives heart rate variability (HRV) metrics, which serve as physiological indicators of stress associated with sensory overload. Validation experiments were conducted with five high-functioning children with ASD, where heart rate and HRV stress scores were measured before and after controlled physical activity, using wrist and finger sensor placements. Comparative analysis with a commercial wearable band showed a strong correlation (r = 0.97) and a minimal mean difference in BPM of 2.00, highlighting the feasibility of our HRV-based stress wearable in real-world use. Our system aims to improve stress management and strengthen communication between children with ASD and their caregivers in educational and everyday settings.

FMLDS2025-259

Design Optimization of Analog and Digital Circuits using Artificial Intelligence

Hafiz Arslan Ramzan

Abstract:

The optimization of analog and digital circuit design using artificial intelligence (AI) techniques is explored in this paper. We investigate different approaches, such as machine learning, reinforcement learning, and evolutionary algorithms, highlighting how these techniques can improve the efficiency and performance of circuits. Case studies demonstrate how AI-driven optimization can lead to significant improvements like reduced energy consumption and enhanced signal integrity. Future directions aim to overcome obstacles related to computational complexity and workflow integration, consequently simplifying the integration of AI into circuit design. This research investigation indicates how AI possesses the ability to transform the field of electrical engineering.

FMLDS2025-260

An Intelligent Video Surveillance System with Temporal-Enhanced YOLOv8 for Real-Time Fire, Accident, and License Plate Detection in Public Safety Monitoring

Md Zahidul Islam, Md Rashed, Md Imran Hossain and Feroza Naznin

Abstract:

Real-time detection of safety-critical events such as fires, traffic accidents, and vehicle license plates is a key enabler for intelligent transportation and urban surveillance systems. In high-density CCTV networks, these tasks must be performed under diverse environmental conditions, including low light, motion blur, and compression artifacts, while meeting strict latency requirements. Conventional single-frame object detection methods often suffer from unstable predictions, producing false positives that can overwhelm monitoring operators and automated alert systems. To address these challenges, we propose a temporal-enhanced YOLOv8-based detection framework that explicitly incorporates temporal reasoning into the detection pipeline. Our approach combines histogram equalization for enhanced visual contrast, YOLOv8 for spatial detection, ByteTrack for robust object association, and a 1D Temporal Convolutional Network (1D-TCN) for temporal filtering of event predictions. This integration not only stabilizes detections across frames but also significantly reduces false alarms in continuous video streams. And dual-channel alert system, integrating multimedia notifications and voice calls, ensures a rapid response from stakeholders. Performance was evaluated against state-of-the-art methods, achieving an overall accuracy of 91.60%, surpassing techniques like color analysis with wavelet transform and YOLOv8-EfficientNetB0. With low latency (13.3 ms for fire, 11.4 ms for accidents) and high precision (94.4% for accidents, 95.4% for number plates), it excels in challenging conditions. This system contributes significantly to human well-being by enabling faster emergency response, enhancing public safety, and supporting smarter urban management.

FMLDS2025-261

HESS: Height-Aware Benchmarking of Monocular Depth Estimation Using Synthetic and Real Datasets

Khulan Khalzaa

Abstract:
Accurate depth estimation is vital for autonomous driving and traffic monitoring, yet benchmarking remains challenging due to the scarcity of LiDAR ground truth in realworld datasets. We introduce a height-aware pseudo-groundtruth evaluation framework for monocular depth estimation (MDE). The framework leverages the MultiHeightView dataset, which captures real and synthetic traffic scenes across multiple camera viewpoints, and introduces the Height Error Sensitivity Score (HESS), a novel metric quantifying robustness to height variation. Pseudo-ground-truth depth is validated using manual laser measurements and an Intel RealSense sensor, providing
a cost-effective and scalable alternative to LiDAR. Beyond evaluation, we develop a fusion pipeline that integrates Depth Pro with auxiliary perception module YOLOv11 segmentation, to analyze whether structured visual cues mitigate depth estimation errors. Experiments reveal that Depth Pro struggles with occlusion, far-field objects, and viewpoint shifts, while fusion strategies partially improve stability under challenging conditions. Overall, our results demonstrate that height-aware
evaluation and detector-guided fusion provide complementary insights, providing a scalable and privacy-preserving benchmark for MDE in traffic environments. Keywords—Monocular depth estimation, camera height, pseudo-ground-truth, synthetic datasets, traffic scene analysis.