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CONTENTS

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TOPICS

Track 1: Human-Computer Interaction
- Accessibility and Inclusive Design
- Augmented and Virtual Reality Interfaces
- Collaboration and Learning
- Context-aware Computing
- Emotional and Affective Computing
- Eye Tracking and Brain-Computer Interfaces
- Gesture and Speech Recognition
- Haptic Feedback Systems
- HCI Theories and Methods
- Human-Robot Interaction and Collaboration
- Mobile HCI and Automobiles
- User-Centered Design and Usability Testing

Track 2: Intelligent Control Systems and Optimization
- Applications in Manufacturing and Production
- Big Data Optimization Challenges
- Energy Optimization in Smart Grids
- Evolutionary Computation and Control
- Intelligent Fault Detection and Diagnosis
- Machine Learning Optimization Techniques
- Metaheuristics and Evolutionary Algorithms
- Multi-Objective Optimization Approaches
- Optimization in Scheduling and Logistics
- Optimization in Wireless Networks
- Real-Time Optimization and Adaptive Control
- Stochastic and Robust Optimization

Track 3: Robotic and Automation Applications
- AI-Driven Robot Learning
- Autonomous Navigation and SLAM (Simultaneous Localization and Mapping)
- Cognitive Approach for Robotics
- Humanoid Robots and Social Robotics
- Industrial Robotics and Automation
- Medical and Rehabilitation Robotics
- Robot Perception and Sensor Fusion
- Robotic Manipulation and Grasping
- Soft Robotics and Bio-Inspired Robots
- Swarm Robotics and Multi-Robot Systems
- Underwater and Space Robotics
- Weapon and Ammunition Systems

Track 4: Artificial Intelligence (AI)
- AI for Healthcare and Biomedicine
- AI for Image and Video Processing
- AI in Autonomous Vehicles and Drones
- AI in Cybersecurity and Threat Detection
- AI in Predictive Maintenance
- Cognitive Computing and Decision-Making Systems
- Deep Learning Techniques and Architectures
- Explainable AI and Ethical Considerations
- Grid and Cloud Computing
- Natural Language Processing and Chatbots
- Quantum Computing
- Reinforcement Learning Applications

Track 5: Electrical and Electronics Technologies
- Electric Vehicle Technologies
- Embedded Systems and IoT Devices
- High Voltage Engineering
- MEMS and Nanoelectronics
- Microcontroller and FPGA Applications
- Microwave and Antenna Technologies
- Photonics and Optoelectronic Devices
- Power Electronics and Renewable Energy Integration
- Sensor Networks and Smart Devices
- Signal Processing and Communication Systems
- Smart Grid and Energy Storage Technologies
- VLSI Design and Embedded Systems

Track 6: Interdisciplinary Topics
- AI Ethics in Robotics and Autonomous Decision-Making
- AI for Electronic Circuit Design Optimization
- AI-Based Predictive Control in Electrical Systems
- AI-Enhanced HCI Techniques
- HCI in Autonomous Systems (e.g., Self-Driving Cars)
- Machine Learning for Signal Processing
- Optimization in Robotics Control
- Robotics in Renewable Energy Maintenance
- Smart Home and Smart City Applications
- Wearable Electronics and Human-Centric IoT

Medical Robotics: An Overview

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Invited Speaker

Abstract - In the modern world, technology provides a wide range of opportunities for human life. These opportunities are used in daily activities, business life, transportation, health, defense, and education. Technology in diagnosis and treatment is becoming widespread in many areas such as imaging, patient monitoring, laboratory and analysis devices, surgical operations, and rehabilitation units. Robotic systems have been successfully applied in medical fields since the 1970s with various methods. In this work, an overview of medical robotics is presented. Robotic systems are widely applied in the medical field in areas such as surgical robots, therapy robots, and rehabilitation robots.

Keywords – Medical robotic

Performance and Mission Optimization in Flight Systems Using Metaheuristic Algorithms

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Presentation/Paper Type: Oral

Abstract **–**As flight systems evolve toward greater autonomy and complexity, the ability to optimize mission performance under dynamic, uncertain, and resource-constrained environments becomes a critical engineering challenge. Traditional optimization methods often struggle to cope with the high dimensionality, nonlinear constraints, and real-time requirements inherent in modern airborne platforms. This presentation explores the application of metaheuristic algorithms—such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing (SA)—to address mission planning, flight profile optimization, and multi-objective decision-making within avionic systems.

The session outlines how these algorithms, inspired by natural processes, offer flexible and adaptive search capabilities for solving combinatorial and continuous optimization problems encountered during both pre-flight planning and in-flight reconfiguration. It also examines the integration of AI techniques with metaheuristics, forming hybrid intelligent architectures capable of learning from mission data and responding to environmental changes in real time. Emphasis is placed on digital twin-based simulation, edge AI deployment, and the increasing role of adaptive optimization in next-generation mission systems. Real-world use cases and validation challenges from the defense aviation domain are presented to demonstrate the practical impact and implementation considerations of these methods.

Keywords –Metaheuristic Optimization , Flight Mission Planning, Avionic Systems Engineering, Adaptive Algorithms, Artificial Intelligence in Aerospace

Digital Twin And Artificial Intelligence Integration In Simulation Systems

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Presentation/Paper Type: Oral

Abstract - This study presents an overview of the integration of Digital Twin and Artificial Intelligence (AI) technologies within modern simulation systems, with a focus on applications in defense and aerospace domains. The objective is to highlight how simulation environments are evolving from static, reactive platforms into intelligent, data-driven ecosystems capable of real-time adaptation, learning, and decision-making.

The methodology involves a conceptual framework that defines the digital twin as a real-time, virtual representation of a physical system, continuously updated through sensor data. Artificial intelligence enhances this framework by enabling predictive analysis, anomaly detection, and autonomous decision support. Together, these technologies transform simulation systems into proactive tools for testing, training, and maintenance.

The presentation classifies integration approaches into three layers: data, model, and decision. Benefits include increased realism, adaptability, and operational efficiency. Challenges such as data quality, synchronization, and cybersecurity are also addressed, emphasizing the need for robust architectural strategies.

In conclusion, the integration of digital twins and AI represents a paradigm shift in simulation technology. These systems not only simulate real-world behavior but also provide actionable insights and intelligent support, paving the way for more autonomous and responsive systems in critical industries.

Keywords **–** Digital Twin, Artificial Intelligence, Simulation Systems, Predictive Maintenance, Defense and Aerospace, Autonomous Simulation

Avionics Meets Artificial Intelligence: Intersections and Innovations

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Presentation/Paper Type: Oral / Abstract

Abstract – The integration of artificial intelligence (AI) into avionics is driving a profound transformation in the aerospace and defense sectors. This transformation is not solely the result of technological progress but is also enabled by interdisciplinary collaboration and the establishment of dynamic innovation ecosystems. These ecosystems—comprising academia, industry, and government—create a strategic framework for co-developing complex, high-tech systems. Collaborative models such as joint development projects, public-private partnerships, and open innovation practices reduce R&D costs and risks while accelerating technological advancement. Effective role distribution among institutions, combined with clear communication protocols, plays a vital role in aligning goals and managing inter-organizational complexity. Moreover, AI-driven business development requires new approaches such as data-centric design, iterative prototyping, and integrated AI governance frameworks. While collaboration offers significant opportunities—shared expertise, market access, and innovation—it also presents risks, including IP disputes and security concerns. Addressing these challenges demands flexible governance, trust-building, and organizational readiness. Successful AI integration in avionics also necessitates cultural transformation, ethical awareness, and robust data infrastructure. This paper provides a comprehensive analysis of collaborative strategies and proposes a vision for a future-ready, adaptive innovation ecosystem capable of supporting sustainable and secure AI adoption in next-generation avionics systems.

Keywords – Artificial Intelligence, Avionics, Innovation Ecosystem, Inter-Institutional Collaboration, Organizational Transformation

Academic Developments and Application Areas of AI Algorithms for Avionics Systems

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Presentation/Paper Type: Oral

Abstract **–** This research examines the growing integration of Artificial Intelligence (AI) algorithms within avionics systems, focusing on their role in enhancing flight control, communication, navigation, and maintenance operations. Given the real-time, safety-critical nature of avionics, AI solutions must meet stringent requirements such as rapid decision-making, determinism, fault tolerance, and regulatory compliance. The study highlights how AI processes extensive sensor data to enable autonomous flight systems, support pilot decision-making, and facilitate predictive maintenance, thereby improving operational efficiency and safety. Key AI applications include fault detection through classification and regression, time series analysis using RNN, LSTM, and GRU models, and dynamic thresholding to reduce false alarms. Explainable AI methods like LIME and SHAP are emphasized to ensure transparency and trustworthiness in safety-critical environments. Hardware-accelerated approaches, including edge computing and FPGA integration, address the demands for real-time performance. The study also emphasises the surge in academic research and industry collaboration, supported by government initiatives, which drives technology transfer and curriculum development in AI for aerospace. This synergy fosters innovation, enhances safety, and improves efficiency in avionics, positioning AI as a transformative force in the aerospace sector.

Keywords – Avionics Systems, Explainable AI, Predictive Maintenance

Artificial Intelligence Approaches for Optimization in Avionic Systems Engineering and Test Processes

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Presentation/Paper Type: Oral

Abstract **–**With the increasing complexity of avionic systems and the growing demand for mission adaptability, traditional systems engineering and test methodologies face significant challenges in terms of efficiency, scalability, and accuracy. This presentation focuses on the integration of artificial intelligence (AI) techniques into system engineering and verification workflows, particularly in the context of rotary-wing platforms. Drawing on field experience from helicopter test environments, the talk explores how AI-based methods—including supervised learning, anomaly detection, and metaheuristic optimization—can be used to enhance test scenario prioritization, fault classification, and data-driven decision support.

In addition, the presentation discusses the use of AI-supported models to dynamically adapt test procedures and system validation processes in alignment with mission-specific constraints. Special attention is given to explainability, reliability, and traceability, which are critical for AI applications in safety-critical domains like defense aviation. By combining conventional engineering discipline with intelligent algorithmic support, the proposed approach aims to create smarter, faster, and more resource-efficient verification architectures that can evolve with system complexity. The presentation also highlights real-world implementation challenges and outlines strategies for embedding AI capabilities into existing test infrastructures without compromising safety or certification standards.

Keywords –Avionic Test Optimization, Artificial Intelligence in Verification,, System Engineering Automation, Fault Classification, AI-Driven Test Planning

Artificial Intelligence-Driven Decision Support System for Career Planning

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Presentation/Paper Type: Oral / Abstract

Abstract **–**Career planning is a critical process for people who aim for professional success. In this process, people's technical skills, social competencies, and personality traits are assessed in addition to their education and work experience. However, making decisions in this process can often be complex and time-consuming. Accordingly, we propose an AI-driven decision support system designed to assist companies in identifying the most suitable candidates and to help individuals discover positions that best align with their skills and traits. The proposed system also aims to identify the technical skills candidates need to develop, considering their personality traits and the requirements of the targeted positions. The dataset is fetched with web scraping from a popular online career portal. After data cleaning, the dataset consists of 576 undergraduate and associate degree programs, 293 industries,1.745 unique skills, and 6.045 job titles. AI-powered PDF reader tools are employed to evaluate resumes. Decision trees and artificial neural networks are utilized to identify users' traits. In the job recommendation phase, the K-Nearest Neighbor algorithm is implemented. Initial results demonstrate that the system can provide meaningful insights and tailored recommendations for individuals and companies.

Keywords –Career Planning, Machine Learning, Personality Analysis, Decision Support System and Artificial Intelligence

Machine Learning-Supported Strategic Procurement Application for a Construction Chemicals Manufacturer

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Presentation/Paper Type: Oral / Abstract

Abstract – Cement, cellulose, calcite, kraft paper, and polymers are the primary raw materials in the production of construction chemicals, with cement and cellulose playing critical roles. Forecasting the prices of these materials is crucial for optimizing costs, identifying profitable products, and targeting the right market segments. Accurate price predictions enable manufacturers to adapt to market conditions and make informed strategic decisions. This study focuses on developing a machine learning-supported application for strategic decision-making in cement procurement for a construction chemicals manufacturer in Eskisehir, Turkiye. Reliable data spanning the past 10 years was collected for attributes influencing cement prices. Missing data due to access limitations were completed using linear and spline interpolation. To prevent overfitting, attributes highly correlated with cement prices were selected. Machine learning algorithms, including K-Nearest Neighbors, Linear Regression, Random Forest, Support Vector Machine, XGBoost, and Decision Tree, were implemented based on these attributes. Their performance was evaluated using metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and R^2 Score. The results provide valuable insights for cost optimization and procurement strategies. Future research will expand the scope to include price predictions for other essential raw materials in construction chemical production.

Keywords – Machine Learning, Cement, Price Prediction, K-Nearest Neighbors, Random Forest, Support Vector Machine, XGBoost, Decision Tree

Investigating EEG Band Dynamics in Motor Imagery Tasks: A Topographic Brain Mapping Study of a BCI-Trained Individual

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Abstract **–** Electroencephalogram (EEG) signals are very suitable for Brain-Computer Interface (BCI) applications due to their cost-effectiveness and high mobility. Although EEG signals have a high temporal resolution, their spatial resolution is low. In this study, four-class Motor Imagery (MI) EEG signals of an individual who received BCI training were analyzed with the topographic brain mapping method to examine the spatial distribution of EEG. The analysis was performed by examining each EEG waveband for each second of the MI task. As a result, Delta and Theta bands related to concentration and learning showed activity in the first seconds. For Alpha, Beta, and Gamma activities, processes related to active thought occurred in the first seconds, and processes related to decision-making happened in the last seconds. When the activities of EEG bands for each electrode channel are determined, the success in BCI applications can be increased. The study has the potential to be a reference for other studies on paradigm creation and improvement.

Keywords *– BCI, EEG, EEG Wave Bands, Motor Imagery, Topographic Brain Mapping*

Detecting Clickbait Turkish Titles in YouTube Videos Using Machine Learning

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Presentation/Paper Type: Oral / Abstract

Abstract **–**As content consumption on platforms like YouTube grows, misleading titles—commonly known as "clickbait"—become more widespread. These titles attract users with exaggerated or deceptive wording, increasing clicks while reducing platform credibility. With millions of videos available, finding reliable content becomes harder, and clickbait titles contribute to misinformation. Therefore, detecting such titles automatically is essential. This study aims to develop a machine-learning model that can distinguish Turkish YouTube video titles as either clickbait or non-clickbait. The dataset is collected using the YouTube API and includes a balanced selection of both categories. The model analyzes the linguistic structure, choice of words, and contextual meaning of the titles to identify deceptive patterns. To assess its effectiveness, the model is evaluated based on accuracy, precision, and recall metrics. Detecting misleading content more effectively aims to improve content quality on digital platforms and offer users a better experience.

Keywords – clickbait, youtube, machine learning,Turkish, Natural Language Processing

LQG/LTR Controller Design to Single-Link Rotary Flexible Joint

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Abstract – In this study, a methodology is presented for a linear quadratic control structure that can be used in the presence of an insufficient measurement case for a single-link flexible joint. In the proposed structure, the linear quadratic control structure is modified by integral action over the system model. The design of a linear quadratic Gaussian control system with integral (LQG-I) support is performed over the modified system. The LQG structure contains a linear quadratic estimator (LQE). Kalman-based LQE is used to estimate unmeasurable states. In order to increase the stability of LQG, loop transfer recovery method (LTR) is implement and LQG controller is approximated to LQR. In the study, the controller is analyzed over a simulation of the dynamic model. With the analysis made in the frequency domain over the model, LQG input defined LTR analysis is performed. The response of the system at different inputs is analyzed with the determined parameters. It is compared to the LQR controller, where all states can be measured, with the LQG controller, where only one state can be measured and the other states is estimated. As a result of comparative results over simulation, it is seen that LQG can provide LQR performance in case of insufficient measurement.

Keywords *– Flexible joint, LQR, LQG, integral aided LQG, loop transfer recovery, LQG/LTR*

High-Quality Synthetic Image Generation for Accurate Classification of Brain Tumors Using ACGAN

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Abstract

In this study, synthetic images were generated using the Adversarial Conditional Generative Adversarial Network (ACGAN) to create a dataset for brain tumor detection and classification. Brain tumors pose challenges in diagnosis and treatment, further complicated by the scarcity of labeled medical images. ACGAN enables the generation of diverse synthetic datasets even with limited data by producing conditioned samples. The study consists of three stages: first, an ACGAN-based deep learning model was trained with existing brain tumor datasets. Second, synthetic images of different tumor types were generated. Third, the realism of these images was evaluated using the Fréchet Inception Distance (FID) metric, which was calculated as 4.6, indicating high similarity to real images. Results show that ACGAN produces high-quality synthetic images that closely resemble real data distributions. The quality of glioma and meningioma images outperformed other GAN-based methods. Additionally, ACGAN effectively maintains class distinctions, enhancing the differentiation between "healthy" and "tumor-bearing" individuals. In conclusion, ACGAN proves to be a valuable tool for brain tumor classification and medical imaging applications, demonstrating its potential in scenarios with limited labeled data.

Keywords; ACGAN, Brain tumor, machine learning, deep learning

Ensuring product detection and product counting on the assembly line using deep learning (YOLOv11)

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Abstract **–**This study used the YOLO (You Only Look Once) algorithm and the Ultralytics library for product counting and inspection on the suspension system assembly line. Suspension systems, which connect a vehicle to its wheels and manage its interaction with the road, are crucial for vehicle control and passenger comfort. Key components, such as the Z-rod, tie rod, swing arm, and tie rod end, play a vital role in the production process. Accurate product counting on the assembly line is essential to detect any shortages or surpluses. Relying on operator discretion for product detection can lead to customer complaints and financial losses. To address this, the YOLO algorithm was employed to perform faster, more accurate product counting and inspection. YOLO, a deep learning-based object detection method, was implemented using the Ultralytics YOLOv11 model. Suspension part images were labeled with bounding boxes and class labels for training. During the training process, hyperparameters were optimized to improve accuracy. After training, the model was tested on new data, successfully detecting and counting products. In conclusion, using YOLO and Ultralytics significantly improved the assembly line's product counting and inspection processes, eliminating operator errors and enabling faster, more precise counting. This deep learning approach enhanced production efficiency, ensuring product quality and reliability.

Keywords *– YOLO, Deep Learning, Ultralytics, Suspension, Detect*

Parçacık Sürüsü Optimizasyon Algoritması Kullanılarak IEEE 33-Bus Sisteminde Elektrikli Araç Şarj İstasyonlarının Optimum Yerleşimi

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Presentation/Paper Type: Abstract

Abstract – Bu çalışmada, IEEE 33 baralı sistem üzerinde elektrikli araç (EA) şarj istasyonlarının en uygun konumlandırılması için Parçacık Sürüsü Optimizasyon (PSO) algoritması kullanılmıştır. Amaç, sistemdeki hat kayıplarını minimize ederek şarj istasyonlarının yerleşimini optimize etmek ve enerji dağıtım sisteminin verimliliğini artırmaktır. Çalışmada, PSO algoritması kullanılarak sistemin hat kayıpları göz önüne alınmış ve sonuçta EA şarj istasyonları için en uygun bara konumları belirlenmiştir. Elektrikli araçların yaygınlaşmasıyla birlikte, şarj istasyonlarının şebeke üzerindeki etkileri, özellikle gerilim kararlılığı, güç kayıpları ve yük dengesi gibi parametreler açısından kritik öneme sahiptir. Elde edilen sonuçlar, kullanılan optimizasyon algoritmasının hat kayıplarını önemli ölçüde azalttığını ve enerji dağıtım sisteminin performansını iyileştirdiğini göstermektedir. Bu bağlamda, PSO algoritması, şarj istasyonlarının optimal yerleşimi ve boyutlandırılması için etkili bir yöntem olarak değerlendirilmiştir.

Keywords –IEEE 33 baralı sistem, elektrikli araç şarj istasyonu, optimizasyon, Parçacık Sürü Optimizasyonu (PSO), hat kayıpları

Approximate Solutions of Hyperbolic Telegraph Equations Arising in Circuit Theory

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Abstract – In this study, the hyperbolic telegraph differential equation describing the behavior of certain wave-like phenomena, such as the transmission of signals along a telegraph line is considered. Numerical solutions of a telegraph equation are computed by using various operator-difference schemes and physic-informed neural networks. The error analysis is performed and the results are compared.

Keywords – Hyperbolic Equations, Numerical Solution, Error Analysis, Difference Scheme, Neural Netrowk

Hybrid Deep Learning for Acute Lymphoblastic Leukemia Diagnosis

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Abstract **–** Accurate and rapid diagnosis of Acute Lymphoblastic Leukemia (ALL), a hematologic malignancy marked by immature lymphocyte proliferation, is crucial. Traditional diagnostic methodologies, including manual microscopy and bone marrow aspiration, are inherently subjective, labor-intensive, and subject to inter-observer variability, potentially compromising diagnostic accuracy. This study proposes a hybrid computational framework for ALL diagnosis utilizing microscopic blood smear images from the ALL-IDB dataset. To mitigate overfitting, image preprocessing, including resizing and rotational and mirroring data augmentation to triple the training dataset, was performed prior to a two-stage methodology: (1) transfer learning with pre-trained deep neural networks (ResNet-50, VGG-16, Xception, InceptionResNetV2), and (2) stacked generalization ensemble learning, integrating the top-performing individual models. Transfer learning yielded accuracies of 96.06% (InceptionResNetV2), 98.79% (ResNet-50), and 99.09% (VGG-16) on the augmented data. Subsequently, these models were integrated into a stacked ensemble, resulting in an accuracy of 100%. This hybrid framework, combining the feature extraction capabilities of transfer learning with the robust predictive power of ensemble learning, offers a significant advancement over conventional diagnostic methodologies. The achievement of 100% accuracy underscores the potential of this approach to serve as a reliable, objective, and efficient adjunct to traditional diagnostic workflows, providing clinicians with a valuable second opinion.

Keywords **–** *Acute Lymphoblastic Leukemia, Transfer Learning, Ensemble Learning, Image Preprocessing, Computer-Aided Diagnosis.*

Lateral Resolution Enhancement of Ultrasound Images via Auto-Encoder Network

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Abstract – Ultrasound imaging is widely used for medical diagnostics, but its resolution is inherently constrained by factors such as wavelength, focal length, scan line density, and frame rate. A fundamental trade-off exists between lateral and temporal resolution, where increasing scan line density enhances spatial detail at the expense of reduced frame rates. This study explores the potential of deep learning, specifically an AutoEncoder-based approach, to enhance lateral resolution without sacrificing temporal resolution. The performance of the AutoEncoder is evaluated against traditional interpolation methods, including nearest, linear, and spline interpolation, using structural similarity (SSIM), peak signal-to-noise ratio (PSNR), multi-scale SSIM (MS-SSIM), and feature similarity (FSIM) metrics. The results demonstrate that the AutoEncoder outperforms interpolation methods, achieving the highest SSIM and FSIM, indicating superior structural preservation and feature retention. Additionally, the RF signal analysis shows that while the AutoEncoder maintains the overall waveform structure, minor amplitude and phase deviations exist. These findings suggest that deep learning-based super-resolution can effectively enhance lateral resolution while minimizing traditional resolution trade-offs.

Keywords *– Ultrasound Imaging, Resolution Enhancement, lateral resolution, Deep Learning, Interpolation*

Deep Learning-based Ensemble Multi-Architecture Model with Hybrid Approach for CIFAR10

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Abstract – In this study, we introduce a new deep learning-based ensemble model for CIFAR10 dataset that uses the majority voting ensemble technique. The proposed model consists of one LSTM-CNN hybrid architecture with AdaBoost ensemble technique and five different CNN architectures. The test accuracy of some classes in the CIFAR10 dataset, which are similar to each other, such as cats and dogs when using only CNN architectures is low. At this point, there is a significant advantage to using the LSTM-CNN – CNN is for extracting visual features and LSTM is for analyzing sequential relationships.- hybrid architecture combined with AdaBoost ensemble technique in the model, which is dramatically increases the accuracy of these image classes, in particular. The goal of our approach is to achieve more accurate predictions by combining the strengths of each architecture. We compare the performance of our proposed model with that of pre-trained models such as Densenet121 and RenseNet50. The results show that the proposed model outperforms pre-trained models in terms of accuracy. The accuracy of the proposed model is 94,52%, which is 2,61% and %4,12 higher than the accuracy of Resnet50 and Densenet121, respectively.

Keywords – Image Classification, Ensemble Modeling, Deep Neural Networks (DNN), Ensemble technique, Convolutional Neural Networks (CNN), CIFAR-10

Yapay Zeka ile Kanser Tedavisini Geliştirme: Neoadjuvan Tedavi Yanıtını Tahmin Etmek İçin Derin Öğrenme

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Özet **–** Mide kanseri, dünya genelinde en ölümcül hastalıklardan biri olup, kanserle ilişkili ölümler arasında üçüncü sırada yer almaktadır. Neoadjuvan tedavi, ameliyat öncesinde tümörleri küçültmek için uygulanan bir yöntemdir. Ancak, bu tedaviye verilen yanıtın doğru bir şekilde değerlendirilmesi, geleneksel histopatolojik incelemelerde zaman alıcı olması ve gözlemciler arası farklılık göstermesi nedeniyle zorluklar barındırmaktadır. Bu çalışmada, yapay zeka ve derin öğrenme tabanlı modellerin bu süreci daha hızlı, doğru ve standart hale getirme potansiyeli araştırılmıştır.

Bu kapsamda, YOLOv9 ve EfficientDet modelleri kullanılarak histopatolojik görüntüler analiz edilmiştir. YOLOv9, gerçek zamanlı tümör tespiti sağlarken, EfficientDet çok ölçekli özellik çıkarımı ve sınıflandırma işlemlerinde kullanılmıştır. Çalışmada, veri toplama, görüntü işleme, transfer öğrenme ve model optimizasyonu aşamaları uygulanarak modellerin performansı F1-skora, doğruluk ve geri çağırma metriklerine göre değerlendirilmiştir.

Ön bulgular, yapay zeka destekli analizlerin, neoadjuvan tedavi yanıtlarını tahmin etmede geleneksel yöntemlerden daha başarılı olduğunu göstermektedir. Yapay zeka tabanlı modellerin patolojik incelemelere entegre edilmesi, erken teşhis süreçlerini hızlandırarak kişiselleştirilmiş tedavi yöntemlerinin geliştirilmesine katkı sağlamaktadır.

Anahtar Kelimeler *–Yapay Zeka, Derin Öğrenme, Tümör Tespiti, YOLOv9, EfficientDet, Neoadjuvan Tedavi, Patoloji Analizi*

A Novel Framework to Reduce Response Times for Fire Stations

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Presentation/Paper Type : Poster

Abstract
Fire emergency response plays a vital role in urban safety by providing timely interventions that mitigate loss of life, injuries, and property damage. Urban expansion, population growth, and high-rise construction lead to complex incidents that often require multiple fire engines arriving at different times. This research defines extra time as the difference in arrival times of multiple fire engines. We propose a novel framework that optimizes incident allocation by minimizing two performance measures: existing response time and response time with extra time.
This research develops two mathematical models using a resource location allocation approach. We apply these models to fire stations of the City of Mississauga, Ontario, Canada, and implement Machine Learning to address study-data limitations. We solve the models using Gurobi-Python and visualize fire station service areas in ArcGIS. Comparing the results with city data reveals gaps and provides insights for improvement.

Keywords – Fire and Emergency Response, Location-Allocation, Mathematical Modeling, Machine Learning, GIS

Introduction

Mississauga Fire and Emergency Services (MFES) operates 32 front-line vehicles (including pumpers, squads, and aerial and rescue units), 9 support units, along with 12 reserve vehicles to provide year-round emergency response. From 2009 to 2022, MFES handled an average of 29,339 calls per year. Between 2003 and 2020, Mississauga recorded 166 fire-related injuries and 35 fatalities. Residential occupancies make up 93.24% of the city's property stock and account for 66.9% of fire losses. Industrial occupancies, despite comprising only 2.29% of the property stock, contribute to 11.6% of fire losses during the same period [4]. These statistics highlight the critical role of fire and emergency services in saving lives and preventing property damage. Currently, MFES uses an effective automated vehicle location system to deploy the nearest available vehicle, considering both in-station and en-route resources. Station modeling utilizes the network analyst tool and Geographic Information System (GIS) data to simulate emergency response coverage across Mississauga's road network. This research seeks to build on the current methodology and provide a framework for long-term planning and analysis of fire station allocations.

Response Time and Service Areas

North American cities adhere to the National Fire Protection Association (NFPA) standards, which defines response time as the total duration from when a fire or emergency call is received by the dispatch center to when the first engine arrives at the scene [5]. It has three key components:

- Call Processing Time: The time between when the emergency call is received and when the appropriate fire engines are dispatched.
- Turnout Time: The time between when firefighters are notified and when they leave the station.
- Travel Time: The time taken by a fire engine to travel from the station to the emergency scene.

A fire station service area (otherwise known as a response area) is the geographic region that a fire station is responsible for covering within a specified response time. Currently, one of the primary performance measures for the city fire department is minimizing the response time of the first arriving fire engine (i.e., NFPA 1710 or existing response time).

Other Components of Response Time

The NFPA 1710 sets clear benchmarks for both the response time of the first arriving unit and the required depth of response for effective incident mitigation. Fire stations use protocols to categorize buildings (e.g., Single-Family Dwelling, Garden-Style Apartment, High-Rise, etc.) and identify incidents as low, medium, or high hazard types, each

requiring a predetermined number of fire engines for dispatch [3]. For example, NFPA 1710 recommends a turnout time of 80 seconds and a travel time of 240 seconds (4 minutes) for the first-arriving engine company to a fire suppression incident [5]. It also emphasizes the importance of assembling an effective response force. However, population growth and the horizontal and vertical expansion of cities make fire and emergency responses more challenging.

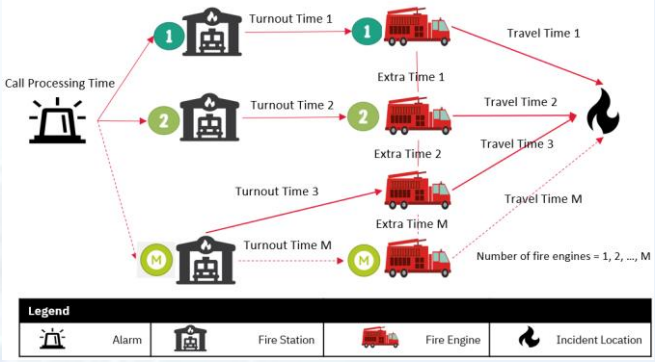


Figure 1. Incident Response Components

For incidents requiring multiple fire engines, each unit may arrive at different times (e.g., fire engines dispatched from different stations, additional assistance needed after reassessments, or similar scenarios). A response cannot be considered complete until the full complement of personnel and apparatus is on scene to meet the critical tasking required. This staged arrival inherently adds time to the total response, impacting operational effectiveness, particularly in complex or high-risk environments. Therefore, response time metrics should account not only for the first arriving unit but also for the full depth of response necessary to achieve effective fire suppression and emergency management.

This research integrates an additional component, referred to as extra time, into response time (See **Figure 1**). We define extra time as the difference between the arrival of the last fire engine and the first fire engine at an incident location (if fire engines are dispatched together, extra time is zero). Now, we present two performance measures to evaluate fire station response time as follows:

- The Existing or NFPA Response Time: The time taken for a fire engine from the closest available fire station to arrive at an incident location.
- The Proposed Response Time: The time taken for all fire engines for the closest fire stations (e.g., one, two, or more with different arrival times) to reach at an incident location.

The Novel Framework

The proposed novel framework does not replace the current one but enhances it in two main ways:

- The current framework used by municipalities only measures existing response time. While it considers low, medium, and high hazard incident categories, it lacks a quantitative measure for such incidents. Our novel framework integrates the proposed response time, accounting for the impact of medium- to high-hazard incidents.
- This framework optimizes fire station allocation on a yearly basis rather than at the minute, hour, day, or week scale used by municipalities. While the municipalities' approach is very effective for operational and daily decision-making, our framework serves as a proactive strategic planning tool, offering a broader, long-term perspective on fire engine allocations.

Methodology

We designed two mathematical models using a resource location allocation model. Our models minimize each response time while considering the fixed number of fire stations, fire engines, and incident frequencies [2]. The basic structure of the first mathematical model, including its indices, parameters, decision variables, and objective function, is outlined as follows:

$i = 1, \dots, n$	Incident locations
$j = 1, \dots, m$	Fire station locations
r_i	The daily frequency of incident at location i
d_{ij}	The distance of location i from fire station j
s_j	The average speed of fire engines of fire station j
P_j	The average call processing time at fire station j
O_j	The average turnout time of fire station j
c_j	The daily capacity of fire station j
H	A very large number
Y_{ij}	Binary variable indicating 1; if an incident location i is responded by fire station j, 0; otherwise
T_{ij}	The existing response time to an incident location i responded by fire station j

$$Min\ Z = \sum_{i=1}^{n}\sum_{j=1}^{m} r_i Y_{ij} T_{ij} \quad (1)$$

$$\sum_{j=1}^{m} Y_{ij} \le H r_i \ \forall i \quad (2) \qquad \sum_{j=1}^{m} Y_{ij} \ge \frac{r_i}{H} \forall i \quad (3)$$

$$T_{ij} = (s_j * d_{ij}) + P_j + O_j \ \ \forall i,j \quad (4) \qquad Y_{ij} < c_j \ \forall i,j \quad (5)$$

$$T_{jk} \ge 0 \ \forall j \quad (6) \qquad Y_{ij} = \{0,1\} \forall i,j \quad (7)$$

This model does not consider the type of incidents, as it focuses solely on minimizing the existing response time. Equation (1) defines the objective function, which minimizes the existing response time for each incident location. Constraints (2) and (3) ensure that all incident locations are responded. Constraint (4) computes the existing response time. Constraint (5) controls the fire stations capacity. Finally, Constraints (6) and (7) specify the variable domains. For the second model, some modifications are necessary, which involve rewriting all the previous parameters and variables with the addition of the incident type index k. This model minimizes the proposed response time, and we replace Constraint (4) with the following constraint:

$$T_{jk} = (s_j * d_{ij}) + P_j + O_j + Et_k \ \ \forall i,j,k \quad (8)$$

Where Et_k respresent the average of extra time for type k incidents.

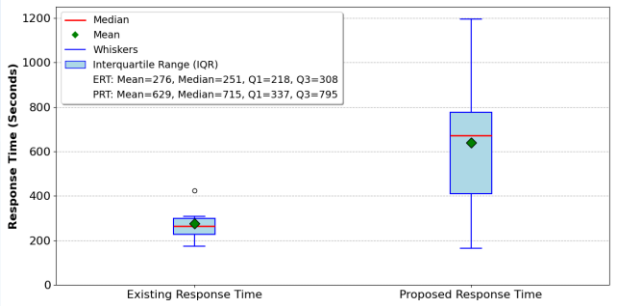
Study Data

This research uses 2022 fire and emergency data from Mississauga's Fire and Emergency Services. However, some city areas did not experience any emergencies and, therefore, did not report any incidents during the study period. We used the total number of incidents in the city for the previous eight years [3]. We then applied machine learning techniques to predict incident patterns in those unreported areas [1], completing our framework.

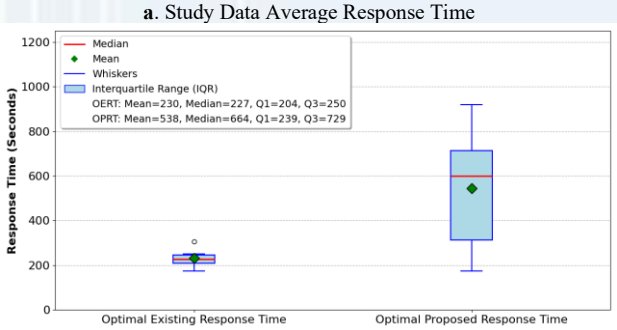
Analysis and Results

First, we conducted data preprocessing and solved the model using an integrated Gurobi-Python programming environment. For direct comparison, we used the direct distance between incident and fire station locations. **Figure 2.a** shows the average existing and proposed response times for the study data. The Existing Response Time (ERT) averages 276 seconds with an interquartile spread of 90 seconds, while the Proposed Response Time (PRT) averages 629 seconds with a spread of 458 seconds. This difference indicates the impact of including extra time in the model. This assumption not only more than doubles the response times but also increases variability. This significant change highlight the need for deeper evaluations of fire station performance in high scale and major emergencies, as these events (even if less frequent) can have catastrophic consequences. **Figure 2.b** applies the same procedure to the optimized model results. The average of Optimal Existing Response Time (OERT) is 230 seconds with an interquartile spread of 41 seconds, and the average of Optimal Proposed Response Time (OPRT) is 538 seconds with a spread of 490 seconds. The trend remains consistent, confirming the model's validity. Additionally, comparing the two charts reveals that optimal allocation of fire stations can improve the ERT by more than 16% and PRT by over 14%.

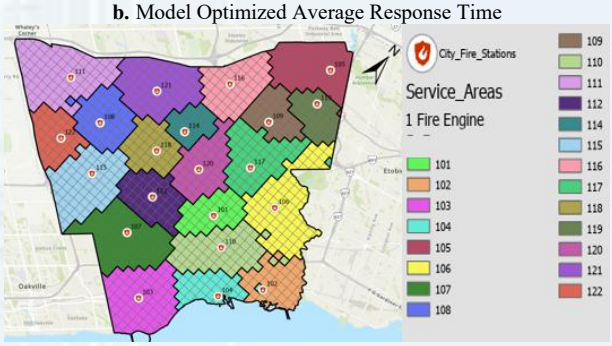
Figure 2.c presents an example of the optimal existing response time service areas, visualized using ArcGIS Pro software. Each fire station's service area is designed to minimize existing response times by efficiently dispatching available fire engines. Therefore, regardless of the available data and resources (i.e., fire stations and fire engines), this methodology can be applied to any case for designing and developing service areas.



a. Study Data Average Response Time



b. Model Optimized Average Response Time



c. Optimized Service Areas

Figure 2. Results of Two Performance Measures

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References

1. Dey, A., Heger, A., & England, D. (2021). Urban Fire Station Location Planning: A Systematic Approach using Predicted Demand and Service Quality Index. *CoRR, abs/2109.02160*. https://arxiv.org/abs/2109.02160

2. Farahani, R. Z., Asgari, N., Heidari, N., Hosseininia, M., & Goh, M. (2012). Covering problems in facility location: A review. Computers & Industrial Engineering, 62(1), 368–407. https://doi.org/https://doi.org/10.1016/j.cie.2011.08.020

3. Fire & Emergency Services Plan. (2024). https://mississauga.ca/wp-content/uploads/sites/4/2024/03/27172627/2024_FD_Fire-Emergency-Services_Final.pdf

4. Fire & Emergency Services Risk Assessment, (2023). Provided by Mississauga Executive Officer, Fire & Emergency Services Division.

5. NFPA (National Fire Protection Association). (2021). https://www.nfpa.org/