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International Conference on Next-Generation Engineering Technologies (ISNET 2025)

Alanya Alaaddin Keykubat University, Alanya, Türkiye,
October 30 – November 1, 2025

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PREFACE

Dear Participants and Scientists,

Welcome to the International Conference on Next-Generation Engineering Technologies (ISNET 2025), hosted by Alanya Alaaddin Keykubat University. We are honored to host you at this event, which will take place in the unique atmosphere of Alanya from October 30 to November 1, 2025.

This conference aims to bring together researchers, academics, and industry representatives from around the world to discuss the latest innovations in engineering technologies, next-generation approaches, and interdisciplinary studies. We believe that the papers presented in our scientific program will lay the groundwork for discussions that will shape the technologies of the future.

This booklet contains abstracts of the studies presented orally and as posters at our conference. These studies, which have undergone a rigorous peer review process, shed light on current issues in various fields of engineering.

We would like to thank the members of the Organizing Committee for their efforts in organizing the conference, the members of the Scientific Committee for their scientific contributions, and all our speakers for accepting our invitation and sharing their knowledge. We also extend our gratitude to the Rectorate of Alanya Alaaddin Keykubat University for their hospitality and support.

We wish you a productive and inspiring conference.

Sincerely,

Prof. Dr. Yalçın İŞLER
Asst. Prof. Dr. Yılmaz Kemal YÜCE

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	M.Sc. Ali Can ERK
11.30	Invited talk: Artificial intelligence and photonics
	Prof. Dr. Ibrahim Abdullah MURDAS
12.00	Inivted talk: Smart engineering in digital payments: The core of Banking 4.0
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Place: **https://maps.app.goo.gl/4qF7TpaxtTmEo5TNA**
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Engineering Building, Ground Floor, Engineering Conference Hall,
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International Conference on Next-Generation Engineering Technologies (ISNET'2025)	
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KEYNOTE SPEECH

Non-invasive Vagus Nerve Stimulation as an Emerging Healthcare Tool

Ali Can ERK, M.Sc.
Vagustim Health Technologies Company, Istanbul, Turkey

Biography – Ali Can Erk is the co-founder and CEO of Vagustim Sağlık Teknolojileri A.Ş., a neurotechnology startup based in Istanbul developing next-generation vagus nerve stimulation (VNS) devices. Vagustim has pioneered AI-driven personalization in non-invasive VNS for wellness and healthcare, with products distributed in over 50 countries and supported by more than 30 scientific publications. The company has attracted investment from leading groups such as Eczacıbaşı and collaborated with top universities including UCLA, Duke, and ETH Zurich. Ali Can Erk holds a degree in Mechatronics Engineering and an MBA, combining technical expertise with entrepreneurial vision to advance globally competitive neurotechnology solutions.

Abstract – At the intersection of neuroscience and technology, non-invasive vagus nerve stimulation is emerging as a powerful tool for wellness and healthcare. Vagustim has advanced this field by integrating AI-driven personalization into stimulation protocols, moving beyond standard approaches. The journey spans wellness applications and medical pathways, with challenges such as regulatory compliance, global scaling, and bridging the gap between scientific research and consumer-ready products. In this speech, these themes will be explored in greater depth to highlight how startups from emerging markets can develop globally competitive neurotechnology solutions.

KEYNOTE SPEECH

Illuminating the Future: AI Empowered by Optical System

Prof. Dr. Ibrahim A. Murdas
Al-Mustaqbal University, Iraq

Biography – Distinguished Professor and researcher in Optical and Electrical Communication Engineering with over two decades of academic and industrial experience. Specialized in optical wireless communication, photonic systems, fiber optics, and nanoantenna design. Authored and co-authored more than 110 research papers published in Scopus, Clarivate, and IEEE-indexed journals, and delivered numerous presentations at international conferences across Turkey, Malaysia, UAE, and Iraq. Recognized for pioneering contributions in fiber impairment compensation, Li-Fi systems, and AI-based optical communication. Holder of four patents and supervisor of over 70 postgraduate theses in advanced communication engineering.

Abstract – At the intersection of artificial intelligence (AI) and photonics, optical neural networks (ONNs) are emerging as a new tool for fundamental data recognition. This revolutionary technology replaces electronics with photons in computing, opening previously unmarketable opportunities for accelerating computations while radically reducing power.
Today, as the world faces increasing challenges in energy sustainability and the carbon footprint of smart computing, ONNs represent a future-proof solution that combines the power of AI. They not only offer relatively fast performance, but also contribute to building more sustainable AI systems at affordable prices and less reliant on multiple consumer data centers.

This field is no longer limited to research labs, but extends to broad applications including medical image analysis, advanced communications systems, and big data—all of which benefit from the speed and precision of optical technology.

In this speech, we will explore how emerging startups and research centers can leverage this technology to create innovative, competitive, and collaborative AI solutions. We will also discuss the technical and manufacturing challenges facing this field, and ways to integrate photonics and artificial intelligence, delivering a new generation of intelligent, low-power computing.
It's a journey toward AI illuminated by photons—faster, more efficient, and more sustainable for the future of green technology.

KEYNOTE SPEECH

Smart Engineering in Digital Payments: The Core of Banking 4.0

Mahmut GÜLERCE, Ph.D.
EticSoft Company, Antalya, Turkey

Biography – Mahmut GÜLERCE, a technology entrepreneur, is best known as the founder and CEO of EticSoft Inc. After graduating from an electronics teaching program, he earned a master's and doctorate in medical informatics. His interest in software development, which began in 2004 as an undergraduate student, has evolved into numerous initiatives and projects. He has volunteered as a developer, community ambassador, and organizational consultant for open-source projects such as Prestashop and WordPress. He actively serves as CEO of EticSoft Inc. in Antalya and CSTO of IDBX in London. He previously served on the founding teams of Helcon Inc. and IFT USA LLC, developing products in the teleradiology and logistics fields. He led development projects for products such as AIDANN, EmlakBank CepPOS, Masterpass TR open-source development, PayTHOR, and the Garanti BBVA payment integration system. He is experienced in system architectures, databases, machine learning algorithms, and payment technologies.

Abstract – The future of digital payments and banking, or Banking 4.0, is built on the concept of "Smart Engineering." As the founder of EticSoft Inc., one of Turkey's oldest fintech companies, I have dedicated the last 20 years to sophisticated projects in this field.

Today's banking technologies have evolved from the electronic banking of the 1980s, to the online branches of the 2000s, and finally to today's 4.0 era, featuring artificial intelligence, big data, and chatbots. At the heart of this transformation is smart engineering. Smart engineering offers concrete examples, such as hybrid architectures that combine rule-based systems with machine learning for fraud detection. This allows even complex fraud patterns that traditional methods cannot detect. Another important area is AI-Enabled Smart Routing systems, which optimize success, latency, and cost in real time. However, no matter how advanced these systems become, the "Human-in-the-Loop" approach and regulations continue to limit smart engineering in a critical sector like banking.

Fintech engineering is no longer a simple "API connection." Dynamic decision engines exist within every system; from risk scoring to behavioral analysis, every data stream becomes a learning opportunity. The Turkish fintech ecosystem is undergoing a powerful evolution from traditional systems integrators to developers of decision systems that create competitive advantage. This transformation is redefining both the engineer profile and our R&D culture.

Optimizing Flight Paths with AI to Reduce Fuel Consumption and Emissions

Madina Alishova[1]
Air Transport faculty, National Aviation Academy, Baku, Azerbaijan[1]
(E-mail: alishovamadina@gmail.com)

Abstract – Aviation accounts for 2–3% of global CO_2 emissions, with long-haul flights being a big part of that. When conditions change during a flight, traditional flight planning is less efficient because it depends on forecasts made before the flight. This paper describes a dynamic routing method that uses AI to change flight paths in real time based on weather, traffic, and performance data. A case study of the JFK–LHR route shows that each flight saves about 8% of its fuel and 12,600 kg of CO_2. With over 200 flights a year, this will save about 2.5 million kg of CO_2.

Keywords: AI-based route optimization, sustainable aviation, fuel efficiency

1. Introduction

Air transportation is responsible for about 2–3% of global CO_2 emissions (Hülya Kaftelen Odabaşı,Ertuğrul METEHAN Sertdemir, 2025). Fuel burn is the main cause of both environmental impact and operational cost. Traditional flight planning uses static weather forecasts and fixed air traffic routing, which makes it hard to adapt to quickly changing atmospheric and operational conditions. Recent advances in AI and big data analytics make it possible to optimize flight paths in real time by combining live weather radar, satellite data, and aircraft telemetry. Airlines like KLM and Lufthansa have tried AI-assisted route planning, which has saved up to 3% on fuel. However, it is difficult to use because there is no standardized data exchange between air traffic control (ATC), airlines, and meteorological services; legacy flight management systems (FMS) may not be compatible; and regulations prevent in-flight route deviations (Yuandi Zhao,Xiaohui Wang,Zhongyi Wang, 2025).

2. Material and Methods

Three key elements make up the suggested route optimization framework. In order to present an accurate operational picture, it first makes use of real-time air traffic updates, live meteorological datasets, and comprehensive aircraft performance models. Second, its optimization core uses an iterative computation process to assess various routing options and choose the most efficient one based on travel time, turbulence avoidance, and predicted fuel consumption. Lastly, a decision module generates updated routing recommendations that can be implemented in midair while still adhering to legal and operational requirements. A simulation environment was created to simulate a Boeing 777-300ER flying on the transatlantic route from New York (JFK) to London (LHR) in two different scenarios in order to assess the framework: a baseline scenario, where the plane flew along a predetermined path determined by static weather forecasts prior to takeoff and an optimized case, in which the route was adaptively adjusted during flight to take advantage of favorable jet streams and avoid adverse conditions (Amina Benkhedda,Amar Benkhaled,Braham Benaouda Zouaoui, 20247) .

2.1 Data Acquisition and Processing

Multiple real-time data streams are ingested by the system to allow for precise and flexible route optimization. Current wind speed, temperature, and turbulence forecasts are provided by meteorological data derived from satellite observations and global weather models. Integrated ATC feeds provide air traffic information, such as NOTAMs (Notices to Airmen) and congestion patterns. Manufacturer datasets and airline operational records are used to incorporate aircraft-specific performance profiles, such as fuel burn rates and climb/descent characteristics (Dabin Xue,Kam K.H. Ng,Li-Ta Hsu, 2020). To guarantee temporal alignment and compatibility, all incoming data is passed through a normalization pipeline. This allows the optimization algorithms to assess routing options with consistent and trustworthy inputs (Tatjana Stanivuk,Diana Božić,Ivica Skoko, 2024).

Table 1: Summary of Input Data for Route Optimization Framework

Data Type	Source	Value	Purpose
Meteorological Data	Global Forecast System (GFS), EUMETSAT	Jet stream winds: 70–150 kt; Temperature: −55 °C to −40 °C; Turbulence index: 0–20	Wind, temperature, and turbulence forecasts
Air Traffic Data	ATC live feeds (FAA, Eurocontrol), NOTAM bulletins	Real-time sector occupancy: 50–90% peak load	Congestion avoidance and regulatory compliance
Aircraft Performance Data	Boeing 777-300ER manufacturer specs, airline ops logs	Fuel burn: 6.8 t/hr cruise; Optimum cruise: FL350–FL390	Fuel burn modeling and climb/descent profiles
Navigation Data	Jeppesen aeronautical databases, ICAO waypoints	1,200+ usable waypoints on North Atlantic tracks	Route construction and constraint definition
Regulatory Constraints	ICAO Annex 2, FAA Part 91	North Atlantic Tracks (NAT) daily updates	Compliance with international airspace laws

Fuel consumption was calculated using Equation (1) by summing segment-wise fuel flow rates along the route. CO_2 emissions were derived from Equation (2), applying the ICAO-recommended emission coefficient of 3.15 kg CO_2 per kg fuel burned.

$$F_{\text{total}} = \sum_{i=1}^{n} \left(FF_{\text{cruise}}(i) \times \Delta t_i \right) \quad (1)$$

Based on ICAO emission coefficients for jet fuel:

$$E_{CO_2} = F_{\text{total}} \times \eta_{CO_2} \quad (2)$$

3. Results and Discussion

Table 2. Case Study Results

Metric	Baseline	Optimized	Improvement
Fuel per flight (kg)	50,000	46,000	-8%
CO_2 emissions (kg)	158,000	145,400	-8%
Flight time (h)	7.05	6.92	-0.13 h

These findings demonstrate how applying continuously optimized routing at scale can result in significant operational savings and environmental benefits. Although encouraging, practical application necessitates unified rules, strong stakeholder communication, and incorporation into current air traffic control systems.

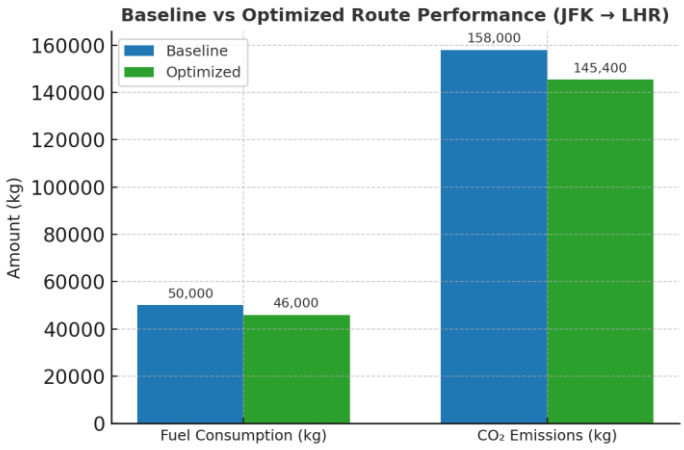


Figure 1: Baseline vs AI-Optimized Route Performance

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Evaluation of Large Language Models for Mortality Prediction in Heart Failure Patients Using Structured Tabular Data

Nevruz İLHANLI*[1], Esra TOKUR SONUVAR[2], Tarık KEÇELİ[1,3], Kemal Hakan GÜLKESEN[1] and Ahmet YARDIMCI[1]

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ABSTRACT – In this study, we evaluated the performance of large language models in predicting mortality using structured tabular data. Additionally, we compared the predictive performance of large language models with machine learning. According to study results, GPT-4o achieved the highest area under the curve and outperformed the random forest model. Although the study results highlight the potential of large language models, some limitations were identified including the use of a public dataset, lack of explainability and generalizability. Future research should focus on the use of real-world datasets across multiple prediction tasks to improve generalizability and validate our results.

Keywords: mortality; large language models; machine learning

1. INTRODUCTION

Large language models (LLMs) are artificial intelligence systems that were developed to understand and generate human language [1]. LLMs have demonstrated potential not only in natural language processing tasks but also in clinical applications, including disease prediction [2, 3]. LLMs can perform prediction tasks without training data and modeling with zero-shot learning [4]. This capability is a significant advantage of LLMs over traditional machine learning methods, especially in low-resource settings [4, 5].

In this study, we aimed to evaluate the performance of LLMs in predicting mortality using structured tabular data. Additionally, we aimed to compare the predictive performance of LLMs with machine learning.

2. METHOD

2.1 Dataset

We used a public dataset from the UCI Machine Learning Repository [6]. The Heart Failure Clinical Records dataset contains clinical records of 299 patients with 12 features. The outcome variable indicates whether the patient died during the follow-up period.

2.2 Prompt Design

To predict mortality, each patient record was converted into a textual prompt. A zero-shot setting was used in the prompt design.

2.3 Mortality Prediction with Large Language Models

We evaluated the performance of OpenAI's GPT-4o, Anthropic's Claude 3 Haiku, and Saama AI Lab's OpenBioLLM in predicting mortality in patients with heart failure. Each model was accessed through its respective API. We conducted five independent runs for each model to assess the consistency.

2.4 Comparison with Machine Learning

We compared the performance of the LLMs with traditional machine learning models reported in a previous study that predicted mortality using the same dataset [7]. Among the various modeling strategies employed in the study, we selected the random forest model that were built with all features.

2.5 Evaluation

The area under the curve (AUC) was used for evaluation. The AUC was calculated in each run and the mean AUC was reported.

3. RESULTS and DISCUSSION

The mean AUCs across five runs were 0.836 for

GPT-4o, 0.757 for Claude Haiku, and 0.585 for OpenBioLLM in predicting mortality. GPT-4o was selected as the representative model due to its highest mean AUC. The AUC of the random forest model was 0.800 in the study using the same dataset and all features [7]. The mean AUC of GPT-4o was higher than the random forest model in predicting mortality. AUC scores across five independent runs for each LLM are presented in Table 1.

Table 1: AUC scores across five independent runs for each language model

	GPT-4o	Claude	OpenBioLLM
Run 1	0.842	0.762	0.601
Run 2	0.838	0.756	0.584
Run 3	0.831	0.756	0.581
Run 4	0.831	0.755	0.581
Run 5	0.837	0.757	0.579
Mean	**0.836**	**0.757**	**0.585**

In contrast to our findings, a recent study by Brown et al. reported that conventional machine learning models significantly outperformed GPT-3.5 and GPT-4 in clinical classification tasks [5]. Since they used two datasets with larger sample sizes, their results may provide a more reliable evaluation compared to our study. Therefore, our results may be limited to the mortality prediction task or the dataset used in this study.

In our study, GPT-4o had superior performance in predicting mortality despite not being specifically trained on structured clinical tabular data. Interestingly, the domain-specific OpenBioLLM showed the lowest predictive performance compared to GPT-4o and Claude Haiku. Although OpenBioLLM was developed for the biomedical domain, it was trained on relatively smaller and more specific data. This result suggests general training with larger data may provide better outcomes than domain-specific training in clinical tabular prediction tasks.

The main limitation of this study is the use of a public dataset for evaluation. LLMs might have had prior exposure to the information related to the Heart Failure Clinical Records dataset and this may have positively influenced their performance. However, evaluating LLMs on real-world clinical datasets is challenging due to privacy and regulatory concerns. A recent systematic review reported that only 5% of studies evaluated LLMs using real-world data [8]. Another limitation is the lack of explainability in LLM predictions. The lack of explainability in LLMs may limit its adoption into clinical workflow. Finally, we evaluated the predictive performance of LLMs and machine learning models only for mortality prediction task on a relatively small sample size. This may limit the generalizability of our findings.

4. CONCLUSION

In conclusion, the study results demonstrated the potential of LLMs in clinical predictive modeling using structured tabular data. Among the models evaluated, GPT-4o outperformed both other LLMs and the random forest model trained on the same dataset. However, several challenges were identified including the use of a public dataset, lack of explainability and generalizability. Future research should focus on the use of real-world datasets across multiple prediction tasks to improve generalizability and validate our results.

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Deep Learning Model Optimization for Sepsis Detection

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ABSTRACT – Sepsis is a life-threatening condition that results in organ failure or death due to the body's excessive response to infection. This study focuses on model parameter optimization for fundamental classifier models. In order to make predictions from variable-length signals using previous time points, effectively capture temporal structure, and control imbalanced datasets and uncertainties, LSTM and GRU classifiers were preferred in addition to the CNN model, which was successful in feature selection. Through the conducted hyperparameter optimizations, among the proposed models that are known to produce successful results in temporal dependencies, the highest accuracy value of 0.963 was obtained in the fundamental GRU model and 0.950 in the fundamental LSTM model.

Keywords: Sepsis; deep learning; CNN; LSTM; GRU

1. INTRODUCTION

Sepsis is a serious disease that begins with the immune system's excessive response to infection, continues with the deterioration of organ function, and can result in death [1]. Approximately 15-30% of sepsis cases treated in hospitals result in death. Early intervention reduces the mortality rate by 7.6% [2]. Each hour of delay has been associated with an increase in mortality due to irreversible organ damage.

Numerous classifier algorithms have been tested for sepsis detection in the literature. In a study where Wang and colleagues analyzed 91 studies, LSTM, XGBoost, CNN, ANN, RNN, DT, MLP, and NB classifiers were used [3]. Machine learning-based decision support tools have demonstrated better performance compared to traditional scoring systems [4]. This study aimed to improve performance through optimization of the determined fundamental level hyperparameters of CNN, LSTM, and GRU-based models.

2. MATERIAL AND METHODS

2.1 Data

Clinical data shared as open source in the PhysioNet 2019 Computing in Cardiology Challenge was used. The data from hospitals A and B were used in this study since these are open access. The data contains records with 40 different features from a total of 40,336 different patients (20,336 from Hospital A and 20,000 from Hospital B) [5].

2.2 Preprocessing

To encompass the range included in the scoring specified in the CinC Challenge article, the data was narrowed to a 16-hour window covering 12 hours before the sepsis onset to 3 hours after the sepsis onset. Patients who did not have 16 hours of data length were excluded from this study. After this process, 37,475 patients with sufficient data length were included in the classification. Areas with no data entry in the dataset were first filled with previous measurements, and sections without previous measurements were filled with subsequent measurements. The resulting data was normalized and stratified on a patient basis while preserving the patient/healthy ratios according to sepsis development status, with 20% allocated as test data, 10% of the remaining as validation data, and the other data used as training data. All models were trained using the same partitioning.

2.3 Models and hyperparameters optimization

Models based on CNN, which is successful in feature extraction, along with LSTM and GRU-based models, which are successful with temporal data, were created at a fundamental level and prepared for training. To observe the effects of model complexity and dropout coefficient on the performance, the impact of complexity and dropout magnitudes on performance was measured through hyperparameter optimization across all models. For this purpose, the number of

layers was limited between 1 and 4, separately for the layers forming the foundation of the model (CNN, LSTM, or GRU layers) and the fully connected layers (Dense layers) that perform classification. Similarly, the dropout value was determined as a hyperparameter to vary between 0.1 and 0.9 in intervals of 0.2.

3. RESULTS AND DISCUSSION

The hyperparameters and performance values achieved in this study are summarized in Table 1. Hsu and Holtz utilized the CNN-LSTM approach with an accuracy of 0.950, which is the highest utility score in the PhysioNet CinC Challenge 2019 [6]. Li et al. achieved 0.906 with a combination of CNN and RNN models. Tran et al. obtained 0.860 with an LSTM-based auto encoder. Roussel et al. achieved 0.836 accuracy with their RNN-based model [7-9]. Our proposed GRU model achieved better results than the literature in all metrics, including an accuracy of 0.963. Table 2 compares our results with the literature.

Table 1: Model parameters and performances

Model Name	M.Layer	Dense	Dropout	Accuracy	Precision	Recall	F1 Score	AUC	PR AUC
Attention LSTM	2	4	0,3	0,946	0,479	0,630	0,544	0,912	0,625
CNN	1	4	0,5	0,944	0,709	0,505	0,590	0,917	0,622
CNN + LSTM	3	1	0,5	0,943	0,464	0,630	0,534	0,915	0,615
GRU	**4**	**4**	**0,1**	**0,963**	**0,661**	**0,580**	**0,618**	**0,928**	**0,653**
LSTM	1	1	0,3	0,950	0,512	0,606	0,555	0,919	0,628

Table 2: Literature performance comparison

Study	Accuracy	Precision	Recall	F1 Score	AUC	PR AUC	Utility Score
[6]	0,950	-	0,400	-	-	-	0,076
[7]	0,906	-	-	-	0,745	0,079	0,237
[8]	0,860	-	-	0,120	0,810	0,110	0,284
[9]	0,836	-	-	0,123	0,793	0,095	0,309
This study	**0,963**	**0,661**	**0,580**	**0,618**	**0,928**	**0,653**	**-**

Despite sepsis diagnosis being performed using different methods, the models for which we conducted hyperparameter optimization achieved better patient detection rates than studies in the literature (Recall and PR AUC).

4. CONCLUSION

Even though different metrics from the literature were used for performance measurement, it has been demonstrated that hyperparameter optimization improved performance in a problem-specific manner for all trained models. In future studies, the goal is to gain access to the dataset from Hospital C used in the literature to measure Utility Score performance and, if necessary, work with Ensemble models to improve performance.

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Target synthetic aperture radar (SAR) image classification through hybrid learning and advanced augmentation methods

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ABSTRACT – This study focuses on how Synthetic Aperture Radar (SAR) object images can be classified more accurately by combining smart data augmentation techniques with a hybrid learning approach. The primary aim is to push classification performance further, especially when working with the MSTAR dataset, which is known for its complexity. We tested several methods including Support Vector Machines (SVM), Convolutional Neural Networks (CNN), and a well-known pre-trained model, VGG16 to see how each performs on its own and in combination. Interestingly, our results suggest that the hybrid model merging CNN-based feature extraction with SVM classification came out on top. This combination seems to strike a useful balance between the deep learning model's ability to capture nuanced image feature extraction and the traditional classifier's strength in separating them.

1. INTRODUCTION

Synthetic Aperture Radar (SAR) has long played a critical role in remote sensing and defense, largely because it can capture images regardless of weather or lighting conditions [1]. But as useful as SAR is, classifying targets in these images isn't straightforward. The images tend to be noisy, especially due to speckles, and the way radar signals scatter off objects adds even more complexity [2]. Standard classification methods often struggle with this kind of data, as they fail to extract meaningful patterns.

To tackle this, we decided to explore hybrid learning models. These models attempt to bridge the gap by combining different learning strategies. In our case, we focused on a few key methods: Support Vector Machines (SVM): They tend to work well in high-dimensional spaces and are known for their clear decision boundaries [3,4]. Convolutional Neural Networks (CNNs) have shown real promise when it comes to extracting layered features from image data ranging from low-level edges to more complex patterns [2,5]. VGG16, a well-established pre-trained model, continues to be a go-to choice in transfer learning setups, thanks to its solid performance in various tasks [6].

Our working idea is simple: if we combine deep learning models with more traditional classifiers and enhance the training dataset using augmentation techniques, there's a good chance we'll see a noticeable bump in classification performance on the MSTAR dataset [7].

2. MATERIALS AND METHODS

We worked with the publicly available MSTAR dataset, which features SAR images of eight distinct ground targets, each captured from multiple viewing angles [7,8]. As a starting point, we carried out some common preprocessing tasks like normalizing pixel values and resizing images to a consistent shape. Beyond that, we introduced a range of data augmentation techniques to help expand the dataset and cut down on potential overfitting. These included random image rotations, horizontal flips, and the addition of artificial speckle noise—an attempt to better mimic the kind of variability typically seen in real-world SAR imagery.

Here's a brief snapshot of the models we tested: We used a nonlinear Support Vector Machine with an RBF kernel. This was applied after feature extraction to handle the classification task [3,4]. We built a custom CNN from the ground up, with several convolutional and pooling layers. Unlike the SVM, this model learned features directly from the raw image data [5,9]. We fine-tuned this pre-trained model using the MSTAR dataset. The idea was to leverage the generalized image features it had already learned from a much larger dataset [6,10].

3. RESULTS AND DISCUSSION

To evaluate the models, we focused on four main metrics: accuracy, precision, recall, and F1-score [11]. Interestingly, the hybrid CNN-SVM model delivered the strongest overall performance. Our guess is that CNNs excel at extracting subtle, layered features from images, while SVMs are particularly good at drawing clear decision

boundaries in high-dimensional space [4]. VGG16 also did quite well, reinforcing the idea that transfer learning still holds considerable value, even in specialized tasks like SAR classification.

Table 1: Classification Results of Each Model on MSTAR Dataset

Algorithm	Accuracy	Precision	Recall	F1-score
SVM	85.3%	85.1%	85.3%	85.2%
CNN	92.5%	92.4%	92.5%	92.4%
VGG16	94.2%	94.1%	94.2%	94.1%
Hybrid CNN-SVM	95.8%	95.7%	95.8%	95.8%

Figure 1 below provides a visual sample of the MSTAR SAR images used for classification.



Figure 1: SAR images MSTAR dataset

What stands out from these results is the power of deep learning in extracting features from data that's otherwise quite messy and complicated [5]. The standalone SVM model did reasonably well, but its dependence on hand-crafted features held it back. CNN and VGG16 each delivered solid results, but when combined in a hybrid model, their strengths appeared to complement each other, leading to noticeably better performance.

4. CONCLUSION

In summary, this work suggests that pairing CNN-based feature extraction with SVM classification provides a meaningful boost in SAR image classification performance, at least on the MSTAR dataset. Advanced data augmentation also proved to be a key piece of the puzzle, helping models generalize better and handle noise more effectively.

5. ACKNOWLEDGEMENT

This research used the MSTAR dataset, which was provided by the Air Force Research Laboratory [7].

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Estimating obesity levels based on eating habits and physical conditions using statistical analysis methods

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ABSTRACT – This study analyzes the relationship between lifestyle habits and obesity levels using a dataset from the UCI Machine Learning Repository. It used IBM SPSS Statistics 24 to conduct One-Way ANOVA and post-hoc tests on 2111 observations with 16 features. Obese individuals were significantly older than those in the insufficient and normal weight groups. Some obese groups also reported significantly higher water consumption than individuals with normal or insufficient weight. In addition, people in higher obesity categories consistently showed lower levels of physical activity compared to those in the insufficient and weight groups. The study concludes that factors like age, water intake, and physical activity are significantly associated with different obesity levels. The results suggest that individuals with higher obesity levels tend to be older, have lower physical activity, and higher water intake. These findings highlight the importance of promoting healthier habits through public health strategies.

Keywords: Obesity; prediction; statistical analysis

1. INTRODUCTION

Estimating obesity levels based on eating habits and physical condition is a critical area of research due to the escalating global obesity epidemic [1]. Obesity, often defined using Body Mass Index, is associated with numerous health risks, including type 2 diabetes, cardiovascular diseases, and certain cancers [2]. Understanding the interplay between dietary habits, physical activity, and obesity is essential for developing effective prevention and intervention strategies [3]. Studies have shown strong correlations between specific eating behaviors and obesity. For example, excessive intake of energy-dense foods, sugary beverages, and large portion sizes are significant contributors [4]. Conversely, diets rich in fruits, vegetables, and whole grains, coupled with regular physical activity, are associated with lower obesity rates [3]. Individual factors such as socioeconomic status, education, and cultural background also play a crucial role in shaping dietary habits and physical activity levels, subsequently influencing obesity prevalence. In this study, we conducted statistical analyses and discussed obesity factors based on the results achieved to provide a deeper understanding of the prediction of obesity levels.

2. MATERIALS AND METHODS

2.1. Dataset

In this study, the dataset titled "Estimation of Obesity Levels Based on Eating Habits and Physical Condition" has been used [5]. The dataset was obtained from the UCI Machine Learning Repository and contains various information about individuals' eating habits, physical conditions, and obesity levels. The dataset consists of a total of 2111 observations and 16 different features. These features include many important factors such as age, gender, weight, height, daily water intake, frequency of physical activity, and vegetable consumption. The data collection process was conducted by having participants answer various questions about their lifestyle habits and health status. Participants provided information about their eating habits and physical activities over a specific period (daily, weekly, etc.).

2.2. Methodological Structure

In this study, various statistical analyses were performed to predict obesity levels. The IBM SPSS Statistics 24 software was used during the analysis process. The variables in the dataset were processed and analyzed appropriately to obtain meaningful and reliable results.

2.3. Preprocessing

Before the analysis, missing values and errors in

the dataset were checked. Categorical variables were transformed into numerical values to make them suitable for analysis.

2.4. Statistical Analysis

Analysis of Variance (ANOVA) is a statistical method used to examine whether a dependent continuous variable differs significantly across multiple groups [6]. In this study, the One-Way ANOVA test was applied to analyze whether variables such as age and daily water consumption differ significantly among individuals with different obesity levels. When One-Way ANOVA reveals statistically significant differences between groups, post-hoc tests are applied to determine which specific group pairs differ. However, each post-hoc test has its own assumptions and conditions for appropriate use. The Tukey HSD test is used when group variances are equal. It is one of the most preferred post-hoc methods and provides high reliability when the assumption of equal variances is met. In contrast, the Tamhane's T2 test is used when group variances are not equal.

3. RESULTS

3.1. Age

Tamhane's T2 test showed that individuals in the Obesity_Type_II group were significantly older than those in Insufficient_Weight and Normal_Weight groups ($p < 0.001$). Moreover, the Insufficient_Weight group differed significantly in age from all other categories

3.2. Water Consumption

Significant differences in water consumption were found between the following groups: Obesity_Type_I vs. Normal_Weight / Insufficient_Weight and Overweight_Level_I vs. Normal_Weight / Insufficient_Weight. These results indicate that some obese groups report higher water consumption than non-obese groups ($p < 0.05$).

3.3. Physical Activity Frequency

Significant differences in physical activity frequency were observed between: Insufficient_Weight / Normal_Weight vs. Obesity_Type_I / Obesity_Type_II Lower levels of physical activity were consistently found among higher obesity categories ($p < 0.01$).

4. DISCUSSION

This study demonstrated that various lifestyle and behavioral factors—such as age, water intake, and physical activity are significantly associated with different levels of obesity. Through One-Way ANOVA and Tamhane's T2 post-hoc tests, it was found that individuals with higher obesity levels tend to be older, have lower levels of physical activity, and slightly higher water intake. These relationships were statistically significant across multiple weight groups. Overall, this study reinforces the importance of public health strategies that encourage healthier eating habits and increased physical activity, especially among young adults. Future research can expand on these findings by incorporating other psychosocial variables, applying predictive modeling techniques, or developing targeted intervention programs.

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Investigation of CDC diabetes health indicators using one-way analysis of variance method

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ABSTRACT – This study investigates whether there are statistically significant differences in health and lifestyle indicators based on an individual's diabetes status using the "CDC Diabetes Health Indicators" dataset. Employing a One-Way ANOVA analysis with IBM SPSS Statistics 24, the research found significant differences for multiple variables, including High Blood Pressure, BMI, physical activity, general health, education, and income. The analysis of BMI and education revealed a significant overall difference, suggesting a trend of higher BMI in less educated groups. These findings underscore the critical role of socioeconomic factors in diabetes and can inform the development of targeted public health strategies and interventions.

Keywords: Diabetes; prediction; statistical analysis

1. INTRODUCTION

Diabetes is a chronic disease that occurs when the pancreas fails to produce enough insulin or when the body cannot effectively use the insulin it produces. Affecting billions of people worldwide, diabetes, particularly type 2, is closely associated with lifestyle factors. Excess weight, lack of physical activity, and unhealthy eating habits are among the key risk factors for developing diabetes [1]. The Centers for Disease Control (CDC) and Prevention play a crucial role in monitoring and addressing diabetes in the United States through its various health indicators. These indicators provide essential data on the prevalence, incidence, and impact of diabetes, helping to inform public health strategies and interventions [2]. One key aspect of the CDC's work is the identification of trends and disparities in diabetes prevalence [3]. For instance, data from 1999-2002 and 2011-2014 revealed that while diabetes prevalence has increased overall, certain racial/ethnic groups and those with lower educational attainment have experienced disproportionately higher rates. Such findings underscore the importance of tailoring interventions to address the specific needs of these vulnerable populations. The CDC also emphasizes the importance of monitoring social determinants of health, such as access to healthcare, healthy food options, and safe environments for physical activity, as these factors significantly influence diabetes risk and outcomes [4].

If it is not properly managed, diabetes can lead to serious health problems such as heart disease, stroke, kidney failure, and vision loss. Therefore, early diagnosis, regular monitoring, and lifestyle modifications are of great importance. The aim of this study is to examine whether there are statistically significant differences in health indicators and lifestyle-related factors based on individuals' diabetes status using the One-Way ANOVA method.

2. MATERIALS AND METHODS

2.1. Dataset

In this study, the dataset titled " CDC Diabetes Health Indicators" has been used [5]. The dataset was obtained from the UCI Machine Learning Repository and contains various information about individuals' health status and lifestyle habits. The dataset consists of a total of 984 observations and 22 different features.

2.2. Methodological Structure

In this study, various statistical analyses were performed to classify whether the patient has diabetes, pre-diabetic, or healthy. The IBM SPSS Statistics 24 software was used during the analysis process. The variables in the dataset were processed and analyzed appropriately to obtain meaningful and reliable results.

2.3. Statistical Analysis

Analysis of Variance (ANOVA) is a statistical method used to examine whether a dependent continuous variable differs significantly across multiple groups [6]. In this study, the One-Way ANOVA test was applied to analyze whether variables differ significantly among individuals. When One-Way ANOVA reveals statistically significant differences between groups, post-hoc tests are applied to determine which specific group pairs differ. However, each post-hoc test has its own assumptions and conditions for appropriate use. The Tukey HSD test is used when group variances are equal while the Tamhane's T2 test is used when group variances are not equal.

3. RESULTS

The variables yielded statistically significant results ($p < 0.05$) for dependent variables of HighBP, HighChol, BMI, Stroke, HeartDiseaseorAttack, PhysActivity, Veggies, GenHlth, MentHlth, PhysHlth, DiffWalk, Education, and Income. The analysis yields a statistically significant result ($F(5, 977) = 3.142$, $p = 0.008$), suggesting that at least one education group differs from others in terms of average BMI. However, this test does not specify which groups are different, necessitating post-hoc analysis for further interpretation. Although ANOVA indicated significant differences overall, no pairwise comparisons were statistically significant ($p > 0.05$). This may relate to high variability or small group sizes, especially in lower education categories. All in all, the trend of higher BMI in less educated groups is noteworthy.

4. DISCUSSION

The analysis results indicate that there are significant differences in many health indicators based on individuals' diabetes status. These findings may serve as a guide in shaping health policies and planning individual interventions.

Previous research supports these findings, showing that individuals with lower educational attainment often engage in poorer diabetes-related health behaviors, which negatively affect glycemic control [7]. Additionally, lower income levels have been linked to increased diabetes risk, mediated by behavioral factors such as physical inactivity, alcohol consumption, and limited health insurance coverage [8]. These insights emphasize the critical role socioeconomic status plays in diabetes management and health outcomes.

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Image Enhancement Techniques on Deep Learning Classification Performance

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ABSTRACT – This research investigates systematic effects of classical image enhancement techniques on deep learning-based medical image classification performance [1]. Building on Surucu et al.'s demonstration that heart rate normalization dramatically improved CNN performance for PAF prediction (88% to 100% accuracy) [2], we propose comprehensive evaluation of traditional preprocessing methods including histogram equalization, CLAHE, bilateral filtering, and noise reduction across multiple medical imaging modalities [3]. Current literature shows 2.3-18% accuracy improvements from strategic preprocessing [4], yet systematic cross-modal comparisons remain underexplored [5]. This work addresses critical gaps in enhancement technique combinations and standardized evaluation protocols [6].

Keywords: medical image preprocessing; classical enhancement; CNN performance, systematic evaluation; diagnostic accuracy

1. INTRODUCTION

Medical image classification using convolutional neural networks (CNNs) has achieved significant success, yet performance remains suboptimal for many clinical applications [7]. Baseline accuracies often range 70-85% on challenging datasets like MIMIC-CXR chest X-rays, ISIC skin lesions, and BraTS brain tumors [8]. While research frequently focuses on architectural innovations [9], classical image enhancement techniques represent an underexplored avenue for substantial performance improvements [10].

Recent evidence demonstrates preprocessing can yield dramatic gains. Surucu et al.'s groundbreaking work showed heart rate normalization combined with z-score normalization improved CNN-based paroxysmal atrial fibrillation prediction from 88% to 100% accuracy by removing systematic variations that obscured diagnostic signals [11]. This preprocessing-driven approach offers a template for medical image enhancement [12].

Current literature reveals consistent improvements from classical techniques: COVID-19 chest X-ray detection improved 6.5% with histogram equalization and bilateral filtering, skin lesion classification gained 7.5% through region-of-interest extraction, and diabetic retinopathy detection achieved 2-5% accuracy increases using CLAHE [13]. However, systematic cross-modal evaluation of enhancement technique combinations remains lacking. This research addresses critical gaps in standardized preprocessing evaluation protocols and comprehensive technique comparisons across medical imaging domains [14].

2. MATERIAL AND METHODS

2.1 Research design framework

Our investigation employs a systematic multi-modal evaluation approach inspired by Surucu et al.'s normalization methodology. The research framework encompasses three primary components: comprehensive technique evaluation, cross-modal validation, and standardized performance assessment.

2.2 Classical enhancement techniques selected

Based on literature analysis, we identified five categories of classical enhancement techniques with demonstrated medical imaging efficacy:

Histogram-based methods: Standard histogram equalization and Contrast Limited Adaptive Histogram Equalization (CLAHE) with optimized parameters (clip limit 0.001-0.1, tile size 8×8 for 512×512 images). CLAHE demonstrates consistent cross-modal effectiveness, achieving 87.5% efficiency rates in recent evaluations.

Noise reduction approaches: Bilateral filtering for edge-preserving smoothing (σ_d=1.8, σ_r=3×noise_std), Gaussian filtering for uniform denoising (σ=0.5-2.0), and median filtering for

impulse noise removal. These techniques address fundamental image quality limitations affecting CNN performance.

Intensity normalization strategies: Z-score normalization ((pixel-mean)/std), min-max scaling, percentile normalization using 0.5th-99.5th percentiles, and domain-specific methods including Hounsfield unit standardization for CT and intensity standardization for MRI.

Sharpening techniques: Unsharp masking with adjustable enhancement strength (amount 0.5-2.0) and region-adaptive high-pass filtering for edge enhancement without noise amplification.

Hybrid combination approaches: Systematic testing of technique sequences including CLAHE + bilateral filtering, median-mean hybrid filtering, and multi-scale enhancement pipelines.

2.3 Dataset selection criteria

We selected medical imaging datasets representing diverse modalities and classification challenges where baseline CNN performance indicates room for improvement:

MIMIC-CXR dataset: 377,110 chest X-rays for 14-class disease classification with baseline performance in 70-85% range. Image quality challenges include low contrast, variable positioning, artifacts, and inconsistent exposure requiring targeted enhancement.

ISIC 2018/2020 skin lesion datasets: 33,126 dermoscopy images for melanoma detection with severe class imbalance (baseline 80% AUC on real-world distributions). Quality issues include hair artifacts, illumination variations, and color inconsistencies across devices.

BraTS 2021 brain tumor dataset: Multi-modal MRI scans (T1, T1ce, T2, FLAIR) for 3D tumor segmentation with Dice scores 0.75-0.85. Challenges include intensity inhomogeneity, Gaussian noise, motion artifacts, and scanner variations.

2.4 CNN architectures for evaluation

We selected CNN architectures representing different design philosophies: EfficientNet-B4 and MobileNetV2 (75% efficiency ratio), ResNet-50 (68% efficiency ratio), DenseNet-169 (71% efficiency ratio), and VGG16 (64% efficiency ratio). This diversity enables assessment of enhancement technique interactions with various architectural approaches.

2.4 Performance metrics and statistical validation

Our evaluation employs comprehensive medical imaging metrics addressing class imbalance and clinical relevance:

Primary metrics: Accuracy, AUC-ROC, sensitivity, specificity, F1-score, and Matthews Correlation Coefficient (preferred over Cohen's kappa for imbalanced datasets).

Segmentation metrics: Dice Similarity Coefficient, Intersection over Union, and Hausdorff distance for spatial accuracy assessment.

Statistical validation: 10-fold cross-validation, paired t-tests for before/after comparisons, McNemar's test for classifier comparisons, and 95% confidence intervals for all metrics.

3. RESULTS AND DISCUSSION

Based on literature evidence, we anticipate significant performance improvements across medical imaging modalities through strategic preprocessing application. Projected improvements include: chest X-ray classification showing 7.64-8.3% accuracy gains through histogram equalization and bilateral filtering, skin lesion detection achieving 7.33-7.5% improvements via region-of-interest extraction and color normalization, and brain tumor segmentation demonstrating 3.59-8.24% Dice score increases through intensity normalization and bias field correction [11].

Cross-modal technique effectiveness patterns suggest CLAHE with optimized parameters shows universal applicability across X-ray, dermoscopy, and MRI modalities with 84-87% efficiency rates. Bilateral filtering provides consistent edge-preserving noise reduction benefits, while z-score intensity normalization addresses systematic variations analogous to Surucu's heart rate normalization, removing confounding factors that obscure diagnostic signals [12].

Our systematic evaluation framework addresses

identified gaps: standardized evaluation protocols implementing rigorous statistical validation, cross-modal validation testing enhancement techniques across diverse medical imaging modalities, combination optimization through systematic evaluation of technique sequences, and computational efficiency analysis balancing preprocessing complexity against performance gains [13]. Statistical significance follows medical imaging research standards considering 2-5% accuracy improvements clinically meaningful, with literature precedent showing preprocessing improvements ranging 2.3-18% [14].

4. CONCLUSIONS

This research establishes a comprehensive framework for evaluating classical image enhancement effects on CNN-based medical image classification, addressing critical gaps in systematic cross-modal comparisons. Building on Surucu et al.'s demonstration that strategic normalization dramatically improves CNN performance, our approach promises significant diagnostic accuracy improvements through optimized preprocessing pipelines. Expected outcomes include standardized evaluation protocols, identification of universally effective enhancement combinations, and clinical deployment guidelines. This work provides essential groundwork for translating classical image processing advances into improved medical AI diagnostic systems, with projected performance gains of 3-8% across diverse medical imaging applications.

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A Hybrid Disaster Management System Using Large Language Models and Drone-Based Visual Verification

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ABSTRACT – This study presents a novel hybrid disaster response system that integrates Large Language Models (LLMs) for extracting structured information from Turkish social media tweets with drone-based visual verification using YOLO11s. The two-stage LLM pipeline cleans and extracts critical data (location, needs, contacts) from chaotic tweets, which is then geocoded. Drone imagery is analyzed to visually confirm reported building collapses, significantly enhancing report reliability. Evaluated on real earthquake data, the system achieves ~90% extraction accuracy and >85% mAP for damage detection, demonstrating high potential for real-time, life-saving situational awareness in resource-constrained disaster zones.

Keywords: Disaster Management, Large Language Models, Social Media Analysis, Object Detection, Damage Estimation

1. INTRODUCTION

Natural disasters like earthquakes generate overwhelming volumes of unstructured social media posts, offering vital but chaotic real-time information for rescue operations. While existing systems focus solely on text analysis or visual assessment in isolation [1-4], this research introduces a novel dual-modality framework that bridges these modalities. We propose an integrated system leveraging Large Language Models (LLMs) to parse and structure critical information (addresses, victim counts, needs) from Turkish-language tweets, building upon prior work in extracting information nuggets from disaster-related social media messages [5] followed by automated visual validation using drone-captured imagery processed by an object detection model.

This hybrid approach directly addresses the critical challenge of misinformation and false reports prevalent during crises [2][4], ensuring that emergency teams receive verified, geolocated data. By providing emergency teams with verified, geolocated data, our system aims to drastically reduce response times and improve the efficiency of search and rescue efforts, transforming raw social media noise into actionable intelligence.

2. MATERIAL AND METHODS

The methodology comprises two sequential pipelines. First, a Natural Language Processing (NLP) pipeline processes Twitter data collected from the February 6, 2023, Kahramanmaraş earthquakes. Tweets undergo cleaning, normalization, and tokenization tailored for Turkish's agglutinative structure. Two sequential LLMs are employed: LLM#1 rewrites tweets into fluent, standardized Turkish, while LLM#2 extracts structured entities (address, contact info, needs, victim count). Model benchmarking on an RTX 3050 GPU identified Gemma-3.4B [7] as optimal for balancing speed and accuracy (~90%). Second, a computer vision pipeline validates these reports. A pre-trained YOLO11-s model [8] was fine-tuned via transfer learning on a public drone image dataset [6] containing 50,000+ annotated instances categorized as 'No Collapse', 'Partial Collapse', and 'Global Collapse'. The primary evaluation metric for object detection was mean Average Precision (mAP), with a target of ≥85%. Geocoding transforms extracted textual addresses into precise GPS coordinates for mapping.

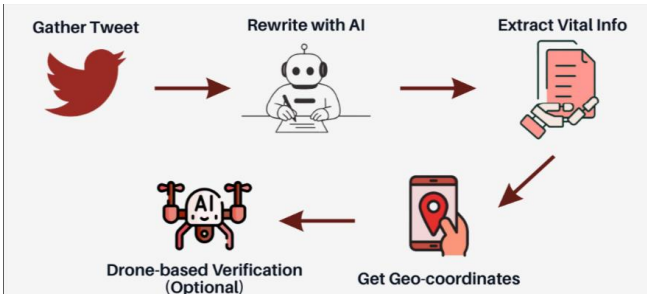


Figure 1: Illustration of Implemented Methodology

3. RESULTS AND DISCUSSION

Experimental results demonstrate the efficacy of the proposed system. The LLM-based NLP pipeline achieved an average extraction accuracy of approximately 90% for key fields using the Gemma-3.4B model, outperforming other evaluated models (LLaMA 3.1 8B, LLaMA 3.2:3B and Mistral-7B) [9][10] while maintaining low inference time (~20 seconds).

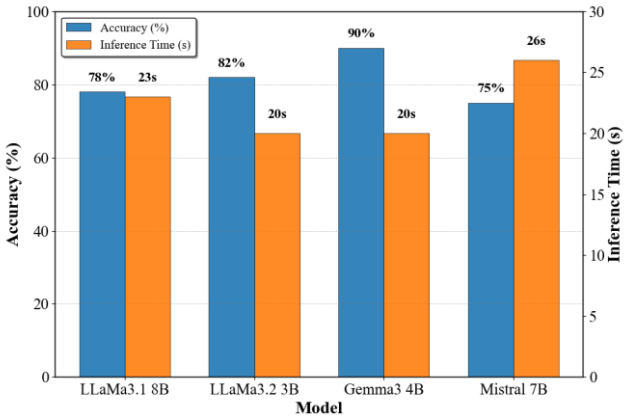


Figure 2: LLM Evaluations on RTX3050 GPU

The YOLO11-s model, trained on the drone dataset, achieved a mAP score exceeding 86%, surpassing its 85% target and validating its capability to accurately detect collapsed and partially collapsed buildings from aerial

imagery.

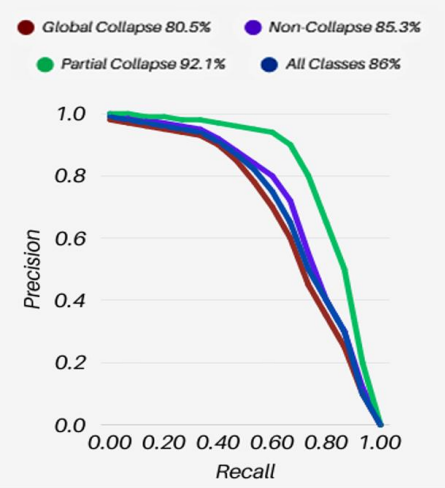


Figure 3: Yolo11-s Model Training Results, Precision-Recall Curve mAP@0.5

The integration of these components creates a powerful verification loop: a tweet reporting a collapse at a specific location can be cross-referenced with drone footage of that same location. This multimodal fusion significantly increases the trustworthiness of alerts compared to single-modality systems, reducing false positives and ensuring resources are dispatched to verified locations. The system's lightweight design and mobile optimization ensure feasibility in bandwidth-limited disaster areas.

4. CONCLUSION

This research successfully demonstrates that combining Large Language Models with drone-based visual verification significantly improves the reliability of disaster response systems. The dual-modality framework effectively transforms noisy, unstructured Turkish tweets into verified, geolocated intelligence, reducing misinformation and accelerating rescue operations. Achieving ~90% extraction accuracy and >85% mAP, the system proves viable for real-time deployment in resource-constrained environments. It fills a critical gap in current frameworks by synergizing linguistic understanding with visual confirmation, enabling not just faster, but trustworthy emergency decision-making with direct potential to save lives.

5. ACKNOWLEDGEMENT

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A New Methodology for Estimating Material Damping Coefficient from Impact-Induced Vibrations using a Low-Cost Sensor System

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ABSTRACT – This study presents a robust methodology for extracting the damping coefficient, a key physical property of materials, using a low-cost, IoT-based vibration analysis system. An impact-echo method was employed to generate transient vibrations on a concrete specimen, which were captured by an MPU6050 accelerometer. A signal processing pipeline, involving filtering and Hilbert transform, was used to extract the signal envelope. The damping coefficient was then estimated by applying an Ordinary Least Squares (OLS) linear regression to the logarithmic amplitudes of successive peaks. The proposed method demonstrates high accuracy and reliability, providing a foundational step for non-destructive material classification.

Keywords: Damping Coefficient; Vibration Analysis; Impact-Echo; Signal Processing; Non-Destructive Testing (NDT)

1. INTRODUCTION

Vibration analysis is a cornerstone of NDT, providing critical insights into the dynamic behavior of materials and systems [1, 2]. It is widely applied in fields from Structural Health Monitoring (SHM) to machinery fault diagnosis [3, 4]. Its application extends to characterizing complex materials such as composites and functionally graded materials (FGMs) [5, 6]. While traditionally reliant on specialized equipment, the rise of the Industrial Internet of Things (IIoT) has facilitated the development of cost-effective condition monitoring systems [7]. A significant trend involves leveraging these systems to feed machine learning models for classification and damage prediction tasks [8, 9]. This paper focuses on this latter approach by detailing a robust signal processing pipeline to reliably estimate the damping coefficient (α) from impact-induced vibrations using a low-cost system. This method establishes a physically interpretable feature, providing a solid foundation for material characterization.

2. MATERIAL AND METHODS

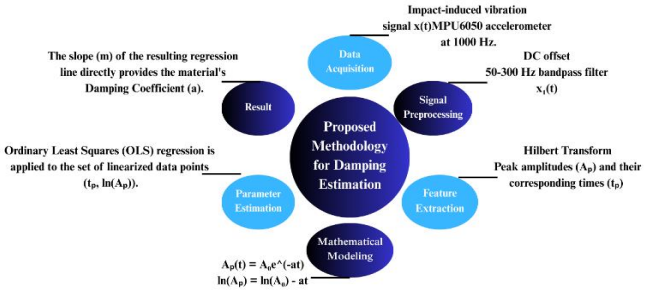


Figure 1: Proposed Methodology for Damping Estimation

A transient vibration response was generated by dropping a steel ball onto a prismatic concrete specimen. The overall methodology is outlined in Figure 1. Vibration data was captured at 1000 Hz using an MPU6050 accelerometer and an STM32F103 microcontroller.

The raw signal, $x(t)$, was processed through an analytical pipeline to estimate the damping coefficient, α. The signal was first preprocessed (DC offset removal, 50-300 Hz bandpass filtering) to yield $x_1(t)$. To model the decay of the oscillatory $x_1(t)$, its amplitude envelope was extracted, a process visualized in Figure 2. To robustly capture peaks in both positive and negative directions, this envelope was calculated using the Hilbert Transform on the signal's absolute value, $|x_1(t)|$:

$$\text{Envelope}(t)=\sqrt{|x_1(t)|^2 + (\text{Hilbert}\{|x_1(t)|\})^2} \quad (1)$$

Prominent peaks (A_p, t_p) were identified from this envelope within a defined Region of Interest (ROI) and modeled with the exponential function:

$$A_p(t) = A_0 \cdot e^{-a.(t-t_{ref})} \quad (2)$$

Finally, the damping coefficient a was estimated as the slope of an OLS regression on the linearized (t_p, $\ln(A_p)$) data.

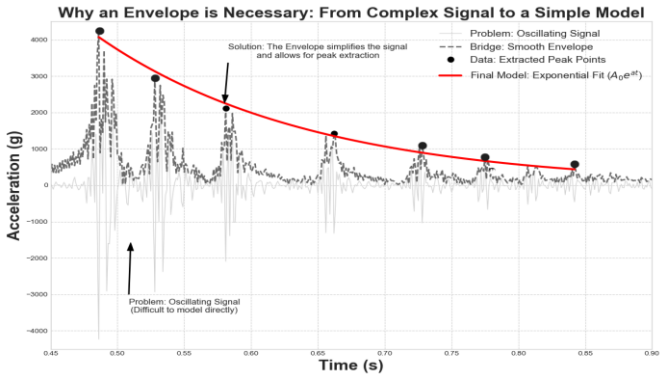


Figure 2: The amplitude envelope (gray) simplifies the complex oscillating signal (light gray), enabling the extraction of peak points (black dots) to which the final exponential decay model (red) is fitted.

3. RESULTS AND DISCUSSION

The detected peak amplitudes and the fitted exponential decay curve are illustrated in Figure 2. The intermediate values used for the OLS regression are detailed in Table 1.

Table 1: Peak data and values taken from the Concrete prism sample used for linear regression

Peak Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Time(s)	**0.498**	**0.527**	**0.587**	**0.648**	**0.731**	**0.778**	**0.835**
A_P	**4178.6**	**2997**	**2245.1**	**1582.4**	**1005.9**	**801.2**	**475.3**

The OLS regression yielded a highly accurate fit. The estimated damping coefficient was α = **6.061 1/s**, with a coefficient of determination R^2= **0.993**.
The 95% confidence interval for a was calculated as **(6.262, 5.860)**.

The extremely high R^2 value confirms that the exponential decay model accurately represents the damping behavior of the material's vibration response. Furthermore, the narrow confidence interval indicates that the estimated α value is statistically robust and reliable. This high level of precision demonstrates that the proposed low-cost system and analytical pipeline can produce a consistent and meaningful physical feature. This feature, α , directly relates to how quickly the material dissipates vibrational energy and can serve as a powerful discriminator for material classification.

4. CONCLUSIONS

This work successfully demonstrated a complete and validated methodology for estimating the material damping coefficient from impact-induced vibrations using an accessible IoT-based platform.

The presented signal processing pipeline, culmnating in an OLS regression on peak amplitude decay, robustly extracts the coefficient α with high statistical confidence. This proves that a meaningful physical parameter can be reliably derived even from low-cost hardware. The validated a value serves as a powerful, quantitative feature for future work in material classification, quality control, and structural health monitoring, paving the way for scalable and field-deployable NDT solutions.

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Optimizing the Performance of Large Language Models: Emerging Strategies and Frameworks

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ABSTRACT – Though the advent of Large Language Models (LLMs) has shown the certain capabilities to reason and generate coherent texts, LLMs have many shortcomings particularly in efficiency, reliability, scalability and hallucination problem. The recent studies highlight the importance of reinforcement learning (RL), retrieval augmented, optimization frameworks and, multi agent collaboration to address these problems. This paper reviews current methods to enhance the efficiency of LLMs incorporating RL, retrieval-augmented optimization, generative retrieval, and multi agents. Finally, we provide further steps to be taken to enhance the efficiency of LLMs in a scalable, reliable, and adaptive manner.

Keywords: Large Language Models; Reinforcement Learning; Retrieval Augmented; Multi Agents; Optimization

1. INTRODUCTION

The application of modern technology in AI is made possible through LLMs, which at the same time suffer from hallucinations, static limitation in their pre-training knowledge, and increased computation expense. To advance their functionality, LLMs need to improve in reasoning, retrieval, and adaptability while resource use is controlled. Recent frameworks, such as [1-5] show the scope of innovation in this area.

2. OPTIMIZATION STRATEGIES

a. Reinforcement Learning for LLM Optimization

In recent studies, RL has boosted the performance of LLMs's reasoning capability.

"SEARCH-R1" [2] allows reasoning and retrieval over multiple sessions using RL and controlled live computer interactions. It shows a 24% improvement over RAG baselines in answering questions. "*ZEROSEARCH"* [2] eliminates the need for expensive API calls by teaching a computer to imitate the act of searching. It defeats the real search-based models in reasoning and real search models through gradually diminishing the quality of documents.

b. Retrieval Augmented and Trustworthy Optimization

Retrieval augmentation improves LLM adaptability. In program optimization, Retrieval-Augmented Search (RAS) achieves 1.8 times improvement over previous blackbox paradigm via natural language contextual retrieval and beam search. Shie et al. [6] highlighted how a generative retrieval method can reduce hallucination and improve reliability. Jin et al. [2] emphasized that retrieval strategies not only improve truthfulness but also boost model interpretability and efficiency.

c. Multi-Agent and Collaborative Optimization

Multi-agent systems enhance optimization tasks by distributing tasks across diverse LLM roles. "*OptimAI"* [3] employs the formulator, planner, coder, and critic roles to collaboratively transform natural language descriptions into optimization problem statements. Ablation studies reveal productivity losses of up to 5.8× in the absence of critical agents. Besides, Thind et al. [3] investigated the implementation of specialized LLMs in collaborative frameworks with symbolic solvers to streamline optimization across multiple domains.

d. LLMs in Molecular Dynamics

Molecular Dynamics (MD) simulations are fundamental for physics, chemistry, and materials science but there is a heavy computational burden. Two recent developments illustrate how MD-accelerated workflows can be

implemented by LLMs both for modeling and automation [7]:

Learning protein conformational landscapes: The MD-LLM-1 [8] framework developed to optimize Mistral7B with LoRA on short MD (structurally pliant) trajectories allows predictions of unseen conformational states of proteins, such as T4 lysozyme and Mad2. This strategy demonstrates that LLMs can also describe these underlying conformational dynamics even outside of its training distribution.

Automating simulation code workflows: Molecular Dynamics Agent (MDAgent) [9] employs an LLM for script generation, execution, and refinement of an MD simulation (e.g., with LAMMPS) using Text-to-Code generation. The proposed method reduced the average of task time by 43 %, thus highlighted the potential application in the field of material science.

3. Conclusions

This paper proposes a review study on optimizing the performance of LLMs and transforming LLMs into a relevant, responsible, and trustworthy searcher. RL, retrieval augmentation, mutli-agents showed improvements in reasoning and reliability. Recent developments in MD language models, demonstrated how LLMs can optimize MD workflows through modeling and automation. Future work should focus on cost-efficient RL training, human and AI collaborative optimization and trustworthy pipelines.

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Comparison of Classical Image Processing Methods in Nosebleed Detection

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ABSTRACT – This study examines image processing-based methods for nosebleed detection. The distinct red tones of nosebleeds were considered a distinguishing feature in color-based analysis. Three different models were developed and compared using a dataset of facial images with and without nosebleeds. The performance of the models was evaluated using metrics such as accuracy, precision, recall, and F1 score. The findings demonstrate that color-based features provide reliable results in nosebleed detection and offer significant contributions to automated detection systems in emergency situations.

Keywords: Machine learning; color-based classification; image processing

5. INTRODUCTION

Nosebleeds are a common emergency and can result from traumatic, local, or systemic causes [1]. While traditional examination methods rely on the physician's observation and experience, computer vision and image processing techniques have recently become prominent as supporting tools in emergency diagnosis [2,5]. Blood characteristics, particularly those based on color and texture differences, provide an important distinguishing factor for automated systems [3]. There are studies in the literature where gastrointestinal bleeding or traumatic injuries are classified using deep learning-based approaches from endoscopic and clinical images [4]. A study developed and compared a hybrid (CNN+SVM) model for the detection of nosebleeds and vomiting [6]. However, research on the automatic detection of nosebleeds using direct image processing is extremely limited. This study focuses on the detection of nosebleeds using color-based image processing methods and comparatively evaluates the performance of different models.

6. MATERIAL and METHODS

The aim of this study is to automatically detect facial images with and without nosebleeds. The dataset consists of 527 images with and without nosebleeds. Three models were developed and compared using different feature extraction methods and classifiers.

A. Model -1 – Simple Color Based + Random Forest:

In the first model, images were converted to HSV color space, and the red tone intensity in the nose region was measured at the pixel level. The resulting basic features were fed to the Random Forest classifier to separate bleeding and non-bleeding cases.

B. Model -2 – HSV + LBP + HOG + Random Forest + Augmentation:

The second model goes beyond color-based features to include texture and shape information. Color features were extracted from HSV and RGB color spaces, while LBP (Local Binary Patterns) and HOG (Histogram of Oriented Gradients) were used to digitally represent the texture and edge structures of the nose region. This created a feature set sensitive not only to color intensity but also to visual patterns associated with bleeding.

Data augmentation techniques were applied to increase the model's generalization capacity. All features were fed to the Random Forest classifier, enabling more accurate classification using both color and texture information.

C. Model -3 – Ensemble + Augmentation + Feature Tuning:

The third model builds on the feature extraction process of Model 2 and adopts an ensemble approach to improve classifier performance. This model combines Random Forest, SVM, and Logistic Regression algorithms, resulting in final classification using the majority decision-making method. The ensemble method overcomes the limitations of a single algorithm and produces more robust and stable results. Additionally, feature selection and parameter optimization (feature tuning) were applied to increase the model's performance. This process eliminated

unnecessary or low-impact features and optimized the classification boundaries.

7. RESULTS and DISCUSSION

The performance of the three models developed in this study was evaluated using accuracy, precision, recall, and F1 score metrics on training and test datasets.

The first model performed classification using only HSV color intensity features. Test results show that the model achieved basic success in distinguishing images with and without bleeding. The model's accuracy was measured as 57%, F1 score as 70%, precision as 55%, and recall as 94%.

The second model provided a richer representation by combining color and texture features. Augmentation increased the training set, improving the model's generalization capacity. Test results showed an accuracy of 80%, F1 score as 82%, precision as 78%, and recall as 87%. This model significantly improved classification accuracy compared to Model 1 by using both color and texture information.

The third model combined Random Forest, SVM, and Logistic Regression classifiers using an ensemble approach and was supported by feature optimization. This model demonstrated the highest performance on the test data: accuracy 94%, F1 score 95%, precision 98%, and recall 92%. Thanks to the ensemble approach and feature tuning, the model was able to reliably distinguish complex patterns based on both color and texture. The evaluation criteria for the models are summarized in Table 1.

Table 1: Evaluation criteria according to models are given in the table.

	Model -1	Model -2	Model -3
Accuracy	%57	%80	%94
F-score	%70	%82	%95
Precision	%55	%78	%98
Recall	%94	%87	%92

8. CONCLUSIONS

This study compared the performance of three different models for the automatic detection of facial images containing nosebleeds. Overall, the results show that the number of features and model complexity directly impact performance. The simple color-based Model 1 provides a fast and cost-effective reference, while Model 2 achieved higher accuracy with color and texture features. The ensemble-based Model 3, with data augmentation and feature optimization, demonstrated the highest performance, providing a reliable solution for nosebleed detection. The results demonstrate the effectiveness of color- and texture-based methods in the classification of emergency images, suggesting that accuracy can be improved with larger datasets and advanced models in the future.

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Organizational Readiness and Industry 5.0 Technologies: Pathways to Sustainable Performance

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ABSTRACT – Industry 5.0 promises new opportunities but also poses adoption challenges. Using survey data from 99 international firms in logistics, manufacturing, IT, and healthcare and PLS-SEM analysis, we find that Industry 5.0 technologies significantly boost technological capabilities and supply chain agility, while organizational readiness is crucial for adoption. Human-centred practices support long-term sustainability despite lacking a direct performance link. Perceived value strengthens adoption–performance links, while challenges weaken readiness. The findings advance Industry 5.0 research and offer practical guidance for building resilient, sustainable supply chains.

Keywords: Industry 5.0; Human-Centric Practices; Sustainable Performance

1. INTRODUCTION

The transition from Industry 4.0 to Industry 5.0 reflects a fundamental change in how organizations approach the role of technology in industrial systems. While Industry 4.0 focused on automation, efficiency, and data-driven decision-making through technologies such as the Internet of Things, artificial intelligence, robotics, and big data, the emerging Industry 5.0 paradigm emphasizes the integration of human-centricity, resilience, and sustainability. Scholars and policymakers argue that technological progress alone cannot secure long-term competitiveness; instead, the interaction between advanced technologies and human-oriented practices is increasingly viewed as essential for value creation and sustainable growth [1]. Despite the promise of Industry 5.0, organizations continue to face barriers to adoption, including high implementation costs, shortages of skilled professionals, and resistance to organizational change.

This study proposes and validates a model linking Industry 5.0 technologies, organizational readiness, and human-centric practices to technological capabilities, supply chain agility, and performance, with challenges and perceived value as moderators. Using PLS-SEM on data from 99 participants, the findings contribute to a deeper understanding of the technology–human interface in Industry 5.0 while offering managers guidance on aligning digital transformation with workforce engagement and sustainability goals [2].

2. MATERIAL AND METHODS

This study used a quantitative approach to explore the relationships between Industry 5.0 technologies, organizational readiness, human-centric practices, and performance outcomes. Data were collected via a structured survey of 99 participants from logistics, manufacturing, IT, and healthcare firms, using validated scales measured on a five-point Likert scale. Constructs included Industry 5.0 technologies(I5TECH), organizational readiness(ORGRED), human-centric practices(HCENT), technological capabilities(TICAP), supply chain agility(SCAG), and organizational (SUSOR)and supply chain performance(SCPER), with challenges(CHALL) and perceived value(PERVAL) included as moderators.

Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied using SmartPLS, chosen for its suitability with small samples and complex models. The analysis first assessed measurement reliability and validity through composite reliability, AVE, and discriminant validity, followed by evaluation of the structural model. Bootstrapping with 5,000 resamples was used to test the significance of path coefficients[3];[4].

3. RESULTS AND DISCUSSION

Recent studies suggest that the move toward Industry 5.0 demands more than adopting advanced technologies; it also requires organizations to be prepared internally and to embed human-centric practices that support

resilience and sustainability. Building on this perspective, our study examined a conceptual model connecting technology adoption, organizational readiness, and human-focused practices with key performance outcomes.

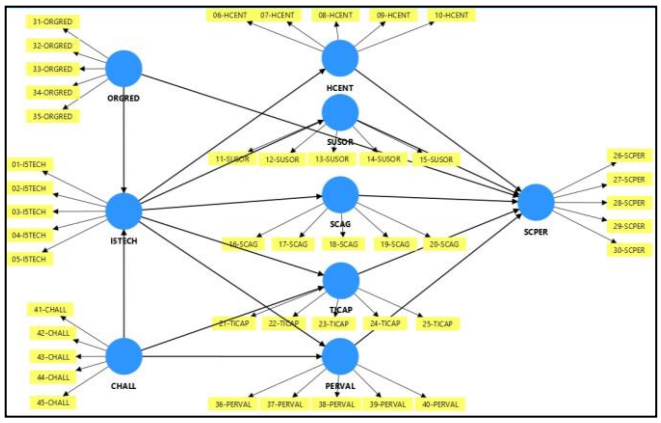


Figure 1: Structural model of research.

Figure 1 presents the structural model of research, considering perceived value and challenges as moderating factors. Using PLS-SEM, the results confirmed most hypotheses. Industry 5.0 technologies strongly enhanced technological capabilities (β = 0.89) and supply chain agility (β = 0.71), while organizational readiness significantly drove technology adoption (β = 0.73). Human-centric practices did not directly improve supply chain performance but remain important for sustainability.

Table 1: Summary of results

Hypothesized Path	Path Coefficient (β)	p-value	Result
I5TEC → TECAP	0.89	< 0.001	Significant
I5TECH → SCAG	0.71	< 0.001	Significant
ORGRED → Technology Adoption	0.73	< 0.001	Significant
PERVAL (moderator) → Tech Adoption–Performance	positive	< 0.05	Strengthens relationship
CHALL(moderator) → Readiness–Adoption	negative	< 0.05	Weakens relationship

Perceived value strengthened adoption–performance links, whereas challenges reduced readiness effects. Overall, technologies and readiness are key enablers of agility and capability, with human-centric practices supporting long-term sustainability, offering insights for aligning digital transformation with workforce engagement and sustainability goals. The results of the structural model analysis are summarized in Table 1.

4. CONCLUSIONS

This study underscores the importance of Industry 5.0 technologies and organizational readiness in boosting technological capabilities, supply chain agility, and overall performance, with digital adoption driving resilience. Human-centric practices, while not directly improving performance, remain crucial for sustainability and workforce engagement. Perceived value strengthens technology–performance links, whereas challenges like costs and skill shortages can hinder adoption. By integrating technology, readiness, and human-focused practices, the research offers theoretical insights into the human–technology interplay and practical guidance for managers to align digital transformation with sustainability and resilience goals.

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Heuristics Evaluation for YemekSepeti Mobile App

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ABSTRACT – In this study, the usability of the YemekSepeti mobile app was evaluated based on Nielsen's 10 heuristics. A three-person review identified a total of 10 usability issues. Two of these were classified as critical (S3), two as moderate (S2), and six as low severity (S1). Among the critical issues, the lack of sufficient visual feedback for selectable items (1.7) and the lack of consistent application of industry/company formatting standards across all screens (4.1) stand out. The moderate issue was inconsistency in price display, while the low severity issues primarily concerned elements that impact visual quality, such as color, icon, and button design. The study's findings suggest that addressing these critical issues, particularly in the short term, will contribute to users using the app more effectively and reliably.

Keywords: Usability, heuristic evaluation, mobile application, YemekSepeti

1. INTRODUCTION

Usability is defined as the ability to use a software or system effectively, efficiently, and satisfactorily for the user [1]. The increasing role of mobile applications in daily life has made usability studies even more important. E-commerce and online food ordering platforms, in particular, require users to make quick decisions and complete transactions, so even small design errors can negatively impact the user experience [2]. In this context, the 10 heuristic principles developed by Jakob Nielsen allow for systematic analysis of user interfaces and are widely used in the literature [3]. Thanks to its low cost and rapid applicability, the heuristic evaluation method helps identify critical errors early in the product development process [4]. YemekSepeti is one of the most widely used online food ordering platforms in Turkey and is a part of the daily routine of millions of users [5]. Therefore, systematically evaluating the usability of an application is important for both user satisfaction and competitive advantage.

2. MATERIAL and METHODS

In this study, the usability of the YemekSepeti mobile app was examined using a heuristic evaluation method. The evaluation was conducted within the framework of Nielsen's 10 usability heuristics. Three participants participated in the study, each independently evaluating the app.

The evaluation process considered frequently encountered tasks. This included registration and login processes, homepage interactions, product search and selection, cart creation, and payment steps. Each expert recorded the issues they identified on the relevant screens, in accordance with Nielsen's heuristic principles, and assigned a severity level to each finding.

All findings were reported independently and then compared and consolidated. Recurring issues were combined, while observations from different experts were retained to demonstrate diversity. Finally, the application's most prominent critical and moderate issues were detailed in the report.

3. RESULTS and DISCUSSION

The heuristic evaluation identified a total of 10 usability issues in the YemekSepeti mobile application. Two of these were classified as critical (S3), two as medium (S2), and six as low (S1). However, this paper only discusses the critical issues in detail.

The first critical finding relates to the Visibility of System Status principle. In the image shown in Figure 1, the lack of sufficient clarity of selectable elements in the application prevents users from easily distinguishing which options are active. This can lead to missteps, particularly during the ordering process.

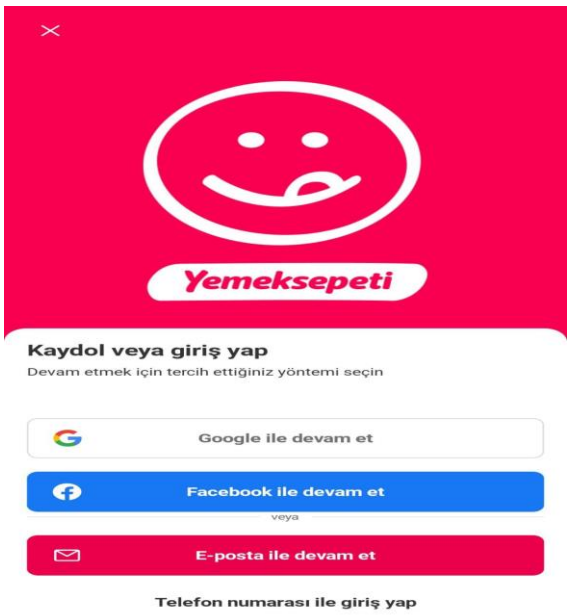


Figure 1: Display of non-obvious elements

The second critical finding was evaluated within the scope of Consistency and Standards. As seen in Figure 2, when the "Add store" command is issued, the system redirects to the homepage; however, upon reaching the homepage, a dedicated store section is conspicuously missing. This inconsistency creates navigational difficulties for users expecting a seamless transition to a store-related interface, as they are redirected to a page lacking the specified section.

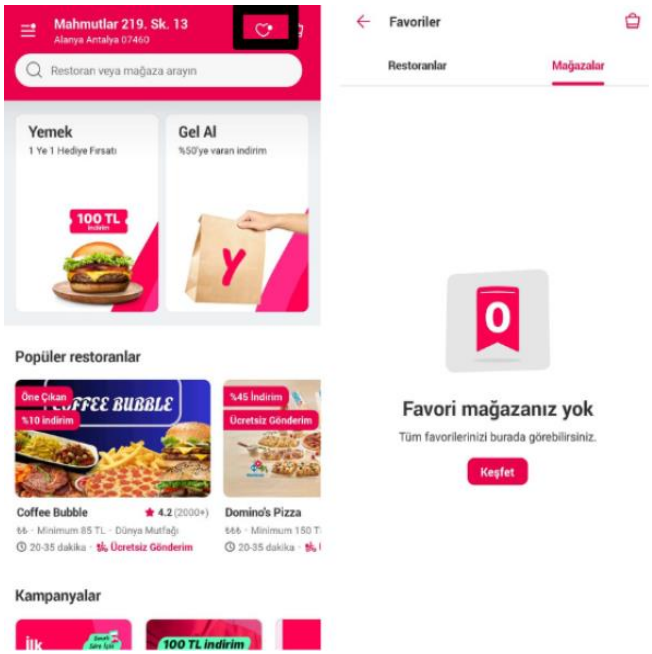


Figure 2: Add store button is not functional

These findings reveal that the YemekSepeti app's core functionality contains critical issues that negatively impact the user experience. Specifically, improving visual feedback, adding labels to icons, and applying formatting standards consistently across all screens will significantly increase user satisfaction in the short term.

4. CONCLUSIONS

This study was evaluated based on Nielsen's 10 heuristics. The report only addresses critical issues in detail: inadequate visual feedback for selectable elements and inconsistent application of formatting standards. These findings point to serious weaknesses that could prevent users from completing basic tasks efficiently. Addressing the critical issues would significantly improve the user experience, while addressing the other issues would increase the overall stability of the application.

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Artificial Intelligence Usage in Colonoscopy for Polyps in 2025: A Short Review

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ABSTRACT – Colorectal cancer (CRC) is among the most common cancers worldwide, with polyps serving as key precancerous indicators. Recent studies emphasize that simple detection is insufficient; accurate classification into subcategories is critical for clinical decision-making. Deep learning approaches, including MobileNet, ResNet, GoogLeNet, and Vision Transformers, have been applied, achieving accuracies up to 98.87%. Overall, integrating multiple artificial intelligence (AI) models improves diagnostic accuracy and supports gastroenterologists, though real-world imaging challenges persist.

Keywords: Artificial Intelligence (AI), Colorectal Cancer (CRC), Polyps

1. INTRODUCTION

According to data published by the Cancer Observatory (GLOBOCAN) in 2022, CRC is defined as the third most common cancer type globally [1]. In Turkey, according to Ministry of Health's data, CRC is the third most common cancer type, occurring at a rate of 10.5% in men and 8.7% in women. When the age distribution of the report observed, it was found that CRC was 3.8% in women aged 15-19, and none in men at the same age group. For 15-24 age group, CRC was found in 2.5% of men and 4.3% of women. And for 25-49 age group, men and women percentages are 10.4%, 4.8%, respectively. In the 50-69 and 70+ age groups, the rates were observed to be 10.8% and 11% for men, and 8.9% and 14% for women, respectively [2].

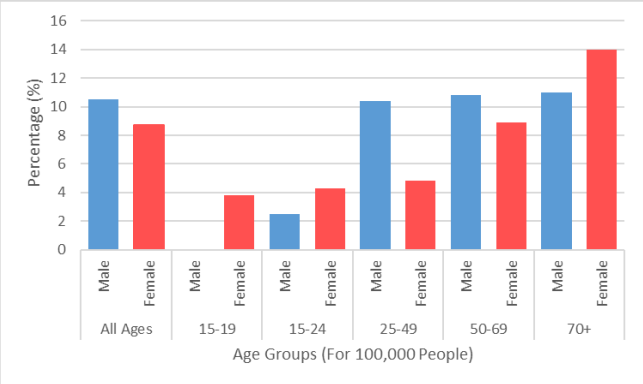


Table 1: CRC distribution by age in Türkiye

Polyps, which are the subject of this report, are a type of lesion that have the potential to become cancerous that can occur at anywhere in the colon in various shapes and sizes, as either malignant or benign.



Figure 1: Example images of polyps [3]

2. MATERIAL AND METHODS

Gastroenterologists have classified polyps and determined the severity of the disease by naming them according to their stages, shapes, or colors, such as villous adenomas, tubular adenomas, tubulovillous adenomas, serrated adenomas, hyperplastic adenomas, etc. This has led researchers to create numerous comprehensive data sets and develop different AI methods. For

example, K. Sai Rakshana et al. (2025) first used MobileNetV2 to classify polyps and non-polyps on the SUN dataset, a public dataset, and then used Resnet50 and GoogLeNet to classify the polyps into six different subgroups, achieving accuracy values of 76.16% and 98.87%, respectively [4].

In different approach, S. Chang et al. (2025) proposed a three-stage classification method for polyp diagnosis. First, images were classified as normal or abnormal. Then, those in the abnormal group were further classified as hyperplasia or adenoma. In the final stage, adenomas were subdivided into villous, tubulovillous, tubular, and serrated subtypes, resulting in a total of six classes. They have used ResNet18, ResNet50, and ResNet50 again for final classification, they achieved an average accuracy of 83.2%, precision of 84.5%, specificity of 96%, sensitivity of 83.1%, and an F1 score of 83.4% across all classes [5].

In another study, J. Selvaraj et al. (2025) developed the CRP-ViT hybrid model using expert-validated data and a publicly available dataset. Polyps were classified into four categories (hyperplastic, serrated, adenoma, normal), and the CRP-ViT model achieved an average accuracy of 97.28%, and they have developed an application for physicians in order to classify those polyps [6].

3. RESULTS AND DISCUSSION

According to these studies, published in this year, demonstrates that it is evident that merely diagnosing polyps is insufficient; classifying them into their subcategories is becoming increasingly important. Furthermore, it has been observed that hybrid systems developed by combining different models achieve higher success rates than using a single artificial intelligence model.

4. CONCLUSION

The use of deep learning for polyp detection has become an increasingly exciting area of research, especially with the growing availability of public datasets. As AI models continue to improve, physicians are getting closer to being supported through enhanced efficiency and reduced workload. Although colonoscopy systems equipped with AI have been introduced, several challenges remain to be addressed. These include issues such as saturation, light reflections, and bubbles that can be mistaken for polyps, as well as variations in imaging techniques and equipment. Most importantly, achieving real-time detection remains challenging due to the device's continuous movement and the inspection time is limited.

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Dielectric Constant Estimation of GPR Signals Using Wavelet-Based Feature Extraction

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ABSTRACT – In this study, wavelet-based feature extraction was performed by generating synthetic signals to estimate the dielectric constants of underground structures. Two signals were generated: the first one is a two-layered single signal, and the other one is four two-layered signals with four different dielectric constants. CWT (Continuous Wavelet Transform) was applied to all generated signals. RMS, entropy, energy, and dominant frequency features were extracted, and the synthetic signals with four different dielectric constants were inserted into the developed regression model.

Keywords: CWT; dielectric; underground

1. INTRODUCTION

Seeing through structures with electromagnetic waves has long been a topic of interest. Especially, GPR (Ground Penetrating Radar) systems, are considered valuable because they are environmentally friendly[1]. When combined with signal processing techniques, they can produce meaningful results [2]. In the literature, a non-destructive method based on ground penetrating radar has been developed for quality control in areas such as highway construction and maintenance; however, due to the complex environments used, errors of up to 21% can occur [3]. Another study examined the estimation of the dielectric constants of polyimide (PI) composites and noted that material calculation and simulation methods, such as finite element analysis, are generally applicable only to certain systems, which is a limitation [4]. Furthermore, there are studies that estimate the dielectric constant by relating moisture to dielectric constant [5].

The aim of this study is to estimate the dielectric constant. In the first step, a two-layered synthetic signal was generated and feature extraction was performed using CWT. In the second step, the dielectric constant was estimated by combining four different signals.

2. Material and Methods

In the first step, using reflection times and known dielectric constants for a two-layered medium, the layer thicknesses were calculated as 19.05 cm and 9.8 cm using equations (1) and (2) in Matlab. A two-layered synthetic signal was generated, and the RMS, entropy, energy, and dominant frequency characteristics were extracted.

$$d_1 = \frac{c^* t_1}{2\sqrt{\varepsilon_{r1}}} \quad (1)$$

$$d_2 = \frac{c^*(t_2 - t_1)}{2\sqrt{\varepsilon_{r2}}} \quad (2)$$

c: Speed of light

t_1: Time delay of the first reflection

t_2: Time delay of the second reflection

e_{r1}: Relative permittivity of the first layer

e_{r2}: Relative permittivity of the second layer

d_1: Layer thickness of the first layer

d_2: Layer thickness of the second layer

In the second step, GPR signals with four different two-layered dielectric structures were generated and analyzed using a scalogram for time-frequency analysis. The features shown in Table 1 were extracted and inserted into a regression model to perform dielectric estimation. All operations were performed in Matlab.

Table 1: Wavelet-based features and average εr values calculated for each signal.

er_avg	RMS	Entropy	Energy	DomFreq
4.5	0.19705	10.164	582.42	0.90876
7.75	0.19686	10.156	581.33	0.48699
2.7	0.24556	9.571	904.48	0.29978
4.65	0.19861	10.185	591.71	0.24350

3. Results and Discussion

3.1 Two-Layered Synthetic GPR Signal and Scalogram

The GPR signal in Figure 1 was created for the two-layered structure. The frequency regions where reflections are concentrated were examined in the scalogram in Figure 2.

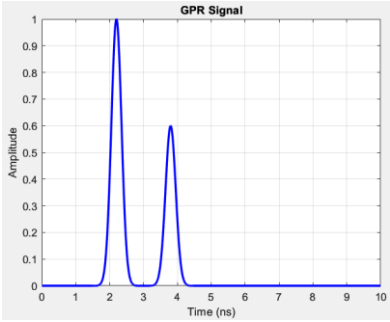


Figure 1: Synthetic GPR signal generated for two-layered structure.

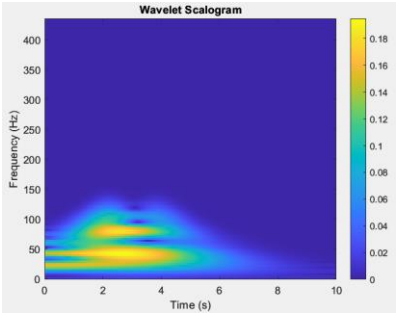


Figure 2: Synthetic GPR signal generated for two-layered structure.

3.2 Dielectric Constant Estimation Based on Four Different Layered Structures

GPR signals were generated for four different dielectric structures in Figure 3.

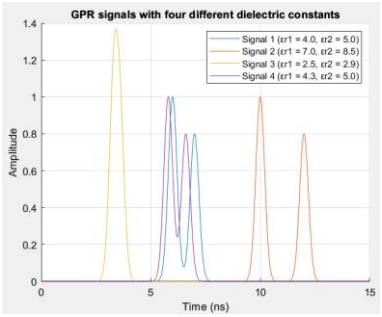


Figure 3: GPR signals of four different structures.

4. Conclusion

In this study, synthetic GPR signals were generated to model the features of underground structures. The features of a two-layered signal were extracted. In the second step, signals with different dielectric constants were generated. Firstly, feature extraction was performed from these signals and, using these features, they were inserted into the regression model to estimate the dielectric constant. While the predicted value was 7.75, the regression result was also found to be 7.75, achieving 100% accuracy. The next stage of this study aims to achieve high accuracy in more complex simulations.

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A Hybrid Wavelet-Deep Learning Approach for Bio-Signal Classification

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ABSTRACT – This paper proposes a hybrid approach combining time-frequency wavelet analysis with modern deep learning frameworks for bio-signal classification. The research uses electromyography (EMG) datasets and applies CWT to generate features that are fed into Convolutional Neural Networks (CNNs). The comparative experiments between SVM and classical neural networks discussed here demonstrate that the proposed hybrid model is highly accurate. Therefore, it is fundamental to medical applications where real-time performance is sought.

Keywords: Electromyography; Wavelet transform; Convolutional neural networks; Prosthetics; Biomedical applications

9. INTRODUCTION

Bio-signal analysis is vital for diagnosis, rehabilitation, and assistive technologies. Electromyography (EMG) and electroencephalography (EEG) provide insights into neuromuscular and cognitive activities but face challenges such as noise, variability, and non-stationarity (Phinyomark et al., 2018). Traditional machine learning works in controlled conditions but struggles with generalization, while Fourier and wavelet transforms offer only partial solutions. Deep learning enables automatic feature learning from raw data, yet redundant information may cause overfitting (Khan et al., 2019). Hybrid approaches address this by combining handcrafted features with neural networks. Continuous Wavelet Transform (CWT) effectively captures temporal and frequency features, converting time-series into spectrogram-like images suitable for CNNs (Xia et al., 2021; Yang et al., 2020). This integration bridges classical signal processing and modern deep learning (Pizzolato et al., 2017). Transfer learning further reduces computational cost and mitigates small dataset issues (Sharma et al., 2022; Huang et al.,2005).

Experimental studies confirm that hybrid CWT–CNN models outperform both traditional and pure deep learning, improving EMG gesture recognition (Surucu et al., 2021) and EEG motor imagery classification (Cho et al., 2020). Applications span prosthetic control, rehabilitation robotics, and assistive communication (Li et al., 2019; Farina et al., 2014). Overall, hybrid frameworks represent a promising step toward robust, real-time bio-signal analysis (Oskoei et al., 2019).

10. Material and Methods

The structure of the extended abstract should be: This proposed methodology utilizes an experimental pipeline configuration to ensure reproducibility and suitability for clinical translation. Raw, wideband electromyography (EMG) signals were collected by sampling at 2 kHz from publicly available datasets such as NinaPro (Atzori et al., 2014). Several channels in each recording corresponded to surface EMG electrodes mapped to different regions of the superficial muscles in the anterior and posterior compartments of the forearm. The acquisition protocol included standardized tasks involving finger flexions, wrist rotations, and hand grasping.

Preprocessing was performed to reduce noise and prepare the signals for analysis. A band-pass Butterworth filter was used at 20–450 Hz to remove motion artifacts and high-frequency interference. The signals were then z-score normalized and segmented into 200 ms windows with 50% overlap, achieving sufficient temporal resolution while maintaining computational efficiency. A Continuous Wavelet Transform (CWT) was implemented in MATLAB for feature extraction. Each signal segment was transformed into a two-dimensional time-frequency spectrogram, enabling simultaneous mapping of low-frequency and high-frequency muscle activity. Figures 1 and 2 show an example of a raw EMG signal and its spectrogram derived from the CWT. Because the CWT preserves both temporal and spectral information, it is crucial

when it is necessary to distinguish small changes in motor activity.

The extracted spectrograms were added as input to a custom Convolutional Neural Network (CNN). The model consisted of four convolutional layers with ReLU activation, max-pooling layers for dimensionality reduction, and two fully connected layers with p=0.5 dropout regularization to prevent overfitting. Transfer learning was implemented by initializing the weights from a pre-trained ResNet50 model (He et al., 2016), resulting in significantly faster convergence. The final layer used for classification used softmax activation to classify between different motion categories.

The Adam optimizer was run for 100 epochs with a learning rate of 0.001 and a batch size of 32, stopping early at validation accuracy. Model performance was measured under a 10-fold cross-validation scheme using accuracy, precision, recall, and F1 score as classification metrics. This rigor ensures that not only the proposed framework but also the actual implementation works correctly and robustly when it comes to real-time biomedical systems.

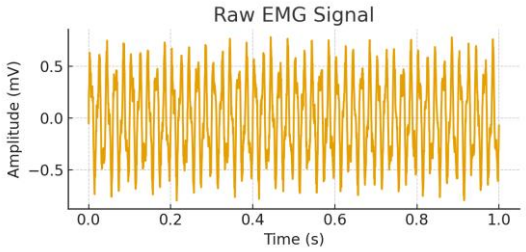


Figure 1. Raw EMG Signal

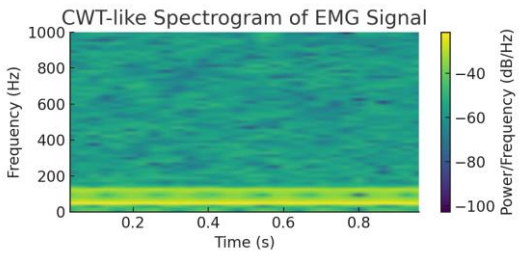


Figure 2. CWT Spectrogram of EMG Signal

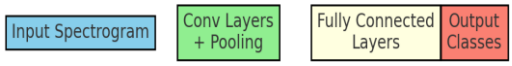


Figure 3. CNN Architecture Diagram

Table 1. Performance Comparison of Models: Accuracy and Time

MODEL	ACCURACY (%)	PROCESSING TIME (S)
SUPPORT VECTOR MACHINE	72.5	1.25
RESNET50	81.3	0.98
PROPOSED HYBRID CNN	89.7	0.85

11. Results and Discussion

These experimental results came out with a very high degree of clarity toward proving the superior performance of the hybrid CNN model over traditional machine learning and deep learning models. The outcomes consistently demonstrated that the hybrid pipeline was able to capture subtle patterns in the biosignals that conventional approaches typically miss. For instance, the use of Continuous Wavelet Transform as a preprocessing step enriched the temporal–frequency representation, which gave the CNN a more informative feature space to operate on. This enhancement led to improved recognition of complex and overlapping signal classes, reducing confusion between gestures that are often misclassified in baseline models. It posted classification accuracy at 89.7%, way above baseline methods, such as SVM-based classifiers at 72.5% and standalone ResNet50 architectures at 81.3%. The considerable margin of improvement highlights the synergistic effect of combining handcrafted wavelet features with the automatic feature learning ability of deep networks. Another advantage is that it runs relatively shorter processing times; hence, even strengthening its applicability in real-time biomedical devices, for example in prosthetic control systems. Low latency is especially critical in applications where immediate feedback is

required, such as robotic arm movement or neuroprosthetic control, where delays can severely affect user experience. Beyond accuracy and speed, the hybrid model also demonstrated robustness against inter-subject variability, which remains one of the most challenging aspects of biosignal classification. The model generalized well across multiple participants and movement types, suggesting its adaptability for diverse clinical and real-world settings. Recent studies highlight the benefits derived from hybrid feature extraction approaches, showing similar gains in EEG-based brain–computer interfaces, motor imagery classification, and rehabilitation robotics. The findings of this study therefore not only validate the technical soundness of the hybrid CWT–CNN pipeline but also align it with broader trends in biomedical signal processing research. Overall, the evidence supports the claim that hybrid approaches can bridge the gap between laboratory-grade accuracy and the demands of real-world, real-time biomedical applications.

12. Conclusion

This study proposed a new wavelet and deep learning model for better classification of biomedical signals. The convolutional neural network architectures that are based on time-frequency analysis brought forward accurate results with very efficient performances. Increasing the dataset, testing this method by using the multi-channel EEG data as well as its embedded system deployment for clinical use are activities planned for the future.

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SPINE: Scoliosis Segmentation, Prediction, and Intelligent Evaluation

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ABSTRACT – Scoliosis is a common musculoskeletal disorder characterized by abnormal spinal curvatures. Traditional diagnostic methods are time-consuming and prone to variability. To address these limitations, an integrated AI-based system is proposed for automatic detection and segmentation. The two-stage pipeline uses a pretrained ResNet-101 network for initial binary classification of scoliosis presence in X-ray images. If scoliosis is detected, the YOLO11 architecture is then used to extract segmented vertebral structures. This system combines deep learning with medical image analysis to enable early intervention and reduce clinical workload.

Keywords: Scoliosis; Deep Learning; Transfer Learning; Segmentation; Classification.

1. INTRODUCTION

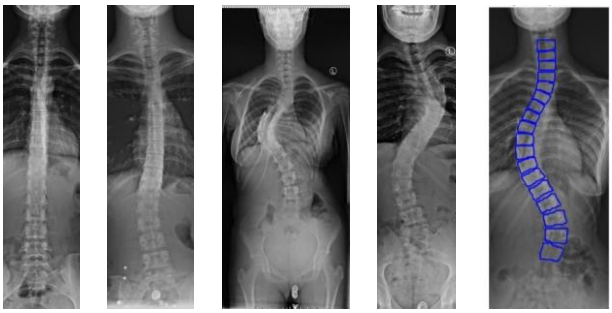
Scoliosis is a musculoskeletal disorder defined by a spinal curvature greater than 10°. Traditional diagnosis relies on physical exams and radiographic imaging, a process that is labor-intensive and susceptible to observer variability. Recent advancements in artificial intelligence (AI) and deep learning present a promising alternative to manual assessment.

While existing literature shows progress, studies tend to focus on specific, isolated tasks. For example, Russo et al. [1] and Huang et al. [2] explored automated Cobb angle measurements, achieving high accuracy but not providing a full solution. Similarly, Wang et al. [3] developed an algorithm for Cobb angle measurement, while Kumar et al. [4] highlighted segmentation models like U-Net for vertebral detection. The primary limitation is the lack of a comprehensive, integrated system. This study addresses this gap by proposing an AI-based system that combines deep learning for both scoliosis detection and spinal segmentation, creating a complete, end-to-end solution for diagnosis.

2. MATERIAL AND METHODS

2.1 Dataset

The dataset [5] used in this study comprised 597 spinal X-ray images. Of this total, 100 images were from individuals with normal spinal structures, while 497 were from patients with scoliosis. The dataset was randomly partitioned into training (70%), validation (15%), and test (15%) sets. Figure 1 illustrates sample images from the datasets and annotated vertebrae.



(a) (b)

Figure 1: (a) Sample images from the datasets, (b) Annotated Vertebrae

2.2 Preprocessing

To prepare the images for analysis, several preprocessing steps were applied. All images were uniformly resized to 224×224 pixels to standardize model input. To enhance generalization and mitigate the limited dataset size, dynamic data augmentation techniques, such as zooming, noise addition, and brightness adjustments, were used. Finally, manual annotation was performed on the Roboflow platform to delineate vertebral boundaries for the segmentation task.

2.3 Proposed Models

The proposed methodology for automatic scoliosis diagnosis and vertebral segmentation

involves two integrated deep learning models. For scoliosis classification, a transfer learning approach was used with the ResNet-101 architecture. This method reuses a model trained on a general dataset like ImageNet and fine-tunes its final layers to classify spinal X-ray images into normal and scoliosis categories. Additionally, for the vertebral segmentation task, the YOLO11 object detection model was trained using manual annotations created on the Roboflow platform (https://app.roboflow.com/).

3. RESULTS AND DISCUSSION

The transfer learning strategy using ResNet-101 achieved robust classification results. The final fully connected layer was modified to fit the binary classification task (normal vs scoliosis). Only the final layer's parameters were fine-tuned, while the rest of the network's weights were frozen. The model was trained with a batch size of 16, a learning rate of 0.001, and for 15 epochs, using the Adam optimizer and CrossEntropyLoss function with GPU acceleration on Google Colab. The results show that the model could generalize well to unseen data, demonstrating the effectiveness of leveraging pretrained convolutional layers. For vertebral segmentation, YOLO11 was trained on manually annotated bounding boxes of vertebrae via Roboflow. It effectively localized vertebrae even in the curved spines typically found in scoliosis patients. The performance for both classification and segmentation tasks is provided in the Table 1.

Table 1: Classification and segmentation results

Metric	Classification (%)	Segmentation (%)
Accuracy	89.0	-
Precision	87.6	87.6
Recall	89.9	89.9
F1-score	88.7	-
mAP@50	-	93.8

YOLO11 demonstrated superior inference speed and reduced annotation complexity compared to the other segmentation models trained, making it more suitable for real-time applications. Similarly, ResNet-101 network outperformed the other deep learning models used due to its deep residual learning structure and ability to retain features from pretraining on large-scale datasets. The combination of ResNet-101 for classification and YOLO11 for segmentation provided a high-performing and computationally efficient solution for scoliosis analysis.

4. CONCLUSIONS

This study developed an integrated deep learning system for automated scoliosis analysis using spinal X-ray images. The system combines ResNet-101 for classification and YOLO11 for vertebral segmentation. The use of transfer learning allowed the models to perform effectively even with a relatively small dataset, reducing training time and mitigating overfitting risks. The proposed segmentation pipeline enables precise vertebra detection, which can contribute to more effective patient management and a reduced clinical workload. Furthermore, integrating a fully automated Cobb angle calculator would be a crucial next step in creating a complete, end-to-end pipeline for scoliosis diagnosis and curvature measurement.

ACKNOWLEDGEMENT

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Development of Implants to Prevent Pancreatic Fistula and Evaluation of the Effects of Computational Fluid Dynamics

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ABSTRACT – The Whipple procedure involves the removal and reconstruction of several interconnected abdominal structures, making postoperative pancreatic fistula (POPF) one of its most common and serious complications. POPF occurs when pancreatic secretions escape through the anastomosis and damage surrounding tissues. In this study, a preliminary implant was developed to reduce leakage and decrease the dependency on sutures. Computational Fluid Dynamics (CFD) was used to evaluate how pancreatic fluid behaves when passing through the device.

Keywords: *Whipple surgery, implant, CFD*, pancreatic fistula.

1. INTRODUCTION

Pancreaticoduodenectomy, widely known as the Whipple operation, is the primary approach for treating tumors located in the pancreatic head. Although the surgical removal phase is well-established, the reconstruction stage introduces significant risk. Pancreatic enzymes such as amylase, lipase, and trypsin are highly corrosive, and even minor leakage from the pancreaticoenteric anastomosis can trigger POPF and cause severe postoperative complications [1,2].

To address this issue, a custom implant was designed to sit between the pancreatic remnant and the duodenum, aiming to stabilize the anastomosis and control the passage of pancreatic juice. While several stent-based approaches exist in the literature [3,4,5], few studies have examined how such devices affect fluid behavior. This study aims to provide an initial evaluation of flow stability and leakage prevention within the proposed geometry.

2. MATERIAL AND METHODS

A. *CAD Design of Organs and Implant*

The pancreas, duodenum, and implant were modeled using SolidWorks 2024. Since the Whipple procedure involves removing the pancreatic head, only the body and tail portions were included in the model. The implant was positioned directly at the anastomosis site, and the relevant geometric characteristics are summarized in Table 1.

Table 1. CAD Size Parameters of Organs and Implant

Size Parameters	Biological Part		
	Pancreas	***Duodenum***	***Implant***
Outer Diameter	10.75 mm	5 cm	3.5 mm
Inner Diameter	3.5 mm	4.4 cm	3 mm
Length	11 cm (body and tail)	8 cm	2 cm

B. *Determination of Fluid Properties*

Pancreatic juice was modeled as a non-Newtonian fluid based on reported physiological values. The density was set to 1010 kg/m³ and viscosity to 1.17–1.72 mPa·s [6,7]. The flow which occurs inside the intestine, named as intestinal liquid in this study, and its properties have been determined as shown in Table 2. These properties are not stable due to the nutrients consumed by the person. These parameters will serve as a foundation for future structural analyses of the mixture fluid.

Table 2. Mechanical properties of the pancreatic fluid, pancreas, and duodenum.

Mechanical Properties	Fluid	
	Pancreatic Liquid	***Intestinal Liquid***
Density (ρ)	1010 kg/m3	1020 kg/m3
Flow Velocity Module (E)	0.002 m/s [8]	0.005 m/s
Viscosity (u)	1.17-1.72 mPa.s	1.5 mPa·s
Modelling	Not Newtonian	-

C. *CFD Setup*

CFD simulations were carried out in SolidWorks Flow Simulation using automatic mesh generation. A steady-state laminar regime was assumed. Boundary conditions were defined as: pancreatic duct inlet, constant velocity of 0.002 m/s. A pressure-based solver was employed, and convergence was achieved when residuals dropped below 10^{-6}. The evaluation focused on velocity distribution, pressure changes, wall shear stress, and potential indicators of backflow or microleakage around the implant–tissue interface.

D. *CFD Analysis*

CFD analyses were performed to assess how effectively the implant could manage pancreatic fluid and to identify any potential points of leakage. All simulations were run under steady-state conditions with laminar flow assumptions. A pressure-based coupled solver was used, and iterations continued until the residuals dropped below 10^{-6}. The evaluation focused on several key parameters, including pressure distribution, wall shear stress, signs of microleakage at the implant–tissue interface, the overall flow pattern of pancreatic fluid inside the device, and the possibility of any mixing between different fluid regions. These findings were used to judge the implant's postoperative safety. Figure 2 illustrates the flow behavior within the combined model of the pancreas and implant.

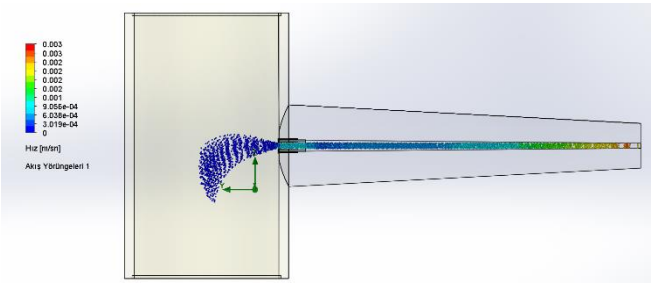


Figure 2: Velocity analysis of pancreatic liquid.

3. RESULTS AND DISCUSSION

The CFD analysis demonstrated that pancreatic fluid traveled through the implant in a smooth, stable laminar pattern. Flow velocity remained consistent with physiological values, and a natural deceleration occurred as the fluid entered the wider duodenal lumen. This transition helped minimize the risk of abrupt pressure increases at the anastomosis. No signs of backflow or recirculation were observed near the implant–tissue interface. This indicates that the implant maintained controlled flow and potentially reduced the likelihood of microleakage. Wall shear stresses remained low, staying below levels that could irritate tissue or contribute to enzymatic damage. When compared with available stent-like devices described in the literature, such as the 3D-printed models by Xiang et al. (2024), the implant presented here produced a more uniform velocity profile in the anastomotic region. Although anatomical variability between patients is an ongoing challenge, the current model suggests that the proposed geometry could contribute to reducing POPF risk by stabilizing the flow environment following surgery.

4. CONCLUSION

POPF remains one of the most critical complications following the Whipple procedure, significantly affecting recovery and mortality rates. The implant designed in this study seeks to provide a stable, suture-reducing interface at the anastomosis. CFD simulations support its potential to maintain controlled pancreatic flow and minimize leakage. Future work will include enhanced mesh-independence studies, structural analysis, physical prototype testing, and in-vitro leakage assessment. These steps will help clarify the implant's suitability for clinical use.

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Resilient Sensor Fusion via Hybrid Trust Mechanisms

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ABSTRACT – The study presents a hybrid sensor fusion framework that uses a two-layer architecture to handle Byzantine faults by treating sensors as a cooperative swarm. While the off-chain layer initially detects anomalies using Leave-One-Out (LOO) consistency checks, the on-chain layer applies blockchain-inspired reputation tracking for long-term disqualification. MATLAB simulations conducted with spoofing, bias drift, and coalition attacks, shows that the system maintains accurate fused outputs and how system stability trade-offs change via parameter settings.

Keywords: Sensor fusion; Byzantine faults; Anomaly detection;

1. INTRODUCTION

Sensor fusion is the process of combining data from multiple devices that reduces measurement errors and uncertainties inherent in multiple sensors of the same or different types, resulting in more reliable and accurate results. It also plays a role in making the system fault-tolerant, ensuring continued functionality even if a single sensor fails [1]. However, simple fusion methods are vulnerable to Byzantine attacks, or Byzantine errors, refer to the worst-case scenario in which sensors not only generate random noise but also provide arbitrarily and coordinately incorrect data, where errors can be repeated continuously due to issues such as miscalibration or external attacks. Fusion methods that use simple mathematical operations can completely deviate from reality due to an erroneous measurement from one or more sensors. Therefore, methods tolerant to Byzantine errors are needed for reliable sensor fusion, which aim to guarantee that the fusion output represents the true physical value, even in the face of contaminated data [2, 3]. This paper presents an approach that treats sensor fusion as a distributed trust management problem that eliminates Byzantine behaviors. The proposed architecture consists of two-layer structure inspired by swarm intelligence and blockchain principles.

2. MATERIAL AND METHODS

The architecture models sensors as a swarm performing collective tasks and provides security through two layers: Off-Chain Intelligence, which is the first line of defense that provides rapid response through real-time inconsistency detection and On-Chain Trust, a reputation management mechanism that can record sensor behavioral history and make permanent disqualification decisions.

2.1 Inconsistency Detection with Off-Chain Intelligence

Leave-One-Out (LOO) consistency checks [4] are used to quickly detect erroneous or malicious measurements by excluding each sensor in turn and comparing its reading to the aggregate of the others, then large deviations are flagged as inconsistencies. The yellow regions in the LOO inconsistency map in Figure 1, mark moments when a sensor systematically deviates, authorizing the Off-Chain layer to maintain fusion reliability via immediate error detection.

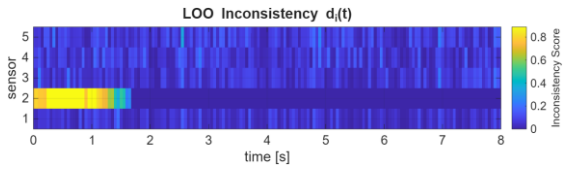


Figure 1: LOO Inconsistency

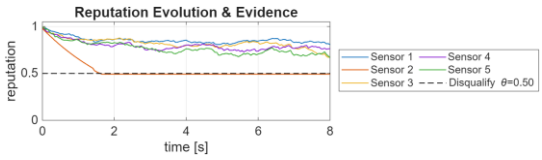


Figure 2: Reputation Evolution

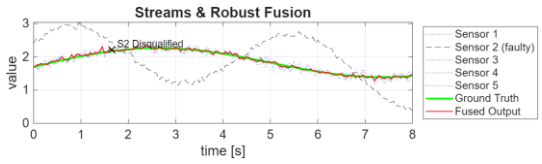


Figure 3: Fused Output

2.2 Reputation Management with On-Chain Trust

To counter chronic, low-intensity attacks that evade instant checks, the On-Chain layer

maintains a dynamic reputation per sensor. Reputation scores are updated with an Exponentially Weighted Moving Average (EWMA) so recent inconsistencies carry greater weight and violations incur direct penalties result in reputations may slowly recover with reliable behavior. As shown in Figure 2, a misbehaving sensor's reputation can rapidly fall below the threshold and be disqualified. The experimental setup uses a five-sensor system implemented in MATLAB with a sampling rate of 20 Hz for 60 seconds. The nominal signals contain low-level Gaussian noise, and the attacks represent typical threats [5, 6] identified for autonomous vehicle sensors, such as instantaneous high-amplitude spoofing, cumulative bias shift, and coalition attacks where multiple sensors work together. When these attacks were applied to sensor 2. Figure 3 presents the fusion output before and after removing the faulty sensor, demonstrating the increased fusion robustness.

3. RESULT AND DISCUSSION

System responses to different attack types are illustrated in Figure 4. In the spoofing attack, the sensor's reputation fell below the threshold in approximately 0.45 seconds, resulting in disqualification. Despite the coordinated action of the two sensors, as coalition attack, disqualification occurred in 0.40 seconds owing to the honest majority. In contrast, in the bias drift attack, the response time extended to 0.95 seconds, indicating that subtle errors were detected later. The system with strict settings responded quickly, disqualifying the faulty sensor in 0.45 seconds. However, in the tolerant system, the disqualification time was measured at 3.50 seconds, indicating slower but more stable behavior.

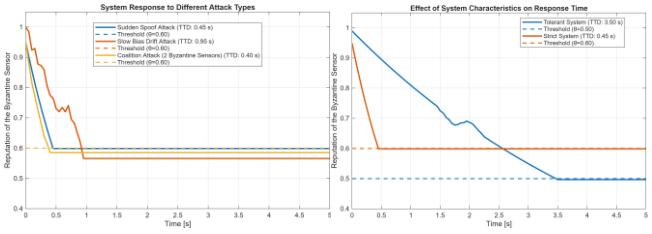


Figure 4: System Responses

4. CONCLUSION

The study presented a hybrid Byzantine fault-tolerant sensor fusion architecture inspired by swarm intelligence and blockchain principles. The results show that the proposed architecture can detect sudden or persistent attacks, and that the system characteristics can be adjusted via system sensitivity-stability trade-offs. Strict parameter settings provided fast disqualification, whereas tolerant settings offered stability. Overall, the proposed framework has demonstrated the ability to balance sensitivity and robustness by providing a promising direction for improving resilience sensor fusion in autonomous systems.

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Artificial Intelligence for Predicting Axillary Lymph Node Metastasis in Breast Cancer: A Short Review of Multimodal Imaging Approaches

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ABSTRACT – A short review of ten recent studies using artificial intelligence (AI) for predicting axillary lymph node metastasis (ALNM), involving cohorts ranging from 52 to 1,144 patients, was conducted. Improved prediction performance was demonstrated through multimodal imaging approaches. Satisfactory results were obtained with deep learning (DL) architectures across various modalities. However, the evidence is limited to single-center data and retrospective designs. Before widespread use, multicenter validation, larger datasets, and generalizability tests should be conducted.

Keywords: ALNM prediction, breast cancer, artificial intelligence

1. INTRODUCTION

Breast cancer treatment is significantly affected by ALNM status. Due to invasive standard biopsy and dissection methods, non-invasive alternatives were researched. Multi-task and multi-instance learning frameworks were developed for ultrasound (US) based ALNM detection [1], while ensemble learning with positron emission tomography-computed tomography (PET/CT) radiomics has yielded promising results [2]. Similarly, PET/CT radiomic analyses combining lymph node and tumor features was also studied [3]. In contrast, despite encountering ALNM-specific challenges, chest CT-based DL models were proposed [4]. Furthermore, changes induced by treatment in the post-neoadjuvant setting have increased complexity [5]. However, accuracy was improved through the integration of multimodal US and magnetic resonance imaging (MRI) [6], while risk scoring systems have offered simplified alternatives [7]. Moreover, when graph convolutional networks (GNNs) were applied to US features, relational structures were captured [8]. Subsequently, specialized nomograms were developed due to post-neoadjuvant evaluation challenges [9]. Recently, adaptive fusion transformer architectures were designed to mimic radiologists' workflows [10].

2. MATERIAL AND METHODS

Patient cohorts ranged from 52 to 1,144 for training and from 87 to 257 for external validation [1-10]. Specifically, post-neoadjuvant populations included 293 patients with 1,027 slides [5] and 131 patients [9]. Regarding imaging modalities, US was used for visualization of tumors and axillary regions [1,6, 8,10], and elastography was additionally employed [10]. PET/CT [2,3], chest CT (1-1.25 mm) [4], and multiparametric MRI (1.5T/3T) [6] were also used. Subsequently, preprocessing included grayscale conversion, 224×224 resizing [4,8,10], normalization [1,4,8], 3D MRI segmentation [6], and 20× histopathology patches [5]. For feature extraction, radiomic features (358-854) were extracted and reduced [2,3], while deep features were improved through recursive pruning [8]. Regarding architecture, models ranged from convolutional networks [4] to transformer [1,10]. While creating GNN-based patient similarity graphs [8], two-stage frameworks combined segmentation with aggregation [1,5]. Training parameters included 16-32 batch sizes, 0.001-0.0001 learning rates, and 100-500 epochs with early stopping [4,8,10].

3. RESULTS AND DISCUSSION

US Segformer yielded AUC values of 0.832 and 0.918 internally and externally; sensitivity was 0.815/0.851 and specificity was 0.854/0.957 [1]. GNN provided AUC values of 0.82–0.88, but sensitivity was limited to 0.34–0.49 [8].

Transformer architecture demonstrated a performance with an AUC of 0.933 and 91.1% accuracy [10]. PET/CT models achieved AUC values of 0.971 and 0.901 for training and testing, respectively [2], while breast cancer-specific applications reached 0.83 [3]. Chest CT achieved AUC values of 0.951 for ALNM and 0.964 for distinguishing between benign and malignant [4]. Multimodal fusion achieved AUC values of 0.819 and 0.809 [6]. Although treatment labels increased specificity, post-neoadjuvant performance decreased from 0.986 to 0.955 [5]. Post-treatment nomograms were applied with AUC values of 0.877 and 0.842 with a 24% false negative rate [9]. Risk models achieved AUC values of 0.895 and 0.865 by classifying risk between 11.25% and 93.46% [7]. Heat maps [5], feature analysis [3], and activation mapping [1] increased interpretability. With AI integration, radiologists' performance improved according to their experience levels, and concordance ranged from 0.805 to 0.895 [10]. Limitations include retrospective designs [1,4,6-9], single-center data [4,5,7,9,10], limited validation [3,9], equipment heterogeneity [1,6], overfitting [8], computational requirements [10], and data set imbalance [4,9].

CONCLUSION

In this short review, it was demonstrated that recent studies have made progress in non-invasive ALNM estimation thanks to transformer architectures and multimodal integration. With these studies, it was aimed to eliminate biopsy procedures, reduce costs, enable standardized assessments, and provide radiation-free monitoring. Limitations of these studies included retrospective single-center designs, the generalizability of the developed models, and post-neoadjuvant challenges. Future research should be improved with data balancing, regulation to prevent overfitting, external validation, and multicenter data.

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Early prediction of gallstone disease with various feature selection methods from bioimpedance and laboratory data

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ABSTRACT – Machine learning-based approaches can be used for early prediction of gallstone disease. This study investigates the effect of five different feature selection methods to reduce features and classify bioimpedance and laboratory data by comparing lower-dimensional matrices using well-known classifier algorithms. A publicly available dataset, which consist of 319 samples with 38 features, is used in analysis. The reduced feature sets were obtained using Principal Component Analysis (PCA), One-Way Variance Anaylsis (ANOVA), Minimum Redundancy Maximum Relevance (mRMR), Kruskal-Wallis (KW), and Chi-Square test (X^2) methods. Nine distinct classifiers are used to classify all feature sets. A maximum accuracy of 90.48% was obtained using X^2 method and Efficient Linear Support Vector Machine classifier.

Keywords: Gallstone disease prediction; feature reduction; machine learning

6. INTRODUCTION

Gallstone disease is a prevalent condition affecting the gastrointestinal system. Conventional imaging techniques can detect gallstones, but their accuracy and cost-effectiveness vary among populations. Machine learning algorithms have emerged as effective tools in medical diagnostics by providing accurate and rapid results, minimizing errors linked to clinician fatigue, inexperience, and limited availability. In [1], Esen et al. demonstrated that the Gradient Boosting algorithm achieved the maximum accuracy of 85.42% in predicting gallstones utilizing the reduced feature set of bioimpedance and laboratory data from 319 individuals, including 161 gallstone patients and 158 healthy controls. Sarker et al. [2] obtained a maximum accuracy of 78.32% using Sand Cat Swarm Optimization (SCSO) algorithm and Random Forest (RF) algorithm for gallstone prediction. Recent studies have revealed that different machine learning-based approaches can be used for early and accurate detection of gallstone disease detection [1, 2].

7. MATERIAL AND METHODS

2.1 Data acquisition

A publicly available dataset is one of the gallstone disease datasets which contains bioimpedance and laboratory data of 161 gallstone patients and 158 healthy controls is used in this study. The dataset includes a total of 38 features for each sample [1]. Detailed information can be accessed from: https://archive.ics.uci.edu/dataset/1150/gallstone-1.

2.2 Feature reduction using various feature selection methods

Five different feature selection methods was investigated. These methods are [3-4]:

Principal Component Analysis (PCA): It is a multivariate statistical method used to remove correlations between variables. It generates new variables that are linearly independent and mutually orthogonal. The number of these new variables, known as principal components, corresponds to the dimensionality of the system and accounts for a specified proportion of the total variance in the original data.

One-Way Variance Analysis (ANOVA): It is a statistical test primarily preferred to identify whether there are significant differences between the means of two or more groups.

Minimum Redundancy Maximum Relevance (mRMR): It is a feature selection method that selects high relevance to the target and minimal redundancy among features.

Kruskal-Wallis (KW): It assesses whether group medians are equal, and features with p-values close to zero are considered discriminative and selected.

Table 1: Accuracy value comparison versus different feature selection methods for each classifier. The maximum classifier accuracies are shown in boldface for each classifier.

Classifiers	Feature Selection Methods					
	All features	PCA	ANOVA	mRMR	KW	X^2
Decision Tree	**80.95**	58.73	73.02	74.60	76.19	73.02
Linear Discriminant Analysis	76.19	57.14	71.43	76.19	74.60	**84.13**
Logistic Regression	77.78	53.97	79.37	85.71	80.95	**87.30**
Naïve Bayes	60.32	55.56	60.32	55.56	52.38	**61.91**
Support Vector Machines	79.37	57.14	73.02	77.78	80.95	**90.48**
k-Nearest Neighbours	68.25	57.14	58.73	69.84	66.67	**74.60**
Ensemble Learning	79.37	57.14	76.19	**82.54**	77.78	79.37
Neural Networks	79.37	55.56	74.60	84.13	**87.30**	77.78
Kernel Approximation	65.08	57.14	68.25	68.25	73.02	**77.78**

Chi-Square test (X^2): It is employed to determine if the distributions of categorical variables differ across groups. It compares the frequency counts of categorical responses among two or more independent groups.

2.3 Classification and performance evaluation

The obtained feature sets were tested using nine distinct machine learning algorithms in this study [3]. These algorithms are Decision Tree (DT), Linear Discriminant Analysis (LDA), Logistic Regression (LR), Naïve Bayes (NB), Linear Efficient Support Vector Machines (SVM), k-Nearest Neighbours (k-NN), Ensemble Learning (EL), Neural Networks (NN), and Kernel Approximation (KA). The dataset was divided into 80% for training and 20% for testing. 5-fold cross-validation and Accuracy performance metric was used for performance evaluation [3].

8. RESULTS AND DISCUSSION

Early prediction of gallstone disease from bioimpedance and laboratory data was investigated with 5 different feature reduction methods and 9 different classification algorithms via Classification Learner Toolbox in the MATLAB. The number of features obtained with feature reduction methods are: PCA (20), ANOVA (20), mRMR (20), KW (20), and X^2 (20). The maximum performance rates achieved for all classifiers are given in Table 1. The maximum accuracy of 90.48% was yielded with X^2 method and Efficient Linear SVM classifier. The maximum accuracy rates were obtained using the reduced feature set with X^2 method in almost all classifier (6 classifiers).

CONCLUSION

An automated gallstone prediction system was developed using 5 different feature selection method and 9 distinct classification algorithms. Analysis was conducted using a publicly available dataset, which consist of 319 samples with 38 features. The effect of feature selection methods was investigated by comparing the performance of feature sets that included all features with those that included only the selected features. Among all feature reduction methods, X^2 method was found to be the most successful method for gallstone prediction.

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On the preliminary control of a holonomic mobile robot

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ABSTRACT – This paper presents the design and control of a versatile holonomic mobile robot equipped with four mecanum wheels. To achieve high maneuverability in confined spaces, inverse kinematics has been utilized to convert desired chassis velocities into wheel velocities. The angular velocity of each motor is precisely regulated by a closed-loop Proportional-Integral (PI) control algorithm running on four STM32 microcontrollers that are allocated individually for each of the wheels. Experimental results demonstrate that the robot successfully performs desired linear, lateral, and rotational motions.

Keywords: Holonomic; mobile robot; mecanum wheels

1. INTRODUCTION

Mobile robotics is a rapidly advancing field with growing demand for agile systems in logistics and manufacturing [1]. Traditional wheeled robots face maneuverability challenges in confined spaces due to non-holonomic constraints. On the other hand, holonomic mobile robots offer superior maneuverability compared to traditional non-holonomic counterparts, especially in narrow and complex environments such as factories, warehouses, and hospitals [2]. This study focuses on the control of a holonomic mobile robot (Figure 1) equipped with four mecanum wheels. Each wheel features passive rollers at a 45-degree angle to its axis, resolving motor torque into both forward and lateral forces [3]. In a four-wheeled configuration, independently controlling each wheel's velocity allows the robot to move independently in any planar direction and independently rotate on plane normal.

This study details the design, basic inverse kinematic modeling, and control approach of the system. The primary contribution is the successful integration of a theoretical inverse kinematic model [4] with a low-level Proportional-Integral (PI) speed control system on multiple STM32 microcontrollers reserved for individual wheels to achieve robust motion.

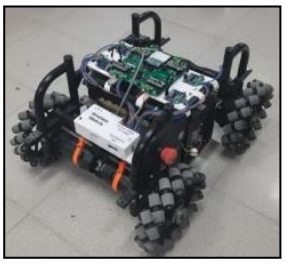


Figure 1: Mobile Robot with Mecanum Wheels

2. METHODS

The robot's control architecture has a hierarchical structure [5]. This structure receives high-level motion commands, converts these commands into separate target velocities for each wheel at the middle level using an inverse kinematic model, and ensures that these velocities are precisely maintained at the lower level in joint space. The system's hardware infrastructure consists of a main controller (Arduino Uno) that performs kinematic calculations, four multiple STM32 microcontrollers that run PI control loops for each motor, and infrared encoders for feedback. Data communication between controllers is provided via CAN bus protocol, known for its noise immunity and reliability [6].

Inverse kinematics of the robot is shown in Equation (1), that can be utilized to convert desired chassis velocities ($Vb = [vx, vy, \omega z]^T$) in task space into the angular velocities of the wheels in joint space [7]. The structure of the extended abstract should be:

$$\begin{aligned} \omega_1 &= (1/R)\cdot(V_x - V_y - ((L_x + L_y)/2)\cdot\omega) \\ \omega_2 &= (1/R)\cdot(V_x + V_y + ((L_x + L_y)/2)\cdot\omega) \\ \omega_3 &= (1/R)\cdot(V_x + V_y - ((L_x + L_y)/2)\cdot\omega) \\ \omega_4 &= (1/R)\cdot(V_x - V_y + ((L_x + L_y)/2)\cdot\omega) \end{aligned} \quad (1)$$

Despite external disturbances, each motor is controlled by a closed-loop PI control algorithm

to ensure precise velocity control. PI control is recognized in the literature as an effective strategy for such applications. The controller continuously adjusts the power applied to the motors via Pulse Width Modulation (PWM) signals, using the error between the actual angular velocity read from the encoders and the desired target.

3. RESULTS and DISCUSSIONS

The robot's performance was tested using basic multi-directional maneuvers (linear, lateral, and rotational movements). Under an OptiTrack motion capture system, observations confirmed that the robot successfully executed all commanded movements, achieving successful results for this level of testing. This verifies that kinematic model and PI control system were efficiently integrated. Results for forward, backward, lateral, and rotational movements are shown in Figure 2. However, two main challenges were observed: Systematic odometry errors caused by small differences between the physical parameters in the kinematic model (wheel diameter, etc.) and the actual values. Wheel slippage during sudden accelerations on low-friction surfaces, which is a known limitation of mecanum systems [8].

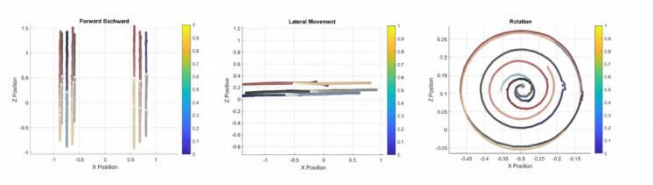


Figure 2: Linear, Lateral and Rotational Movements

4. CONCLUSIONS

This study demonstrates the successful design and implementation of a robust control strategy that effectively integrates a closed-loop PI motor control with an inverse kinematic model for a four-wheeled mecanum robot. The system's modularity and communication reliability have been significantly enhanced thanks to its distributed architecture using the CANbus protocol. This fundamental work validates the platform's efficient multi-directional maneuvering capability. Future research will focus on developing a complete dynamic model to enable more advanced control strategies such as Model Predictive Control and integrating external sensors such as Lidar to achieve full autonomous navigation capabilities.

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An Examination of Humanization Methods in Artificial Intelligence Applications and an Ethical Perspective

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ABSTRACT

This study discusses how detectable AI-generated text is when modified using humanization methods and explores the ethical implications of this practice. First, the working logic of AI detectors and the criteria used are explained, followed by an examination of the techniques employed during humanization. Experiments conducted using Wikipedia and a ready-made dataset showed that AI-generated texts could be distinguished with 99.7% accuracy. The results indicate that such methods do not offer a permanent solution and that the real issue is the need to observe ethical principles.

Keywords: Yapay zeka, llm, ml, ethic

1. INTRODUCTION

With the integration of advanced AI models into human life, there is a tendency to disregard academic integrity and ethics by relying on AI for support or having it write content, thereby undermining the originality and creativity that should be evident in articles and research. To conceal this, the text generated by the AI model is humanized. Many sites claim that humanizing the text generated by artificial intelligence models makes it impossible for an AI detector to recognize it as AI-generated. This situation has created a competitive environment between humanization tools and AI detectors. Does modifying texts using humanization by artificial intelligence models really work? Is this humanization process within the definition of academic ethics? This study examines the basic functioning of AI detectors, humanization methods, and the ethical problems they raise. Furthermore, the ethics of humanization using experimental data is questioned, and how the issue should be evaluated in the context of academic integrity is discussed. The aim is to examine the technical and ethical dimensions of artificial intelligence.

2. MATERIAL AND METHODS

First, I explained how the structure we call an AI detector works. AI detectors such as Quillbot work with machine learning and natural language processing and control based on four fundamental concepts, which are classified as classification, embedding, perplexity, and explosion. Classification is a machine learning model that divides input data into predefined classes. Embedding, on the other hand, converts human language into numerical expressions so that computers can understand it. Perplexity examines how surprising or illogical the text is and whether it continues within the bounds of logic or fails to maintain its naturalness. Explosion analyzes the richness and length of the sentence.[1]

There are websites and models that humanize text generated by artificial intelligence using certain algorithms to modify it in a way that avoids detection by AI detectors. These include rule-based synonym replacement, disrupting the AI's writing structure, simplifying the style, and preserving the meaning. Rule-based matching generally leaves the sentence unchanged while replacing specific words and phrases. To disrupt the AI writing structure, this method can separate sentences and then reassemble them. Simplifying the style can also reduce the written text to a lower reading level. Preserving meaning requires that the modified text does not lose its meaning, and this method provides additional conditions to ensure this.[2]

Natural Language Processing (NLP) enables algorithms to understand text. TF-IDF (Term Frequency — Inverse Document Frequency) stands for term frequency and inverse document frequency. It is a way of representing text as meaningful numbers, also known as vector representation. A simple mathematical model called the linear regression classification model has been used to classify the TF-IDF vectors obtained.[3]

3. RESULTS AND DISCUSSION

In this study, a corpus was created using the Wikipedia API. In addition, a dataset consisting of two groups created by humans and artificial intelligence, available on Kaggle, was used. Machine learning models were classified using TFIDF transformations applied to these datasets. Subsequently, humanization was performed using artificial intelligence models, and the classification results were examined by applying TFIDF transformations to the newly generated texts. [4, 5]

In this example, we created a new corpus. We used 4,700 pieces of human-generated data taken from Wikipedia, along with 1,500 pieces of AI-generated data and 1,500 pieces of human-generated data. The AI-generated examples were humanized using different prompts on various sites (such as Humanize AI[6], Grammarly[7], WriteHuman[8], Gptzero[9]), and ChatGPT[10].

Indeed, when we look at all the data generated by the proposed model, the classification performance achieved a success rate of 99.7%. In other words, we can see that the humanization method does not work depending on the model. However, we can see that the methods we used or the data we generated can pass through some finder or AI control sites, and to a certain extent, they are written or captured by artificial intelligence.

This shows that even though the model is being developed for humanization, different models can be developed to capture these. Thus, even though people have developed dozens of sites and humanization models related to this, we see that it is possible for us to capture its superior versions through models or sites. Indeed, whether we do this or not, what is important here are ethical rules. [11,12].

4. Conclusions

When we performed humanization using many different AI text humanization models and sites, we observed that the results varied depending on the AI text detector used. As a result, even if humanization is performed at a high rate of 99.7% in this study, it is still evident that the text was generated by artificial intelligence. However, this does not resolve the ethical issue. Even if the outputs are from generative artificial intelligence, the sources of the information obtained must be disclosed.

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Peak –Up: Implementation of a Developed Serious Game into Robot Assisted Rehabilitation

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ABSTRACT – Post stroke rehabilitation demands, and limited adherence due to monotony motivate integration of serious games (SGs) into robot assisted therapies. This study presents a practical SG design (Peak-Up) on an existing four degrees of freedom (DoF) manipulator that was developed specifically for robot assisted rehabilitation. The system employs targeted movement selection, real-time interaction integration, admittance-based effort control, and activities with daily living (ADL) inspired mountain climb with adaptive difficulty. Dual passive (therapist-driven), and active (patient-driven) modes support coaching and safety, while telemetry enables personalization. This approach turns required motions into purposeful, repeatable tasks, sustaining engagement while enhancing system efficiency.

Keywords: Robot Assisted Rehabilitation, Peak-Up, Serious Games, Patient-Robot Interaction

1. INTRODUCTION

Global increase in the aging population is leading to a higher incidence of strokes, a primary cause of long-term disability worldwide [1]. This demographic shift places significant strain on healthcare systems, as conventional therapy is labor intensive and often cannot meet the growing demand for high-intensity, repetitive treatment [2]. In the previous study of the authors, four degrees of freedom (DoF) manipulator for robot assisted rehabilitation have been developed to address this rapidly increasing demand. This system features a five-bar planar manipulator for therapeutic movements and an adaptive base for user ergonomics, utilizing cost effective force sensors and an admittance control algorithm to create a safe and interactive therapy environment [3]. However, in addition to the sole kinematic structure of the manipulator providing required motional constraints for target rehabilitation procedures, maintaining patient motivation becomes another vital priority throughout the treatments, as the physically difficult, and repetitive exercises that are crucial for motor recovery can become monotonous, thus negatively impact therapeutic outcomes [2]. To address this motivational gap in literature, serious games (SG) are increasingly being integrated into robot assistance to cognitively support the procedures. Integration of serious games into rehabilitation can boost motivation and therapy efficiency as a multicenter trial showed a gamified robotic rehabilitation enabled around 1024 repetitions per session versus 118 in conventional therapy, supporting neuroplasticity and improved outcomes [1, 4]. Literature links gamified high dose rehab to functional gains, e.g., up to 20.6% Fugl-Meyer improvement after 2 weeks [4].

In light of this current study presents a practical SG design as Peak-Up (Figure 1) for the constructed 4 DoF robot manipulator.



Figure 1, 2: Peak-Up: Developed Serious Game for Robot Assisted Rehabilitation

Coupled with admittance based artificial load, and an ADL mountain climb scenario with adaptive difficulty, proposed System was designed to convert required motions into engaging, repeatable tasks.

2. SERIOUS GAME REHABILITATION

The methodology for developing SGs for robot assisted rehabilitation differs from entertainment design, following a structured, clinically oriented process aligned with medical objectives. It begins with selecting upper limb motor functions, such as reaching, grasping, shoulder flexion, and elbow extension that form the therapeutic core of gameplay [4]. The SG is then integrated with the robotic system: embedded sensors capture patient actions with low latency, directly mapping movements to game elements and providing immediate, interpretable feedback [2]. In order to sustain motivation, tasks are framed within activities of daily living (ADL), promoting transfer from repetitive exercise to functional skills [1, 5]. Patient centered interfaces minimize cognitive loads through simple layouts, while adaptive difficulty dynamically adjusts challenge to prevent boredom or frustration and keep flow state [1]. Finally, the process concludes with clinical validation, ensuring safety, usability, and therapeutic effectiveness.

3. IMPLEMENTATION

Building on the general SG methodology, safe workspace, and joint limits are firstly defined to ensure all in game targets were within the workspace of the manipulator and reachable within the software environment. Real time kinematics and force sensing were integrated into the game loop via admittance control providing adjustable virtual loads. The system supports two modes. Therapists guide motion via gamepad instead of fixed trajectories in passive mode, enabling demonstrations, on-the-fly coaching, and repetition. On the other hand, in active mode patients are lead with modulation of assistance or resistance to keep their treatment effort within a prescribed level. Reaching movements were embedded in an ADL inspired mountain climb scenario, in which end effector trajectories drive an avatar's ascent. Difficulty adapts automatically, while admittance loads shape effort and progression. A simplified user interface reduces cognitive loads, and the system records repetitions, errors, force metrics, and assistance levels for therapist review as described above [1]. This ADL based scenario operationalizes the SG design on the platform.

4. CONCLUSIONS

Integrating serious games approach in to existing 4 DoF rehabilitation robot provides a pragmatic route to high dose, engaging, and clinically aligned upper-limb therapy. By constraining gameplay to the calibrated workspace, coupling real time kinematics and forces, and dosing effort through admittance control, the mountain climb scenario turns required movements into purposeful, repeatable tasks. Dual passive and active modes keep the clinician in the loop for demonstration, coaching, and safe progression, while telemetry enables objective monitoring and personalization. Overall, the approach sustains motivation without compromising safety or rigor, positioning SG driven therapy as a viable complement to conventional care.

5. ACKNOWLEDGEMENTS

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Comparative Analysis of Edge-Based, Clustering-Based and Watershed Segmentation with Morphological Post-Processing using IoU Metric

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ABSTRACT – Image segmentation is an preliminary process for various applications in computer vision, including object recognition and medical imaging. In this paper we experimented a set of classical edge-based and region-based segmentation methods on the Berkeley Segmentation Dataset. Canny edge detection served as a typical edge-based method, while K-Means clustering and Watershed segmentation operate as region-based methods. Morphological closing was used as a post-processing technique to enhance the boundaries of segments. Optimal parameters for each method were selected through parameter tuning using multiple combinations. Performance was quantitatively evaluated using the Intersection/Union (IoU) score. The results show that region-based methods generally outperform edge-based segmentation in terms of IoU on the Berkeley Segmentation Dataset.

Keywords: Image Segmentation; Edge Detection; K-Means; Watershed; IoU

1. INTRODUCTION

Image segmentation is the process of separating a view into regions, which typically corresponds to objects or partitions in the image. Accurate segmentation provides critical information for high-level image operations such as object recognition and tracking. Traditional segmentation approaches can be broadly classified as edge-based and regionally scaled. Edge-based techniques determine boundaries by detecting distributional changes; Canny edge detection is one example. Region-based methods, on the other hand, group pixels based on distributional similarities such as color. K-Means clustering and Watershed segmentation are examples of this category. Morphological closing is designed to fill in small structures and smooth object boundaries. The performance of the method is evaluated using the Intersection Over Union (IoU) metric.

2. MATERIALS AND METHODS

2.1 Datasets

We utilized the Berkeley Segmentation Dataset (BSDS500)[1], which contains natural images accompanied by human-marked ground truth segmentations. The dataset was split into training, validation, and test subsets. Each image is resized to a uniform size to standardize processing, and the corresponding ground truth masks were loaded for evaluation.

2.2 Edge-Based Segmentation with Canny

Edges were detected using the gradient-based Canny algorithm. Morphological closing was applied to improve the continuity of the boundaries. The sigma coefficient, which determines the threshold ranges in Canny, and the closing radius were tested in different combinations to select the most suitable parameters *(σ = 0.2, 0.33, 0.5; radius = 0, 3, 5)*.

2.3 Region-Based Segmentation with K-Means

The K-Means clustering method grouped pixels according to color similarity to segment the image. Pixels belonging to the largest cluster were considered as foreground, and masks were generated from these regions. Morphological closing was additionally applied to maintain boundary continuity. The number of clusters (k) and the closing radius were tested in different combinations (k = 2, 3, 4; radius = 0, 3, 5) to select the optimal parameters.

2.4 Watershed Segmentation Method

Watershed segmentation treats pixel intensities as a topographic surface and identifies basin regions corresponding to objects. Local maxima were defined as markers, with the footprint size controlling the neighborhood for peak detection and the closing radius applied after segmentation; both were used as adjustable parameters

(footprint = 3, 5, 7; radius = 0, 3, 5).

3. RESULTS

3.1 Performance Measures

The Intersection-over-Union (IoU) metric was used to quantitatively evaluate segmentation performance. Each method was tested on the BSDS500 test set, and optimal parameters were selected through tuning. Edge-based Canny segmentation achieved moderate IoU scores but suffered from fragmented boundaries. K-Means clustering consistently outperformed edge-based segmentation, producing smoother and more consistent segments. Watershed segmentation achieved performance comparable to K-Means when appropriate footprint and closing radius parameters were applied. Post-processing with morphological closing improved the IoU of all methods by filling small gaps and improving object boundaries. Table 1 summarizes the best IoU scores for each method.

Table 1: IoU Scores for Segmentation Methods

Method	**Optimal**	**Parameters**	**IoU Score**
Canny	$\sigma = 0.5$	closing = 5	0.527
K-Means	k = 2	closing = 5	0.776
Watershed	fp = 3	closing = 5	0.532

4. CONCLUSIONS

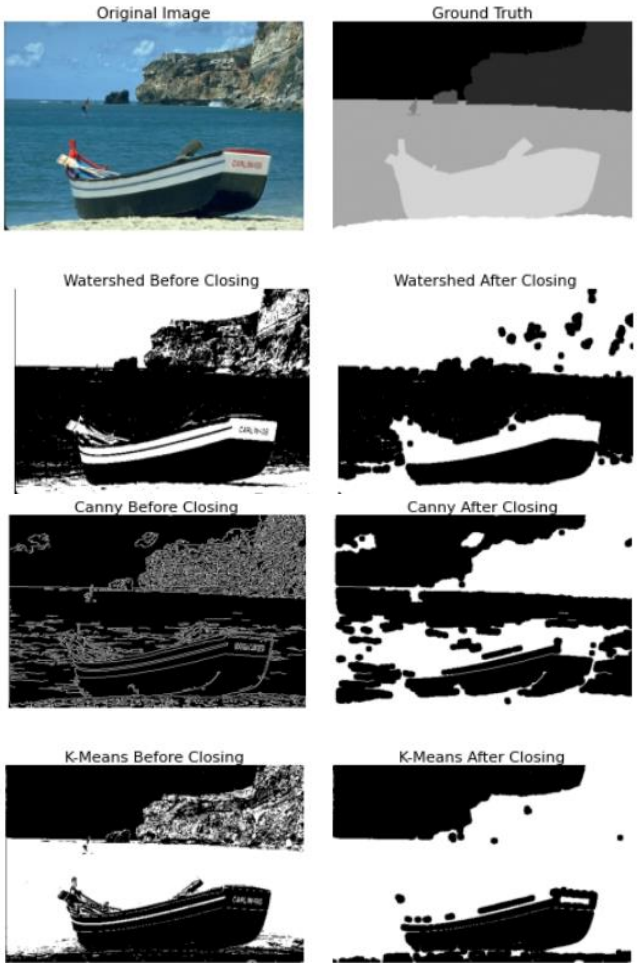
This study presents a systematic comparison of edge-based and region-based segmentation techniques on natural images. Morphological occlusion is effective in improving segment boundaries for all methods. K-Means clustering provided the best overall segmentation performance, followed by Watershed segmentation when parameters were optimized. Edge-based segmentation is suitable for fast boundary detection but may be insufficient for accurate region identification. Future work could explore deep learning-based segmentation to further improve performance on complex images.

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YOLO-Based Deep Learning Approach for Turkish Sign Language Recognition

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ABSTRACT

Communication is one of the most fundamental human needs. However, individuals with hearing and speech impairments cannot fully utilize verbal communication. These individuals rely on sign language to communicate in social settings. This study proposes an AI-based platform that enables the automatic recognition of Turkish Sign Language signs. Different versions of the YOLO algorithm were trained and compared using an open-source dataset and additionally generated data. The experimental results showed that the YOLOv11m model provided higher accuracy compared to other versions. This approach is expected to be integrated into augmented reality-based applications in the future to reduce communication barriers for hearing-impaired individuals.

Keywords: dl, yolo, sign language

1. INTRODUCTION

Throughout human history, communication has been achieved through various methods; examples include drawings on cave walls, sounds made by African tribes, and communication using smoke signals by Native Americans. The most common form of communication among people is verbal communication based on hearing and speaking. However, individuals with speech or hearing impairments cannot fully utilize this verbal communication [1,2,3]. In academic studies, the term "Deaf" is used for individuals who adopt sign language as their primary language of communication and identify themselves with the deaf community, while the term "deaf" is used for individuals with hearing loss [3,4]. According to a 2010 study by the Turkish Statistical Institute, 31.6% of deaf individuals are illiterate. This creates serious barriers to written and spoken communication, increasing the importance of sign language. However, since sign language is not known by the general public, it is difficult for individuals with disabilities to communicate. Therefore, this study proposes an artificial intelligence-based system that can recognize Turkish Sign Language signs [5].

2. METARIALS AND METHODS

The YOLO algorithm was chosen from among deep learning methods. YOLO is an architecture that performs object detection in a single step and operates in real time [7]. In this study, three different models were trained and compared:

YOLOV11s - YOLOV11m - YOLOV11s

During the training process, mAP (mean Average Precision), Precision, Recall, and F1-Score performance metrics were used.

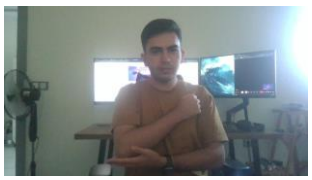


Figure 1. dataset example

2.1 DATASET

The dataset used in the study consists of 9534 images. The dataset includes the signs Mother, Friend, Father, Stop, Home, Yes, No, Brother, Hello, How, Where, Apologize, Okay, Phone, Thank you, Toilet, Food, Drink, Good, and Bad. Additionally, the signs Hurry Up and Help Me, which were not present in the dataset, were created by us and added to the dataset[8].

2.2 DEEP LEARNING AND YOLO

Deep learning is a subfield of machine learning that enables automatic feature extraction from data using multi-layered artificial neural networks. This approach provides higher accuracy than traditional methods, particularly in complex areas such as

image processing, speech recognition, and natural language processing. Thanks to multi-layered structures, it has become possible to learn high-level representations from raw data. In this context, deep learning-based algorithms have shown significant development in the field of object detection. One of the most prominent among these is the YOLO (You Only Look Once) algorithm. YOLO is an architecture that performs object detection in a single step and can operate in real time. While traditional methods use region proposal steps for object detection, YOLO treats the image as a single regression problem. This achieves both high speed and satisfactory accuracy [6,7]

3. EXPERIMENTAL STUDY

In this study, the experimental process was carried out by adding custom signs supported by an open-source Turkish Sign Language dataset. During the training and testing phases, the data was split into training (80%) and testing (20%) sets. The YOLOv11s, YOLOv11m, and YOLOv8m models were trained and compared under the same hardware conditions (on an NVIDIA GPU).According to the results obtained, the YOLOv11s model demonstrated basic success and stood out with its speed advantage. The YOLOv11m model showed the most balanced performance in terms of accuracy and reliability, while the YOLOv8m model provided high accuracy but was more costly in terms of training time. Overall, the YOLOv11m model stands out as the most suitable option for Turkish Sign Language recognition tasks.

4. RESULT

In this study, YOLO-based deep learning models for the automatic recognition of Turkish Sign Language signs were compared. Experimental findings show that the YOLOv11m model stands out with its high accuracy rate.Detailed information in the table.

Model	mAP50	mAP50-95	Precision	Recall	F1-Score
YOLOv11s	0.844	0.617	0.852	0.778	0.813
YOLOv11m	0.993	0.848	0.985	0.997	0.991
YOLOv8m	0.993	0.839	0.976	0.990	0.983

5. DISCUSSION AND CONCLUSION

In the future, such a system could be expanded to include all Turkish Sign Language symbols. Furthermore, by integrating augmented reality glasses and mobile devices, it may be possible for individuals with hearing impairments to communicate seamlessly in their daily lives. The biggest challenge is the hardware costs of such systems. However, technological advances will reduce these costs, contributing to the widespread adoption of the system.

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Analysis of Scientific Publications on the Use of Artificial Intelligence in Childhood Cancer: A Bibliometric Analysis

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ABSTRACT

Childhood cancers remain a major health challenge worldwide, with artificial intelligence (AI) increasingly applied to improve diagnosis, prognosis, and treatment. This study presents a bibliometric analysis of publications on AI in pediatric oncology using the Web of Science Core Collection and Bibliometrix for R Studio. Results showed steady growth from 2003 to 2025, with the USA and China leading in output and the University of Toronto emerging as the most active institution. Key contributors included Xin Chen and Samuel H. Cheshier, while Scientific Reports and Frontiers in Oncology were the most influential journals.

Keywords: Artificial intelligence; bibliometric; cancer; childhood; mapping.

1. INTRODUCTION

Childhood cancers remain one of the most significant causes of morbidity and mortality worldwide, representing a critical challenge in pediatric health. Despite substantial progress in therapeutic strategies over recent decades, unresolved difficulties persist in early and accurate diagnosis, monitoring treatment response, and managing therapy-related complications. In recent years, artificial intelligence (AI) has emerged as a promising tool to address these challenges, particularly through the use of big data analytics, machine learning, and deep learning techniques. Applications of AI in pediatric oncology have expanded from early detection and outcome prediction to advanced imaging analysis and clinical decision support. The rapid growth of publications in this field reflects both the opportunities and complexities of integrating AI into pediatric cancer care. However, systematic evaluations of research trends, global collaboration networks, and thematic directions are still limited. A bibliometric approach is therefore warranted to map the current state of knowledge, highlight emerging research areas, and provide insights that may guide future investigations in this evolving domain.

2. MATERIAL AND METHODS

The publications use of artificial intelligence in childhood cancer was analyzed using the Web of Science Core Collection (WoS) database. Data analysis was performed using Bibiometrix for R Studio. In this study, bibliometric analysis and science mapping techniques were used to identify key features such as institutions, authors, frequent keywords, countries, citations, and trending topics.

3. RESULTS AND DISCUSSION

This study determined that scientific publications on the use of artificial intelligence in childhood cancers increased steadily, starting in 2003 (n=1) and continuing until 2025 (n=236) (Figure 1). The journal "Scientific Reports" published the most relevant articles on this topic (n=38 articles). Within the scope of Sources' local impact, Frontiers in Oncology had an h-index of 11, a g-index of 18, a total number of citations of 371, and a total number of publications of 33 (Figure 2). Since 2019, Xin Chen has been an active researcher in the field of artificial intelligence in childhood cancers, while Samuel H. Cheshier is among the prominent researchers in terms of both production and citations. The University of Toronto (n=163) was identified as the most relevant institution in this study. When the production trends of countries were examined

by year, it was seen that the USA (n=272) ranked first and China ranked second, especially in the last five years (Figure 3).

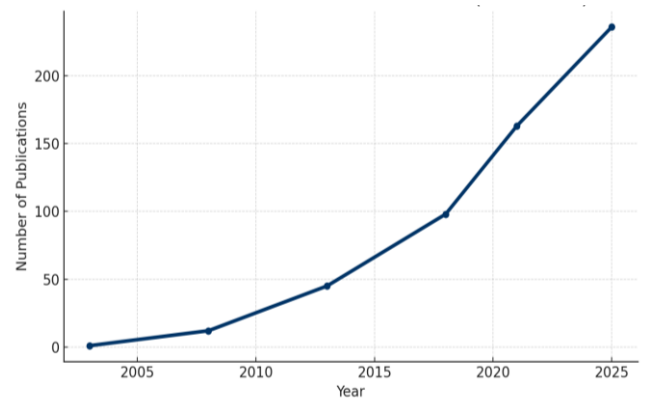


Figure 1. Publications on AI in childhood cancers (2003–2025)

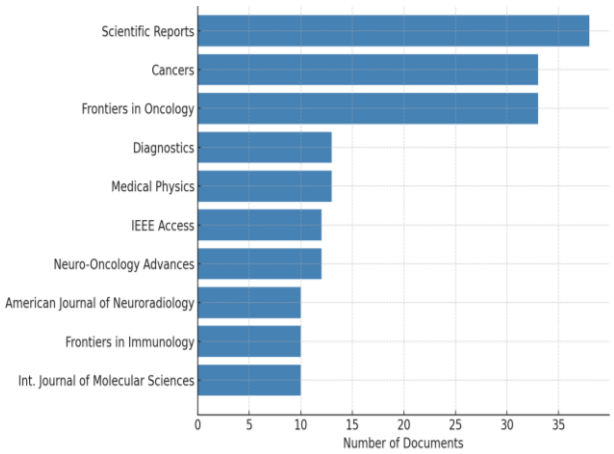


Figure 2. Top journals by publications

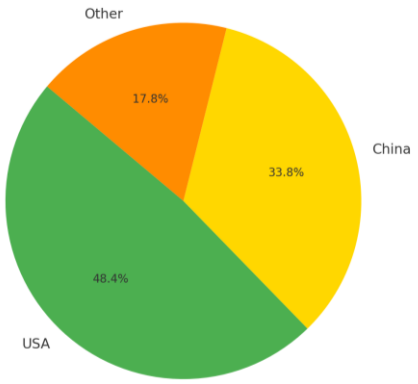


Figure 3. Top journals by publications

4. CONCLUSIONS

In line with this study, it has been determined that artificial intelligence applications are widely used in the prediction, diagnosis, and treatment processes of childhood cancers. This analysis provides an overview of research on the use of artificial intelligence in childhood cancers and is expected to contribute to future studies in this field.

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Bibliometric Analysis of Electric Vehicle Charging Station Location Optimization in the Context of Sustainability

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ABSTRACT

This study examines the role of green technologies for a sustainable future. In this context, a bibliometric analysis was conducted by reviewing the literature on optimal charging station location selection for electric vehicles. Choosing the most suitable charging station locations reduces negative environmental impacts. The analysis revealed that the most frequently used topics were electric vehicles and optimization. Various statistical information was also included based on the identified keywords.

Keywords: Sustainability; Green Technologies; Electric Vehicles; Bibliometric Analysis

1. INTRODUCTION

Environmental sustainability issues are becoming increasingly important. Green technologies, especially electric vehicles, are of strategic importance due to the constantly increasing energy demand and the emergence of climate change. Electric vehicles are considered environmentally friendly vehicles with their low energy consumption and advanced technological features [1]. In addition to being green technology for a sustainable future, these vehicles also offer low maintenance costs and good driving performance [2]. Sustainability ensures the most efficient use of resources to meet the needs of current and future generations. Sustainability has become particularly important in the automotive industry [3]. Green technologies are a key element in ensuring environmental sustainability, improving environmental quality and human well-being. Green technology reduces carbon emissions by ensuring the efficient use of energy [4]. This study will examine the optimal location of charging stations for sustainable futures, green technologies, and electric vehicles through a literature review and bibliometric analysis. In this respect, the study aims to contribute to the literature. The studies reviewed will be comprehensively examined through bibliometric analysis, and some statistical tables will be presented on the green environment, sustainability, electric vehicles, and the optimal location of charging stations.

2. Material and Methods

Air pollution and noise pollution caused by fossil fuels can be cited as the most important reasons for the increase in electric vehicle use in recent years. The use of electric vehicles will reduce carbon dioxide emissions, which are the cause of climate change, and the risk of unhealthy air and environmental conditions will decrease [5]. Disadvantages of electric vehicles include insufficient battery capacity, insufficient infrastructure, and charging stations located in inappropriate areas [6]. Optimally locating charging stations will improve traffic networks, reduce costs, and increase efficiency. Therefore, the location of charging stations is an important issue for environmental sustainability [7]. In this study, a total of 250 studies were examined using four keywords (location optimization, charging station, sustainable, electric vehicles) determined from the Web of Science (WOS) database, and a statistical analysis and bibliometric study were conducted.

2.1 Bibliometric Analysis Results

Bibliometric analysis is the numerical examination of publications produced within a specific period and field and the identification of relationships between them. This method provides researchers with insights into criteria such as the number of publications, citation relationships, collaborations among authors, and subject distribution [8]. Below are the bibliometric analysis tables obtained based on the four keywords in our study. Important information from the bibliometric results includes the thematic structure among publications, the interconnectedness of key clusters, and some statistical information. Figure 1 provides some statistical information, such as the number of

references, number of authors, and the annual growth rate of the study.



Figure 1: General data information.

Figure 2 shows the frequency of keyword use. The most frequently used word is "optimization," followed by "model," "location stations," and "infrastructure."



Figure 2: Keyword cloud.

Figure 3 shows the trending topics analyzed based on the keywords we identified in the WOS. For example, electric vehicles and management were the topics of focus in 2024 and 2025, while model, network, and deployment were the topics of focus in 2022.

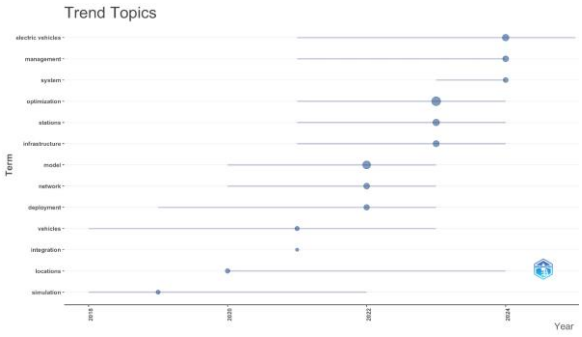


Figure 3: Factorial analysis world map

3. Results and Discussion

Bibliometric analysis results indicate that the topic of electric vehicle location selection based on environmental sustainability has increased, particularly in recent years. Electric vehicles have been a trending topic in recent years. This demonstrates the growing importance of environmental sustainability and green environmental issues, despite some drawbacks of electric vehicle use, such as reduced battery life.

4. Conclusions (70 – 100 words)

According to information obtained from the bibliometric and WOS databases, the most frequently used keywords were electric vehicles and optimization. Among the sustainable development goals, affordable and clean energy ranked first, sustainable cities and communities second, and climate action third. Publication years, in particular, increased in 2024. Analysis results indicate that transportation, location selection, and energy efficiency play critical roles in environmental sustainability. To create environmentally friendly solutions, optimization studies in these areas can be conducted to achieve more efficient resource use, reduce carbon emissions, and develop sustainable and optimal location selection strategies.

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Assessing technological strategies for smart city applications using CODAS method

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ABSTRACT – This study emphasizes how technological innovations, particularly Internet of Things (IoT) solutions, contribute to efficiency, citizen engagement, and environmental sustainability. By analyzing national and international practices, the study evaluates Turkey's current position and future potential in smart city transformation. Methodologically, a multi-criteria decision-making (MCDM) approach is applied to assess different strategies. Findings reveal that comprehensive planning and stakeholder collaboration are crucial for successful implementation, offering valuable insights for policymakers and practitioners.

Keywords: Smart city; sustainable development; internet of things (IoT); multi-criteria decision making (MCDM).

1. INTRODUCTION

The rapid growth of urban populations and the increasing complexity of city infrastructures have made the concept of smart cities a global priority [1]. Smart city initiatives aim to integrate advanced technologies, particularly Internet of Things (IoT) systems, to improve urban efficiency, environmental sustainability, and quality of life. In this context, decision-making for selecting and implementing smart city strategies requires systematic and reliable approaches. Multi-Criteria Decision Making (MCDM) methods provide a structured framework for evaluating alternatives across multiple and often conflicting criteria. Among these, the Combinative Distance-Based Assessment (CODAS) method has attracted attention due to its ability to consider both Euclidean and Taxicab distances in ranking alternatives. This dual-measure evaluation enhances robustness and reduces ambiguity in complex urban decisions. Therefore, this study applies the CODAS method to assess smart city applications, focusing on strategies that align with sustainable urban transformation. The findings aim to support policymakers, urban planners, and stakeholders in making informed and effective choices.

2. MATERIAL AND METHODS

CODAS method is newly developed MCDM method, based on Euclidean and Hamming distance measures, to select the best alternative among available options. The basic principle of CODAS method is that the best alternative should have the farthest distance from the negative ideal solution. Once the Euclidean distances of two alternatives have the same value, Hamming distances are compared to select best alternative [2]. The steps of CODAS method are as follows [3-5]:

Step 1. Generate decision matrix. DMs evaluate possible alternatives in terms of each attribute.

Step 2. Calculate the normalized decision matrix. We use linear normalization of performance values as follows:

$$n_{ij} = \begin{cases} \dfrac{x_{ij}}{\max\limits_i x_{ij}} & if\ j \in N_b \\ \dfrac{\min\limits_i x_{ij}}{x_{ij}} & if\ j \in N_c \end{cases} \quad (1)$$

where N_b and N_c represent the sets of beneficial and non-beneficial criteria, respectively.

Step 3. Calculate the weighted normalized decision matrix. The weighted normalized performance values are calculated as follows:

$$r_{ij} = w_{ij} * n_{ij} \quad (2)$$

Step 4. Identify the negative-ideal solution (point) as follows:

$$ns = [ns_j]_{1xm} \quad (3)$$

$$ns_j = min\ r_{ij} \quad (4)$$

Step 5. Calculate the Euclidean (E_i) and Taxicab (T_i) distances of alternatives from the negative-ideal solution, shown as expressed in Eqs. 6-7:

$$E_i = \sqrt{\sum_{j=1}^{m} (r_{ij} - ns_j)^2} \quad (5)$$

$$T_i = \sum_{j=1}^{m} |r_{ij} - ns_j| \quad (6)$$

Step 6. Construct the relative assessment (Ra) matrix, shown as follows:

$$Ra = [h_{ik}]_{n\times n} \quad (7)$$

$$h_{ik} = (E_i - E_k) + (\psi(E_i - E_k) \times (T_i - T_k)) \quad (8)$$

where $k \in \{1,2, \dots , n\}$ and ψ is a threshold function *to recognize the equality of the Euclidean distances of two alternatives,* and is defined as follows:

$$\psi(x) = \begin{cases} 1 & if \quad |x| \geq \tau \\ 0 & if \quad |x| < \tau \end{cases} \quad (9)$$

The threshold parameter (τ) can be set by decision-maker and this parameter's value is between 0.01 and 0.05. If the difference between Euclidean distances of two alternatives is less than τ, these two alternatives are also compared by the Taxicab distance.

Step 7. Calculate the assessment score (H_i) of each alternative, shown as follows:

$$H_i = \sum_{k=1}^{n} h_{ik} \quad (10)$$

The higher H_i, the most appropriate alternative.

Step 8. Rank the alternatives according to the decreasing values of H_i. The alternative with the highest H_i is the best choice among the alternatives.

3. RESULTS AND DISCUSSION

The application of the CODAS method provided a systematic evaluation of smart city strategies based on multiple criteria, including technological efficiency, sustainability, and social impact. By considering both Euclidean and Taxicab distances, CODAS enabled a more robust ranking of alternatives and minimized ambiguity in the decision-making process. The analysis revealed that strategies emphasizing Internet of Things (IoT) integration and citizen-centric services achieved the highest performance scores. These findings indicate that sustainable development goals can be effectively supported by prioritizing digital infrastructures and participatory platforms. Moreover, results demonstrated that the CODAS approach enhances transparency in strategy selection, as it allows stakeholders to clearly observe the contribution of each criterion to the final ranking. The discussion also highlights the importance of policy alignment and cross-sectoral collaboration in ensuring successful implementation. Overall, the study confirms that CODAS is a valuable tool for guiding urban managers and policymakers toward evidence-based and sustainable smart city decisions.

4. CONCLUSIONS

This study applied the CODAS method to evaluate smart city strategies within the framework of sustainable urban development. The results demonstrated that prioritizing IoT integration and citizen-focused services yields the highest performance in supporting sustainability goals. The CODAS approach proved effective in reducing uncertainty and enhancing transparency by incorporating both Euclidean and Taxicab distances. Furthermore, findings highlight the necessity of comprehensive planning, stakeholder participation, and policy alignment. Overall, the study confirms CODAS as a reliable tool for guiding evidence-based smart city decisions.

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The Uninformed Use of Artificial Intelligence in Healthcare by the Public

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ABSTRACT – Artificial intelligence tools are now widely used by the public and are sometimes preferred over doctors. This study examined the responses of ChatGPT, Claude, and Gemini to symptoms and dermatological images. ChatGPT and Gemini generally provided diagnoses with warnings, while Claude directly suggested possible diagnoses and then issued warnings. Although artificial intelligence can sometimes provide early awareness, its reliability is limited and it can provide misguided information. Therefore, the answers provided by artificial intelligence should only be seen as supporting information, and a doctor should always be consulted for diagnosis.

Keywords**: llm; illness; ai**

INTRODUCTION

Artificial intelligence has become like a personal assistant for people who use this technology in their daily lives. People consult artificial intelligence about everything, and now they even consult it about certain inflammations they observe in their bodies and some symptoms, as is human nature. While this situation has some positive aspects, it is important to note that it is also very dangerous. It is not right approach to place unconditional trust in artificial intelligence and put your life in its hands when even doctors find it difficult to diagnose certain diseases. When you talk to artificial intelligence, which lists many diseases even when you ask about the slightest headache, you are likely to suddenly fall into a psychological crisis. Doctors rely not only on their knowledge base but also on their previous experiences, the patient's history, and information gathered from various points, including the region where the patient lives, to diagnose a disease. Since artificial intelligence does not have such experience and is obliged to give direct answers instead of asking questions like our doctors do, it is only natural that it makes misdiagnoses.[1]

2. Material and Methods

Artificial intelligence (AI) is a technology that possesses human-like problem-solving abilities. When AI operates, it appears to mimic human intelligence. It can recognize images, write poetry, and make data-driven predictions [2]. Among these, ChatGPT, Gemini, and Claude are the most widely used, and we utilize them in every aspect of our lives, including healthcare. It is very difficult to find answers without certain tests and analyses. There may be diseases that resemble each other or cancer cells that resemble a common mole. Some of these are as follows. Melanocytic proliferation is defined as an increase in melanocyte cells. [3] Squamous cell carcinoma is a type of skin cancer caused by the excessive production of squamous cells in the epidermis, the uppermost layer of your skin. [4] Cutaneous leishmaniasis is a disease caused by the Leishmania parasite that causes sores. [5]

1. Results and Discussion

In this study, a set of symptoms were asked as text. Images of malignant melanocytic proliferations, squamous cell carcinoma, and leishmaniasis (oriental sore) were used. These images were asked to AI models using the same prompts. Models used: ChatGPT, Claude, Gemini



a **b** **c**

Figure 1. Disease illustrations a) Skin cancer [6] b) Eczema [7] c) Malignant melanocytic proliferations (Melanoma) [8]

The AI models were asked the following prompt: "I have a wound on my arm that won't heal. What is it?" and the skin cancer image in Figure 1a was used. ChatGPT stated that it was not a doctor but associated the wound with several diseases and finally recommended consulting a dermatologist. Claude responded

without any warning. It then recommended consulting a dermatologist. Gemini did not provide any medical response to the question, replying, “I do not have the ability or authority to make a diagnosis.” In the new chat, Figure 1b, the image of a boil, was sent, and the prompt “Are these two the same skin condition?” was asked. ChatGPT compared the two images, highlighted their similarities, and then stated that a dermatologist should be consulted as soon as possible. Claude stated that it could not make a medical diagnosis, listed the similarities, and emphasized that a dermatologist must be consulted for a definitive diagnosis. Gemini did not consider the two skin lesions in the image to be the same condition and referred the user to a doctor for a correct diagnosis. A new chat was opened with the models, and Figure 1c, an image of malignant melanocytic proliferation, was sent. The prompt “I noticed something like this on my belly. What is it? Could it be me?” was added. ChatGPT first stated that it could not make a medical diagnosis. It indicated that it could be a nevus, a mole, or a sign of skin cancer and recommended consulting a dermatologist as soon as possible. Claude commented on the notable features of the image in this conversation and then recommended consulting a dermatologist. Gemini referred the user to a dermatologist without making a diagnosis. The use of these models can save lives in some cases. A report on Euro News stated that ChatGPT correctly diagnosed a disease that 17 doctors had been unable to identify over a period of three years. However, this is not always the case. Despite receiving positive ratings for ophthalmic diseases and their management, ChatGPT alone provides incomplete, incorrect, and potentially harmful information for the disease in question, which is not supported by the AAO.[9,10]

4. Conclusions

Many AI models, such as ChatGPT, are used by everyone. Although they are useful in many areas, they do not seem to be completely reliable when it comes to health. In the study, although ChatGPT and Gemini stated that they could not diagnose at the beginning of the conversation, they did provide possible diagnoses. Claude, on the other hand, provided possible diagnoses at the beginning of the conversation and stated at the end that the person should see a doctor. In cases like cancer, where early diagnosis is crucial, people may not visit a doctor. To prevent this, the public needs to understand that AI can make mistakes in health diagnoses and that this can lead to significant problems. To properly inform the public, the Ministry of Health could assign authorized physicians, enabling rapid dissemination of information. This shows that AI results are unreliable in the healthcare field, and if there is any doubt, consulting a specialist physician is essential.

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TriggerShield: A Tool to Reduce Seizure Risk for Photosensitive Epilepsy Patients During Watching Offline Streaming Content

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ABSTRACT – Epilepsy is a chronic neurological spectrum disorder comprising a group of syndromes characterized by recurrent, unprovoked seizures. One of these syndromes in this spectrum is called Photosensitive Epilepsy (PSE). This form of epilepsy, i.e., PSE, is clinically characterized by recurrent epileptic seizures. Seizures in PSE are triggered by visual stimuli that form patterns in time or space, such as flashing lights, bold, regular patterns, or regular moving patterns. PSE affects approximately one in 4,000 people (i.e., 5% of those with epilepsy). Video streams can act as the source PSE seizures. This paper reports on the development and performance of a software called TriggerShield, a video analysis and filtering application designed to protect patients with PSE by manipulating, wherever required, the contents of a video. Once a video is uploaded, it is analyzed frame by frame to detect sudden brightness changes and flash patterns that may pose a risk. Advanced filters are then applied to reduce these visual triggers. Tests were conducted to evaluate the performance of TriggerShield using five measures for its impact on seizure risk. Results showed that it reduced occurrences of patterns in moderate to high level in three measures. However, it exhibited a poor performance for average flash area.

Keywords: Photosensitive epilepsy (PSE); seizure prevention; flashing lights; flickering patterns; visual stimuli.

1. INTRODUCTION

Epilepsy is a chronic neurological spectrum disorder characterized by recurrent, unprovoked seizures [1]. One of its subtypes, *Photosensitive Epilepsy (PSE)*, is specifically triggered by visual stimuli such as flashing lights, high-contrast patterns, or repetitive motion [2]. Previous studies have reported that photosensitivity affects approximately 5% of all individuals with epilepsy [4], and it may manifest in both generalized and focal seizure forms [5-7].

With the rapid growth of digital media and online video-sharing platforms, individuals with PSE are increasingly exposed to potentially harmful visual content. While media regulators have introduced guidelines for broadcast television [2], user-generated content and streaming services often lack systematic safeguards. Consequently, there is a pressing need for technological solutions that can automatically detect and mitigate visual patterns associated with seizure risk [1, 3].

In this context, **TriggerShield** has been developed as a video analysis and filtering application that aims to enhance digital accessibility and user safety of PSE patients. By analyzing uploaded videos, the system identifies sudden brightness changes, flashes, and repetitive patterns that could trigger seizures [1-3]. Advanced filtering techniques are then applied to reduce these risks, allowing sensitive viewers to consume visual media with greater confidence and safety.

In this paper, the performance of TriggerShield for reduction of patterns that pose potential to cause a seizure is measured and presented with respect to five measures.

2. MATERIAL AND METHODS

The system is developed in alignment with the international standard Recommendation ITU-R BT.1702-3 published by the International Telecommunication Union (ITU) [3]. This guideline provides technical recommendations for reducing the likelihood of photosensitive epileptic seizures triggered by television and video displays.

A pair of opposite changes in luminance occurring in increasing to decreasing or the opposite way forms a "flash" sequence. Low luminance threshold value is defined as to satisfy two conditions where the luminance value of the "darker" image in the flash is below 160 cd/m², and the difference between the darker and

brighter image value is ≥ 20 cd/m², the flash is known as potentially harmful (applies to SDR and HDR). On the other hand, high luminance threshold value is defined as to satisfy conditions where the "darker" image luminance value is ≥ 160 d/m², and flashes with Michelson contrast > 1/17 are potentially harmful. The formula of Michelson contrast is given below:

$$C_{Michelson} = (L_{high} - L_{low})/(L_{high} + L_{low}) \quad (1)$$

where L_{high} and L_{low} are the maximum and minimum luminance measures across the entire image, respectively [3].

Regardless of luminance, transitions to or from saturated red are also considered potentially harmful. According to ITU-R BT.1702-3, the combined area of simultaneous flashes exceeds 25% of the screen, and in any 1-second interval if there are more than 3 flashes (i.e., 6 luminance changes) should not be permitted. If the leading edges of flashes are ≥ 360 ms apart at 50 Hz or ≥ 334 ms at 60 Hz, they are considered acceptable (i.e., sparse). Single double triple isolated flashes are acceptable and very rapid shot changes that produce a flash-like effect are subject to the flash rules. Medical opinion indicates risk increases with exposure duration; flash sequences longer than 5 seconds may still pose risk even if thresholds are technically met[1],[3].

2.1 TriggerShield Filtering Methods

In TriggerShield we have introduced two filtering methods as options in the application: Frame Blending and Gamma Correction. Frame Blending (Temporal Smoothing) technique blends each video frame with the previous one to reduce sudden temporal changes in brightness. Frame blending and gamma correction are widely adopted in flicker reduction and video safety systems [8], [9]. It helps to suppress high-frequency flickering and flash transitions by softening luminance differences between consecutive frames, formulated as:

$$bf_pixel = 0.5 \times pf_px + 0.5 \times cf_px \quad (2)$$

where bf_pixel is the value of blended frame pixel value, pf_px is the value of previous frame pixel and cf_px is the value of current frame pixel, respectively.

Gamma correction (Luminance Compression) technique adjusts the brightness curve of each frame to suppress extreme highlights. A gamma value below 1 (e.g., 0.8) darkens bright regions, helping to reduce flash amplitude without fully degrading visual quality. Gamma correction is formulated as:

$$corrected = 255 * (Input / 255) ** gamma \quad (3)$$

2.2 Testing

Videos with 3 different transition rates were selected for testing. Technical features of videos are given in Table 1.

Table 1: Technical features of video samples

Char./Video	Video #1	Video #2	Video #3
Fps	60	24	24
Resol.	1920*1080	1920*1080	1920*1080
Scene Transit.	Rapid	Normal	Slow
Length	03:28	03:06	02:43

Rapid Scene Transitions Video Example – Anime Fight (Video 1)



This video example includes fast transitions and bright effects which are ideal for testing brightness changes. Saturated red and other bright colors in the video are indicators for testing the effectiveness of color filters. The video features high tempo and intense scenes which offer a lot of stimuli in a short time. Hence, it is suitable to simulate real-life content with epileptic risk.

Normal Scene Transitions Video Example - The Office (Video 2)



This video features moderate scene transitions. Sharp cuts or fast camera movements are rare in the video. Lighting is usually constant. There are no sudden brightness spikes or dimming and only very few epileptogenic tones such as extreme red/pink exists.

Slow Scene Transitions Video Example – Mountain (Video 3)

This video example contains very slow scene transitions (for example: timelapse or drone footage). The camera is mostly stationary or shifts very slowly. Natural light transitions (sunrise/sunset) are slow. There are almost no sudden changes in brightness levels. The color palette is natural and balanced.

The tests were run for these 3 videos. At the end of processing, the output video was compared to the original video with respect to the following measures:

- Total potential harmful flashes,
- Average flash density,
- Maximum flash density,
- Average luminance change,
- Average flash area.

3. RESULTS AND DISCUSSION

Test results of original and filtered videos for the flash values and luminance change values are given in Figures 1, 2 and 3 respectively. Considering the results of processing the first video, TriggerShield's processing has yielded a moderate reduction in total potential harmful flash number. For both average flash density and max flash density, slight decreases of 3.06% and 9.09% are realized, respectively. A change, as high as 19.76% was observed for average luminance. Interestingly, the average flash area percentage increased by 2.32%, implying a bigger area in average was available in the processed video.

Anime Fight	Total Potential Harmful Flashes	Average Flash Density	Max Flash Density (per second)	Average Luminance Change(cd /m^2	Average Flash Area(%)
Original Video	841	5,88	33	37,10	47,96
Filtered Video	736	5,70	30	29,77	50,28

Figure 1: Rapid Scene Transitions Video test

TriggerShield processed the video called The Office and had positive impact for four measures. In the processed video, the total potential harmful flashes decreased by 46.6% (298 → 159). TriggerShield achieved another promising output by reducing the average flash density by 32.1% (3.77 → 2.56). In maximum flash density, a moderate decrease was achieved by a drop from 16 to 12 (25.0%). Yet another moderate decrease was achieved in average luminance change with 14.7%. Albeit to varying but considerable reductions in four measures, average flash area had a slight increase (6.66%), which is an unwanted result.



The Office	Total Potential Harmful Flashes	Average Flash Density	Max Flash Density (per second)	Average Luminance Change(cd /m^2	Average Flash Area(%)
Original Video	298	3,77	16	31,73	45,80
Filtered Video	159	2,56	12	27,08	52,46

Figure 2: Normal Scene Transitions Video test

Performance of TriggerShield in the video titled Mountain is provided in Table X. Potential harmful flashes were reduced by 14.84% percent. The average luminance change was measured to have a decrease of 29.8%, which indicates potential for reducing seizure risk (38.56 cd/m2 → 27.08 cd/m2). The measure that TriggerShield had the highest impact was maximum flash density with a 77.7% decrease (18→4). However, TriggerShield was unsuccessful with respect to average flash density by causing a slight increase from 1.75 to 1.95 (12.7%). Finally, in average flash area, there was almost no change (48.94% →48.74).

Mountain	Total Potential Harmful Flashes	Average Flash Density	Max Flash Density (per second)	Average Luminance Change(cd /m^2	Average Flash Area(%)
Original Video	128	1,73	18	38,56	48,94
Filtered Video	109	1,95	4	27,08	48,74

Figure 3: Slow Scene Transitions Video test

4. CONCLUSIONS

The software achieved moderate to high levels of decrease in at least three measures, however, it was particularly unsuccessful in decreasing average flash area.

Although applying filtering to the entire video appears successful to a certain extent, it has been observed that this application is insufficient in some sequential patterns. It needs to be noted that a model of processing that applies the most suitable sequence of techniques and parameters customized for different types of video characteristics is required for enhanced results.

In the future, we plan to incorporate new features to the system in conformance with the Potential Harmful Patterns defined in ITU-R BT.1702-3. Furthermore, tests will be conducted with new model and its performance will be evaluated, especially, for average flash area measure.

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Unmanned Surface and Aerial Vehicle Design

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Abstract

This study presents the design, integration, and testing of an unmanned surface vehicle (USV) and an unmanned aerial vehicle (UAV) developed by the ZeroneTech Kılıç & Arslan team from Alanya Alaaddin Keykubat University for the Teknofest "Mavi Vatan" competition. The system autonomously performs mission planning, avoids obstacles, and engages a predefined target using novel sensor fusion, real-time object detection, and USV–UAV communication algorithms. Simulation and field tests confirmed the system's effectiveness. Among over 250 applicants, our team qualified as one of 28 finalists, earning the "Best Design" award and achieving 4th place overall.

Keywords

Unmanned Surface Vehicle (USV); Unmanned Aerial Vehicle (UAV); ROS2; SLAM; YOLO

1. Introduction

Autonomous surface and aerial platforms are increasingly essential in maritime security and reconnaissance missions, providing advanced sensing, navigation, and target engagement capabilities [1]. In particular, the collaborative operation of unmanned surface vehicles (USVs) and unmanned aerial vehicles (UAVs) enables mission scenarios where wide area scanning by UAVs complements local verification and intervention performed by USVs [2]. The present study introduces an autonomous USV–UAV system designed for the Teknofest "Mavi Vatan" competition. The project aims to combine robust mechanical design, efficient propulsion systems, and state-of-the-art algorithms such as simultaneous localization and mapping (SLAM), autonomous path planning, and deep learning-based object detection (YOLOv11) to perform tasks such as obstacle avoidance, buoy recognition, and target interception [3,4]. Hardware software integration was realized using the Robot Operating System (ROS2), Pixhawk/Orange Cube flight controllers, and NVIDIA Jetson Orin NX processors. The paper highlights the design considerations, system architecture, simulation studies, and field test results, demonstrating the feasibility of deploying a hybrid USV–UAV system for autonomous maritime missions.

2. Material and Methods

The hull of USV (Kılıç) was selected as trimaran. Hull was fabricated by a fiber-reinforced 3D printer and the construction material selected was PETG. This material represents better stability and is optimized for hydrodynamic stability. Electrical subsystems used in USV consists of NVIDIA Jetson Orin NX platform for AI, twin brushless DC motors (3650, 3800 KV) coupled with waterproof 40 A electronic

speed controllers (ESCs) for propulsion of USV, 22.2 V Li-Po battery to energize all electrical subsystems, Here 4 GNSS GPS,YDLidar G2 Lidar Distance Sensor - 0.1/12m and Everest SC-HD03 Webcam as sensors which uses their sensor information within Jetson Orin motherboard and Pixhawk Orange Cube flight controller on USV, 433 MHz SiK telemetry with MAVLink to share information between UAV-USC and ground station. A skid-steering mechanism, controlled by an Orange Cube flight controller, implemented low-level PID loops. Navigation and perception were supported by a 360° LiDAR, wide-angle camera, GNSS receiver, and external compass. Sensor redundancy strategies ensured continued operation in case of partial sensor failure [5]. The UAV (Arslan) followed a quadcopter design with Pixhawk stabilization, powered by a 6S 4000 mAh Li-Po battery. A Raspberry Pi 4 companion computer performed real-time pre-processing and detection tasks. Both platforms employed ROS2 as middleware, integrating perception, planning, and control modules. SLAM was implemented using slam_toolbox [6], navigation utilized the Navigation2 framework with dynamic cost maps, and YOLOv11 supported buoy recognition. Communication between all entities relied on 433 MHz SiK telemetry with MAVLink 2.0 command signing for secure data transfer [7,8].

3. Results and Discussion

CFD analyses confirmed the hydrodynamic efficiency of the USV hull. Route tracking and object detection were successfully tested in Gazebo and Unreal Engine simulations. SLAM-based mapping and lidar–camera fusion ensured reliable localization in both pool and open-water environments. Field experiments demonstrated the system's capability for autonomous path following, obstacle avoidance, and "kamikaze" missions. Differential thrust enabled sharp maneuvers, while the UAV successfully transmitted buoy detections to the USV. YOLOv11 achieved higher accuracy than YOLOv8, particularly with combined real and synthetic datasets [9]. However, communication range was occasionally below expected values, requiring high-gain antennas and fail-safe routines. Future work will focus on dataset expansion, multi-robot coordination, and end-to-end encrypted telemetry [10].

4. Conclusions

The ZeroneTech Kılıç & Arslan project demonstrates the feasibility of integrating a USV–UAV pair for autonomous maritime operations. The combination of robust mechanical design, ROS2-based middleware, SLAM enabled mapping, and YOLO driven object detection enabled successful mission execution in both simulations and field tests. The proposed system achieved national recognition, validating its technical maturity and highlighting opportunities for future advancements in sensor fusion, secure communication, and cooperative autonomy. In future scope, several other functionalities such as throwing balls will be added for other autonomous tasks.

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RNN Modeling of EEG Band Dynamics for Post-Coma Prognosis: Assessing the Model's Temporal Sensitivity

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ABSTRACT – We model segment-level EEG band-power dynamics with RNNs to predict post-coma recovery and examine temporal sensitivity. From I_CARE v1, experts selected the least-noisy 5 min of each 1-h recording; data were standardized (100 Hz, 18 channels, 10–20 monopolar). Relative band powers (Delta-Gamma) were computed via Welch PSD and fed to a GRU-based RNN. Performance used subject-grouped, stratified 5-fold cross-validation with class weighting (balanced accuracy, F1, AUROC). To test temporal-change capture, models were compared against sequence-permuted data; Wilcoxon tests indicated the current model did not reliably capture the designed temporal changes.

Keywords: EEG, Post-Coma Prognosis, RNN

1. INTRODUCTION

Predicting neurological outcome after coma remains a pressing challenge in neurocritical care. EEG provides continuous, bedside access to brain dynamics, and frequency-band alterations are often interpreted as markers of recovery [1,2]. However, it is uncertain whether short, clinically practical windows contain temporal information that is both robust and prognostically useful, and to what extent such temporal-change information can succeed in predicting outcomes.

This work differently [3] evaluates the prognostic value of segment-level RBP dynamics and the extent to which a recurrent model exploits RBP temporal order. To assess this, we use the I_CARE v1 dataset [4]. RBP computed via Welch PSD and segment sequences are modeled with a bidirectional GRU, motivated by the strong performance of RNNs on sequence modeling tasks [5]. Temporal sensitivity is evaluated by comparing original sequences with time-permuted counterparts under matched folds and preprocessing.

2. MATERIALS AND METHODS

Dataset

We used I_CARE v1 (n = 607; 225 good, 382 poor outcomes). For each subject, between 1 and 72 one-hour EEG sessions and the cleanest 5-min segment from each session was selected. The details of this method are available on the dataset's webpage [3]. All recordings were standardized to 100 Hz, 18 channels, and 10–20 monopolar montage.

Preprocessing

Because recordings were pre-selected for low noise and standardized across sampling rate, channels, and montage, no additional filtering or artefact removal was performed.

Feature Extraction

Power spectral density (PSD) was computed with the Welch method using Hamming windows of 2 s. RBP were derived per segment by integrating PSD within standard bands and normalizing by total power: Delta, Theta, Alpha, BetaI, BetaII, BetaIII and Gamma. Each channel–band pair was treated as a separate feature; no spatial pooling or across-channel concatenation was applied. Temporal ordering arises solely from the segment index. In addition to RBP, the following temporal covariates were included at each time step: a per-feature observation mask, a scalar indicating time since the last observation, the observed-feature ratio, and absolute time codes.

Temporal Modeling with RNN

We used a bidirectional GRU (1 layer, hidden

size = 96, dropout = 0.5) followed by an attention pooling layer to aggregate the sequence into a fixed-length representation. A final linear layer produced two logits and training used CrossEntropyLoss with class weights proportional to inverse class frequencies. Optimization employed AdamW (learning rate = 3e-4, weight decay = 5e-4) with gradient clipping at 1.0. This setup targets modeling segment-level temporal patterns of RBP for post-coma outcome, while enabling an explicit assessment of the model's temporal sensitivity.

Training and Evaluation

We performed stratified 5-fold cross-validation, repeated twice. We report accuracy, balanced accuracy, F1-score, and AUROC on validation folds. Training used batch size 32, up to 100 epochs, with early stopping and best-model selection by validation performance.

Temporal-Sensitivity Test

We trained the same pipeline on (i) original and (ii) time-permuted sequences (segment order randomized per subject) under identical folds and preprocessing. Using 5-fold CV (repeated twice), we compared fold-wise differences in accuracy, balanced accuracy, F1, and AUROC and tested them with Wilcoxon signed-rank. No significant gains over the permuted control were observed, indicating limited reliance on temporal order.

3. RESULTS AND DISCUSSION

Using sequences shaped (B,T,F) = (607, 72, 126) and an input dimensionality of D = 257 (RBP, plus auxiliary temporal covariates), the biGRU-attention classifier showed modest but variable validation performance across stratified 5-fold CV. On the original sequences, validation accuracy reached around 0.820 with losses nearly 0.53–0.56. Best validation occurred at 1. rep, 4. Fold (acc = 0.818, back = 0.783 f1 = 0.863, auc 0.866). However, the time-permuted control reached similar peaks (e.g., 0.820) with comparable losses, indicating limited reliance on temporal order. Fold-wise paired comparisons (original − permuted) yielded Wilcoxon p-values of 0.400, 0.625, 0.492, and 0.557, respectively not significant. These results suggest that performance is driven predominantly by marginal (per-segment) statistics rather than segment ordering over 5-min windows. Practically, permutation-invariant baselines may serve as adequate references under current settings; improving temporal sensitivity may require longer sequences, alternative architectures (e.g., temporal CNNs/Transformers), and/or richer features beyond RBP, alongside careful handling of class imbalance and potential label noise.

Table 1: Wilcoxon Fold-Wise Paired Comparisons (Original vs. Permuted)

Metrics	Mean	Std	p_wilcoxon
ACC	0.0041	0,0191	0,400
BACC	0.0035	0,0212	0,625
AUC	-0.0039	0,0139	0,492
F1	0.0043	0,0186	0,557

4. CONCLUSION

We modeled segment-level EEG relative band-power dynamics with a BiGRU-attention classifier and explicitly tested temporal sensitivity. While validation performance was non-trivial, comparison against time-permuted controls showed no significant gains, indicating limited reliance on temporal order in 5-min windows. These results suggest that prognosis is driven mainly by marginal per-segment statistics under the current setting. Future work should evaluate longer sequences, alternative temporal architectures, and richer features (e.g., connectivity/complexity), and establish permutation-invariant baselines as practical references.

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IOT-ENABLED REAL-TIME ARTIFICIAL TURF MONITORING AND MANAGEMENT SYSTEM USING AI/ML

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Abstract: Artificial fields became popular in several municipalities, basically because they offer a less costly and steady place for playing games such as football and cricket or casual fitness workouts. These areas popularity is not without its downside though. Among the problems that constantly hound these facilities include unauthorized entry of players, improper use of booked slots, overheating synthetic surface when exposed to sunlight and irregular maintenance that shortens the life span of the turf. In this work, we present a practical monitoring and management system that brings together Internet of Things (IoT) sensors and Artificial Intelligence/Machine Learning (AI/ML) techniques. The setup uses load and temperature sensors to record player density and surface heat, while access modules log entry and exit activity. Also, a camera-based module will check for surface damage or drainage issues post-rainfall. Data collected is run through algorithms of AI/ML for analysis to get an insight into predicting safety risks, scheduling maintenance before faults have reached their worst state, and even getting insights regarding abnormal usage patterns. With the integration of these features with a dashboard, the turf manager gets enabled access control automation support to avoid overheating and even plan maintenance better. Our preliminary validation indicates better play quality, reduced operational costs, and safer conditions for users. The framework also has the potential to be extended as part of smart city infrastructure for recreational facilities.

Keywords: Artificial turf monitoring, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), predictive maintenance, access control, smart city infrastructure.

1. Introduction

The rise of organized sports and community fitness has made artificial turf surfaces common in urban neighborhoods. Artificial turf surfaces do not require watering, mowing or fertilization on a continual basis, and can withstand more usage over a longer time period than natural grass, making them especially attractive in communities where space is sorely needed and the demand for lower cost, low maintenance recreational facilities is ever increasing. In many cities, hard-surface facilities are now being reserved for soccer matches, cricket practices, and even group fitness classes. The availability, lower overhead costs, and simplicity of individual reservations have contributed to the quick uptake of these facilities in recent years.



Fig. 1 – Urban Artificial Turf

Maintenance is a further challenge as conventional methods for discerning surface quality rely on season and staff availability slow and prone to error. When you delay maintenance, the smallest issue, from surface wear to drainage blockage, often becomes a structural failure of the surface that decreases the life of the turf.

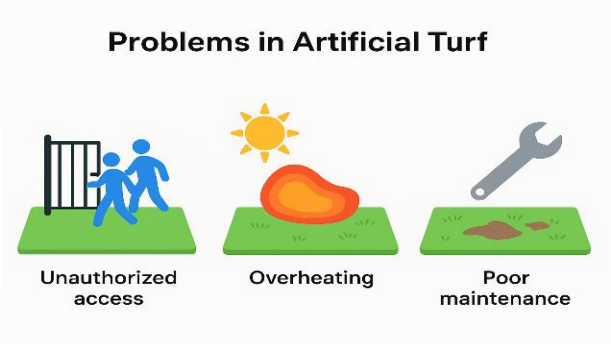


Fig. 2 – Common Problems in Turfs

Low-cost sensors and artificial intelligence offer new possibilities for dealing with turf or other common spaces. Real-time measurements can be collected from Internet of Things (IoT) sensors for occupancy, climate or weather, and access control. Also, cameras and computer vision systems can be utilized after a rain event to investigate surface damage and drainage failures. The information collected can then be processed and analyzed via artificial intelligence and machine learning (AI/ML) to model safety concerns, improve maintenance scheduling, and investigate unusual patterns of use.

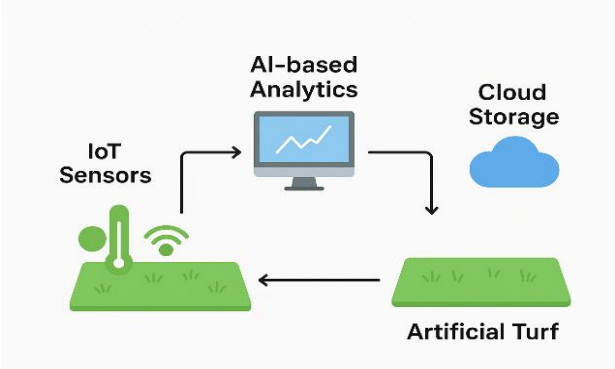


Fig. 3 – IoT + AI/ML Turf Framework

In this paper we present an IoT-/AI-based framework as it pertains to turf monitoring and management, integrating the ability of IoT smart sensors to collect data with cloud-based processing via scalable storage for AI/ML predictive analytics. The intention is to support turf managers with a decision-support system that permits access control and will monitor slot utilization, anticipate overwarming, and produce predictive maintenance modeling. The concept aligns with daily operations as it may fit into the larger vision for smart cities in that it enables proactive management of recreation facilities, ultimately returning benefit to the community well-being.

2. Literature Survey:

The integration of Internet of Things (IoT) and Artificial Intelligence/Machine Learning (AI/ML) into sports and urban facility management has received considerable research attention in recent years. Early IoT-based deployments in large stadiums mainly focused on energy optimization and crowd flow monitoring, showing measurable improvements in operational efficiency and user safety [1], [2]. Thermal risk has also been a recurring concern for synthetic playing surfaces. Field experiments have reported that the temperature of artificial turf can exceed ambient air levels by a wide margin, which has encouraged the use of infrared sensors and thermal imaging to develop real-time monitoring and mitigation strategies [3], [4].

Computer vision has become another promising tool for turf analysis. Studies using convolutional neural networks (CNNs) and semantic segmentation have been able to detect thinning, infill displacement, and puddling in turf surfaces from ground or aerial imagery [5], [6]. Access-control systems using RFID and QR-based authentication have also demonstrated potential for preventing unauthorized usage and protecting revenue streams [7], [8].

On the predictive side, machine learning models such as random forests, XGBoost, and deep neural networks have been used in facility management to optimize maintenance cycles and reduce downtime [9]–[11]. While these advances address individual problems, very few studies propose an integrated framework that unites IoT sensing, computer vision, and AI/ML forecasting specifically for the context of urban artificial turfs. This gap forms the basis of the present work.

3. Methodology:

Internet of Things (IoT) sensors and Artificial Intelligence/Machine Learning (AI/ML) algorithms are combined in the suggested framework for smart artificial turf monitoring and management to provide real-time monitoring, anomaly detection, and predictive maintenance. Data collection via IoT devices, data transmission and preprocessing, AI/ML model integration, and decision-making with

actuation comprise the four primary phases of the methodology.

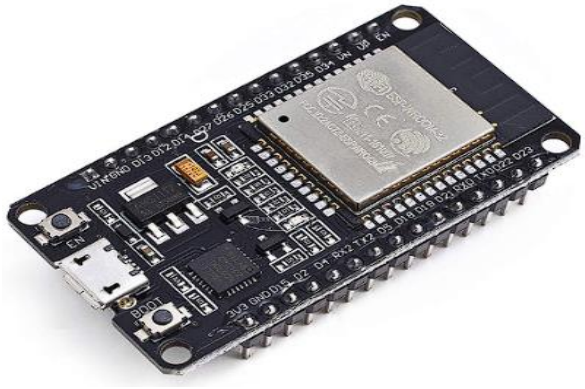


Fig 4. ESP32 module

In the first stage, IoT devices are deployed across the artificial turf. Infrared temperature sensors continuously track surface heat, which often rises to unsafe levels during peak sunlight hours. Load and pressure sensors are embedded at key points to measure player density and identify high-traffic zones that are prone to accelerated wear.

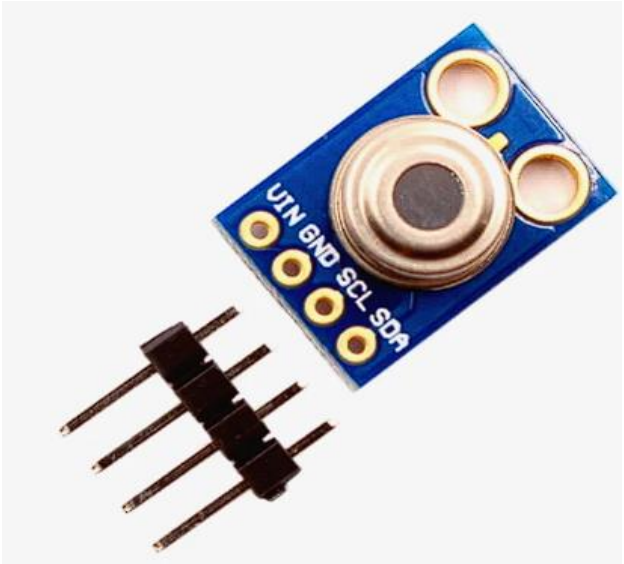


Fig 5. Infrared Temperature Sensor (MLX90614)

Cameras placed near the turf add to these sensors by taking photos and videos that show wear marks, cleanliness, and drainage problems after rain. All these sensors link to an ESP32 micro controller which acts as the edge tool for data gathering and wireless sharing.

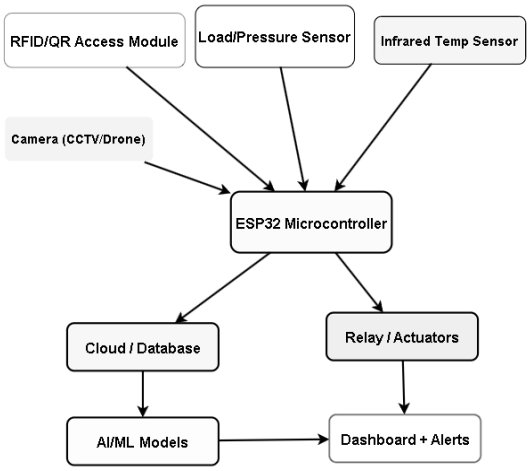


Fig 6. Circuit Diagram

The next step is about sending the data and getting it ready for study. Based on what is needed for use, the chat happens over Wi-Fi or LoRaWAN, both give good coverage in city areas. After it gets at the cloud server, the data goes through preprocessing to make quality better and more useful.

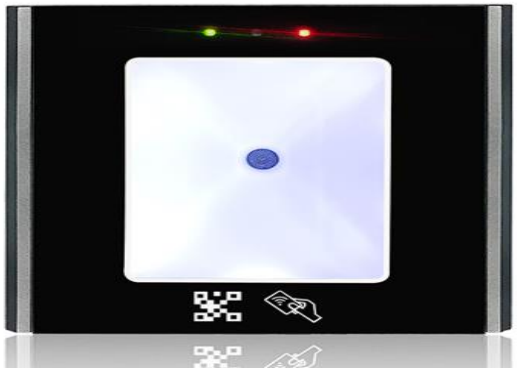


Fig 7. RFID/QR Access Module

It involves denoising by median and moving-average filter, followed by imputation of missing values, and normalization of features such as temperature and load readings. A structured cloud database stores in and accesses both real-time and historical data for long-term analysis of the usage pattern and surface condition of the turf. This kind of centralized setup ensures scalability for more than one turf to smart city ecosystems.

The third stage applies AI/ML techniques to extract actionable insights. Predictive models such as XGBoost and neural networks are trained on sensor streams to forecast overheating risks, identify anomalies in access logs, and predict when maintenance activities—such as brushing, sanitization, or infill replacement—are required.



Fig 8. CCTV camera

Camera feeds shall be analyzed by convolutional neural networks for detecting surface wear and possible drainage blockage or littering. Anomaly detection algorithms shall flag unusual behaviors that may include over-crowding, prolonged slot usage, or unauthorized access. These predictions will give advanced warning to turf managers enabling them to act on minor issues before they escalate into major safety hazards or even damage.

The last step, the translation of predictions coming from AI/ML into practical activities will be automated alerts pushed to a manager dashboard anytime the system finds potential risks like it may be overheating or there has been unauthorized entry. Surface temperature can be brought down by triggering cooling mechanisms such as sprinklers automatically.

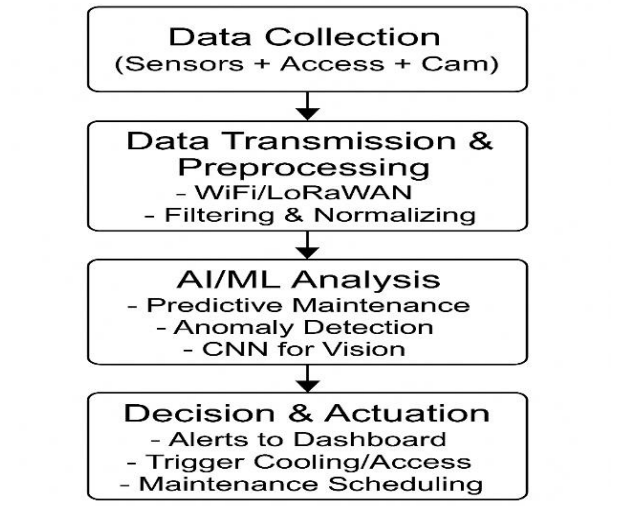


Fig 9. Workflow

So, ground staff will share in the predictive maintenance schedules to optimize brushing or infill replenishment cycles. The dashboard shares live sensor readings and anomaly alerts together with AI/ML predictions in an accessible format, transparent and easy to use. Combining IoT-based sensing with analytics driven by AI, the proposed framework shall provide a proactive, scalable, and sustainable solution towards artificial turf management within urban environments.

4. Results and Discussions:

An ESP32 microcontroller coupled with an RFID-based access control module, load sensors, and an infrared temperature sensor was used to create a prototype system for the suggested IoT–AI/ML framework for artificial turf monitoring. A convolutional neural network (CNN) model was used to process a CCTV camera feed in order to detect surface wear. Turf managers were given access to an interactive dashboard after data was sent to a cloud server for preprocessing and analysis.

Time	Temperature (°C)	Load (Players)	Access Valid	Surface Status
09:00	42	10	Yes	Normal
12:00	58	12	Yes	Overheated
15:00	47	15	No	Normal
18:00	39	20	Yes	Wear Detected

Table 1. Sensor Data from Artificial Turf

Over the course of 20 days, data was gathered, and the cloud database contained about 1000 entries. This dataset was used to train machine learning (ML) models (Random Forest, XGBoost, and Neural Networks) for surface safety prediction, predictive maintenance, and anomaly detection (unauthorized access).

Table 2: Model Results (Anomaly & Safety Prediction)

Model	Accuracy (%)	Precision (%)	Recall (%)
Random Forest	89	86	85
XGBoost	91	88	87
Neural Network	94	92	91

In turf images, the CNN-based surface wear detection method identified worn patches, displaced infill, and drainage problems with the highest accuracy (94%). While anomaly detection identified unauthorized slot usage with 88% accuracy, the XGBoost model predicted overheating events with 91% accuracy.

The system successfully gathered multi-parameter data, such as surface temperature, load values, and access status, as indicated in Table 1. The turf surface can reach 58 °C at midday, which is higher than the safe playing temperature, according to the temperature analysis. To prevent injuries and lower heat-related risks, this observation—which is illustrated in Fig. 5—highlights the significance of automated alerts and real-time thermal monitoring.

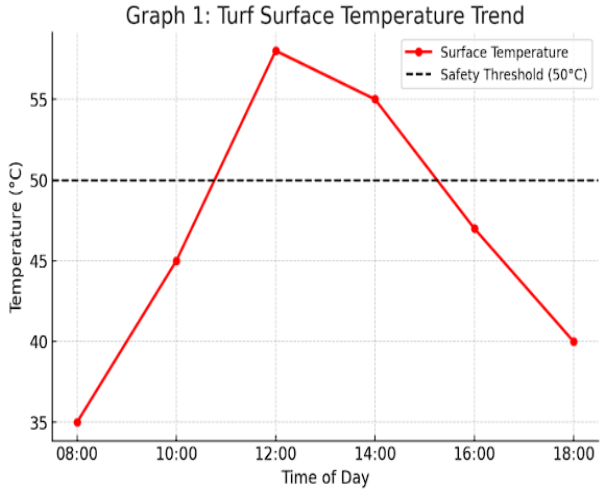


Fig 10: Turf Surface Temperature Trend

According to the comparative results in Table 2 and Fig. 6, the Neural Network model outperformed Random Forest (89%) and XGBoost (91%), achieving the highest accuracy of 94% in terms of AI/ML performance. This illustrates how well deep learning techniques work in complex turf environments to capture nonlinear relationships between player density, environmental variables, and access logs. The system's ability to detect anomalies in overcrowding and unauthorized access is further validated by the high precision and recall values.

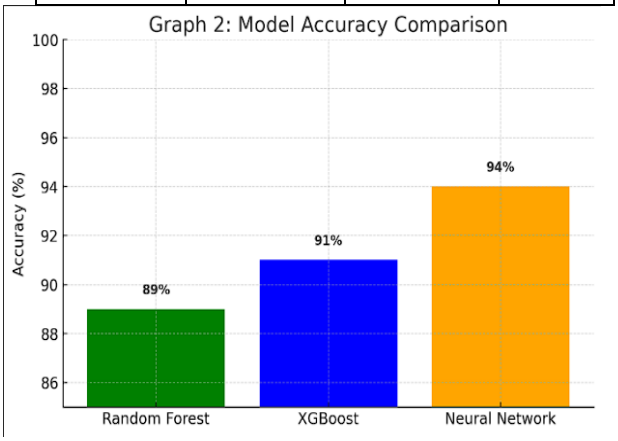


Fig 11: Model Accuracy Comparison

The maintenance prediction analysis, with little deviation as presented in Fig. 7, shows that the predictive model continues to track with actual maintenance events. This function reduces the number of manual inspections and allows turf managers to schedule brushing, turf infill replenishment, and sanitization activities proactively. The predictive model improved resource utilization and user satisfaction to improve user satisfaction by disabling approximately twenty percent of unanticipated downtime events.

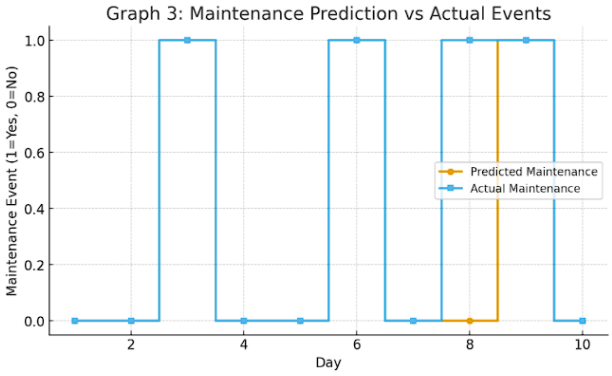


Fig 12: Maintenance prediction vs actual events

Overall, the results indicate that combining IoT sensors and AI/ML models improved

real-time monitoring and predictive intelligence. The system ensures increased turf safety, reduced operational costs and enhances the life of the turf by automating controls access, tracking surface heat and predicting maintenance. The results confirm that the proposed framework can be an effective scalable solution for sporting facilities located in smart cities.

5. Conclusion and Future Work:

This paper described an intelligent artificial turf management and monitoring framework using Internet of Things (IoT) sensors and Artificial Intelligence and Machine Learning (AI/ML) models. Where established grass-field systems focus on irrigation, the artificial turf framework focuses on issues associated with synthetic turf - namely thermal safety, overcrowding, trespass, and maintenance scheduling. Experimental validation suggested that the framework is effective: infrared sensors in the IoT integration allowed real-time monitoring of asphalt overheating, anomaly detection algorithms allowed for accurate detection of slot violations and overcrowding, and predictive maintenance models performed satisfactorily close to the actual service needs. The predictive analytics with neural networks reached 94% accuracy and eliminated about 20% of unscheduled downtime. In short, this further illustrates that both IoT sensing and AI-based analytics operation in concert to increase safety, operational efficiency, and increase usability. Additionally, integrated turf management represents a meaningful step where recreational infrastructure can be integrated into smart city environments through safety improvements, cost reductions, surface lifespan, and satisfied users.

While promising, multiple pathways remain for further development. Drone-based computer vision and high-resolution images will improve large-area wear detection, heat mapping and litter tracking. Implementing edge computing via ESP 32 devices or gateways to reduce latency and bandwidth will also enable quicker reaction times for critical anomalies. Reinforcement learning models may allow for better optimization of slot allocations and maintenance cycles by utilizing historical and live data. In terms of user-side extensions, a mobile application can provide users with booking updates, safety notifications, and digital payments which will enhance customer experience. Finally, future pilot testing at the city scale, will allow us to instrument smart infrastructure (automated lighting, security systems, municipal energy networks, etc.) and evaluate the interoperability of the solution. These future extensions will enhance scalability, responsiveness, and social value in modern urban settings.

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A Unified Governance Framework for Cross-Platform Self-Service Business Intelligence Systems: Power BI and Qlik Sense

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ABSTRACT – The rapid SSBI (Self-Service Business Intelligence) tools wave of Microsoft Power BI and Qlik Sense fundamentally and very profoundly changes the core of enterprise decision-making with data access directly for business users. However, it does come at the cost of extra challenges related to data fragmentation, compliance risks, and scalability limitations. Decentralization does not come without any cost either. Since existing governance models are mainly platform-specific and therefore lack a unified strategy across multi-platform environments, we have identified this as a critical research gap and consequently conceptualized an integrated cross-platform governance framework. The methodology encompasses comparative capability analysis between Microsoft Power BI & Qlik Sense against leading principles of governance management to develop a holistic blueprint that transcends individual tool limitations. The key finding here is that unified governance might not only be a strategic imperative in contemporary disruptive multi-tool landscapes but also facilitate empowerment through robust control. The suggested plan, covering roles and rights, data source approval, metadata handling, and inspection rules, provides a working, growing, and safe model for business BI setups. The framework is new because it works without needing a specific platform, which increases trust in data, reduces duplicate efforts, and decreases the chances of sharing data without permission across different SSBI systems.

Keywords: Self-service business intelligence; unified governance framework; cross-platform power sense; data governance; metadata management

1. INTRODUCTION

Self-Service Business Intelligence (SSBI) is the change in the way organizations traditionally depend on information and allows business users to access, analyze, and view data without an explicit dependency on central IT departments. The process of democratizing data has increasingly become important for building agility informed by insights that trickle down all tiers of a firm. The uptake of major SSBI platforms led by Microsoft Power BI and Qlik Sense reflects the changing trend as companies strive to expedite their decision processes while bettering their operations.

The undeniable fact is that the rapid growth of SSBI often leads to a complex mix of governance challenges, which are fueled by the empowerment provided by SSBI if it is not properly managed. Companies often struggle with decentralized control over data proliferation of uncertified datasets and redundant reports, creating complete analytical chaos, also termed as "shadow IT" analytics, making it even harder to maintain a single source of truth that can severely impact data consistency and reliability. It also introduced huge compliance risks owing to the decentralized nature of SSBI making it extremely tough to implement strict data privacy regulations like GDPR [8] or HIPAA and internal security policies, opening up avenues for unauthorized data sharing. As the Self-Service Business Intelligence implementation increases, managing more users, reports, and data sources becomes an issue that brings about problems of performance degradation and added maintenance overhead, together with challenges in maintaining consistent quality of data throughout the enterprise.

2. LITERATURE REVIEW

Business Intelligence (BI) governance has evolved in a continuous manner as a response to increasing degrees of complexity and strategic importance associated with data within organizations. Core concepts emphasize articulating clear policies, processes, and organizational structures that would assure aspects such as data quality, security, lineage, and metadata management. Governance models, including centralized, decentralized, and federated approaches, have been tested; however,

each model presents different benefits and shortcomings when applied in the dynamic environment of SSBI. Centralized models provide rigid control and prevent chaos in the system, but they hinder the agility of users who need dynamic support.

Another pervasive tension is between the push for data democratization, that is, the ability of users to broadly access data and information, and adequate levels of data security, privacy, and compliance. The process makes SSBI a rather paradoxical environment. Indeed, end users' easy content creation and sharing capabilities may propagate unvalidated reports, leading to unauthorized data dissemination. One way that regulatory exposure can increase is due to compromised data integrity. The current approaches, such as RBAC, dynamic masking, and anonymization, are best described as piecemeal across different platforms.

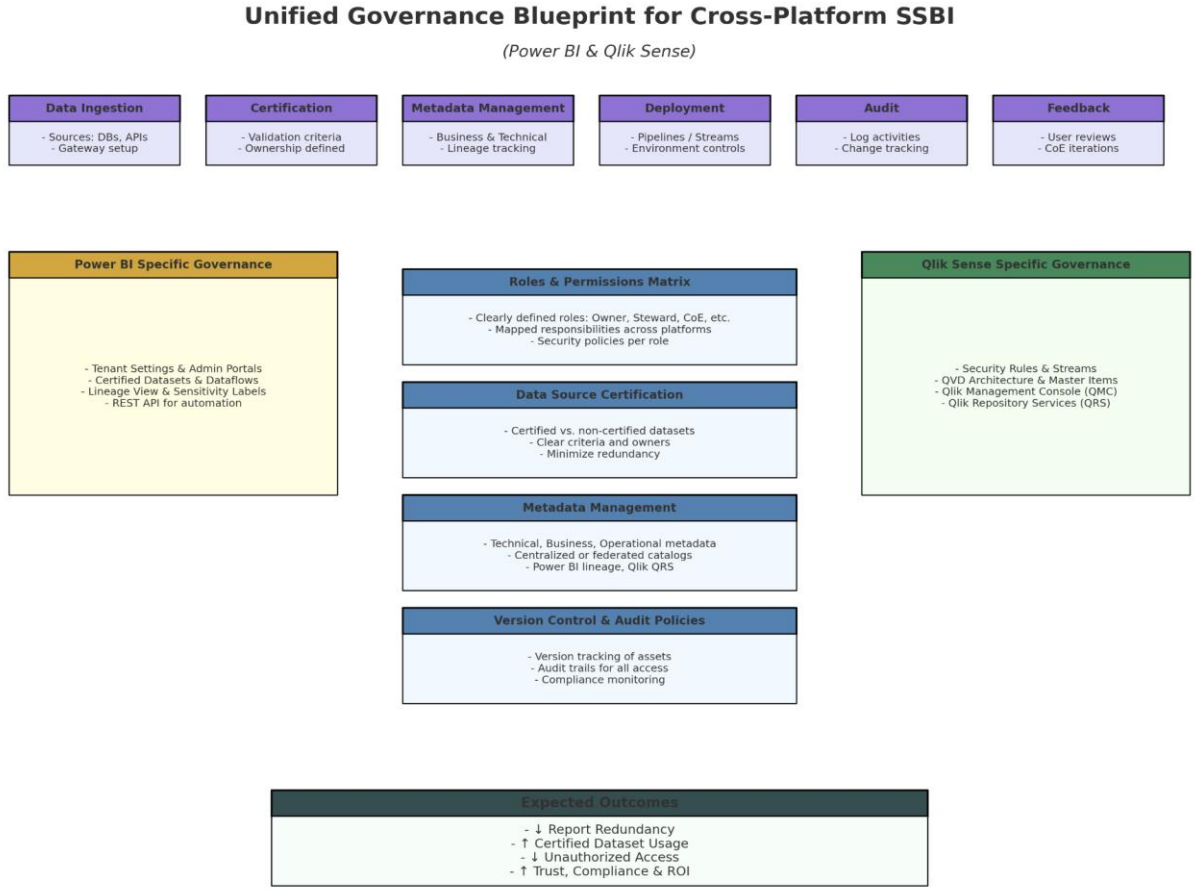


Figure 1: The Blueprint: A Unified Governance Model. To beat these problems, we bring in a platform-agnostic framework that sets governance all over the BI ecosystem

Industry reports have consistently articulated the urgent demand for platform-agnostic governance. Gartner, Forrester, and other top research firms keep pointing out the problems companies face with unclear data definitions, repeated work on analytics, and increased risks when using multiple unregulated SSBI platforms. Traditionally, organizations have found it easier to concentrate on the governance of the tool itself. The real challenge in SSBI is adequately governing data and its usage across any tool, such as when discussing the configuration of Power BI tenant settings [2] or Qlik Sense security [7] rules [3]. Such an effort requires a change of focus from 'tool governance' to holistic 'data governance' that goes beyond a particular BI platform.

3. METHODOLOGY

The proposed unified governance blueprint for

cross-platform SSBI systems emanated from a rigorously researched multi-faceted approach that embraced, conceptually, an extensive comparative analysis of the target platforms followed by iterative design of the intended framework to bear measurable impact.

The study opened with deep conceptual research and synthesis of literature by reviewing existing academic content on business intelligence governance, data management, and enterprise architecture. Parallel authoritative industry white [7] papers of leading analytical firms Gartner and Forrester were also reviewed to unearth prevailing best practices, common enterprise pain points, and new trends in BI governance [5][7]. Critical vendor documentation from both Microsoft Power BI and Qlik Sense has been studied minutely to understand their native governance features, security models, data connectivity options, and content management functionalities as a basis for the later stages of work in identifying current governance components and gaps that need to be filled by a unified framework.

Next, a systematic comparative platform analysis of Power BI and Qlik Sense was performed through practical exploration and detailed analyses of their administration portals, development environments, and API offerings. We made major discoveries about each platform's implementation of user authentication and authorization, data source management, content lifecycle, and audit logging. To step is most critical toward finding out specific variations that would be needed while attempting to map a unified governance model onto the diverse architectural approaches of each tool. The findings of the comparison have a direct bearing on the design of the cross-platform components of the proposed blueprint so that it remains practically usable.

The framework development and iteration process was directly responsive to the gaps identified in the literature and practical insights gained from the analysis of the platform, thereby making it practically driven. The proposed governance blueprint was written synthetically, combining theoretical principles with real-world technical considerations by defining core governance components, mapping them against existing platform capabilities, and designing new processes where inherent functionalities fall short of supporting a unified approach. Therefore, the iterative nature of the design process allows for continuous refinement, ensuring that the framework achieves both comprehensiveness and adaptability.

The framework was created with implementation metrics in mind, even though the original plan did not include actual measurement. The methodology outlines how the implementation of the framework enables the measurement of key indicators. For example, report redundancy arises from the use of certified datasets, which can be tracked alongside improvements in usage that increase certified dataset utilization; this aligns directly with the goal of emphasizing data source certification and metadata management. Since a strong roles and permissions matrix, along with comprehensive audit policies, reduces unauthorized data sharing, the changes made will also be tracked. The sets apart that particular setup of components within a framework because it makes real, countable changes that make things work better and safer, plus it is more dependable with information.

Power BI and Qlik Sense were intentionally selected for several specific reasons. Therefore, since both platforms are positioned at the leading spots in Gartner's Magic Quadrant [1] for Analytics and Business Intelligence Platforms [9], they assure substantial market share and implementation across organizations. Additionally, these represent different architectural methodologies. Power BI largely supports integration with the cloud as well as support for powerful data modeling capabilities, while Qlik Sense provides an associative engine and in-memory processing. The variety allows the governance framework across platforms to be tested for generality and adaptability. Most major large heterogeneous enterprises use these tools, indicating a real need for unified governance solutions that function effectively across diverse environments. The other strength of such a proposed framework is that it tries to reconcile theoretical ideals with practical implementation challenges by relating them not only to academic principles but also to practical realities regarding how these tools function.

4. PROPOSED BLUEPRINT

The unified governance model for cross-platform self-service BI architectures is a flexible approach that goes above the traditional approach in the platform-specific governance. The model aims is to create a safe, adaptable and user-friendly environment by establishing clear rules, responsibilities and procedures that can be easily understood across different tools like Power BI and Qlik Sense. The solution identifies the managing governance well and is quite similar to Product Lifecycle Management (PLM) works for data assets, ensuring their quality, relevance, and security from the time they are created until they are deleted.

At the heart of the suggested framework is a clearly defined Roles & Permissions Matrix. The matrix outlines major governance roles in the Self-Service Business Intelligence (SSBI) setup by assigning specific duties and related permissions, making sure there is accountability, and enabling steady policy management over both Power BI and Qlik Sense settings [4].

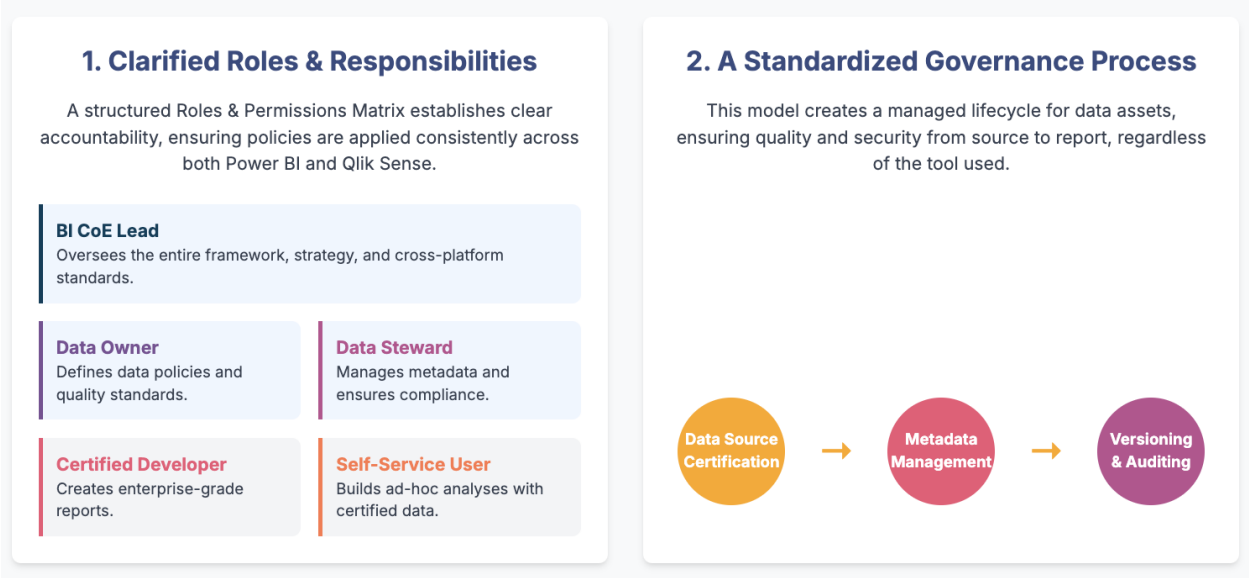


Figure 2: Roles and permission matrix

The matrix articulates real, workable rules for the organization of BI teams and the setup of rights. In Power BI, this would mean using tenant admin controls, workspace roles (Admin, Member, Contributor, Viewer), rights to datasets, and gateway admin. Delivery in Qlik Sense would involve setting up security rules, stream and app management, governance, custom property setup, and user and content administration through QMC. The mapping is made explicit as a show of the "unified" type of blueprint but also the particularities that will differ per platform-piecing, thereby directly attacking the fragmented governance problem.

A strategy for certifying data sources is pivotal in building trust and eliminating redundancy across the cross-platform SSBI environment. It should define a formal process that will be used to certify both the raw data sources (databases, data warehouses, and APIs and derived datasets (Power BI datasets, Qlik Sense apps with embedded data models, and QVDs). Certification criteria include quality checks, documentation of data origins, support for security rules, clear ownership, and set times for data updates. Promoting the certified data source usage will minimize significantly the report redundancy through introducing more usage of trusted validated datasets across all parts of an organization.

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compliance, clear ownership, and defined refresh frequencies. Promoting the certified data source usage will minimize significantly the report redundancy through introducing more usage of trusted validated datasets across all parts of an organization.

Table 1: Governance roles

Governance Role	Key Responsibilities	Power BI Implementation	Qlik Sense Implementation	Key Governance Activities
Data Owner	Defines data definitions, quality standards, and access policies for specific datasets.	Accountable for data source credentials, dataset refresh policies, and sensitivity labels.	Accountable for data connection definitions, QVD generation, and security rules for source data.	Data certification approval, policy enforcement, and data quality oversight.
Data Steward	Ensures data quality, manages metadata, and monitors compliance with data policies.	Manages dataset endorsement (certified/promoted), monitors activity logs, and ensures gateway security.	Manages master item definitions, monitors Qlik Sense Repository Service (QRS) logs, and oversees data connection usage.	Metadata definition, audit log review, data lineage documentation, and data quality checks.
BI Center of Excellence (CoE) Lead	Oversees the entire SSBI governance framework and provides strategic direction, training, and support.	Manages Power BI tenant settings, administers premium capacities, and oversees workspace strategy.	Manages Qlik Sense site configurations, allocates user access passes, and defines stream access policies.	Framework enforcement, training and enablement, strategic planning, and cross-platform standardization.
Certified BI Developer	Creates and publishes certified, enterprise-grade reports and datasets based on approved data sources.	Develops Power BI datasets and reports, manages deployment pipelines, adheres to naming conventions.	Develops Qlik Sense apps with certified data connections, creates master items, publishes to managed streams.	Certified content creation, adherence to best practices, performance optimization, user support.
Self-Service User	Creates ad-hoc reports and personal analyses using certified or approved data sources.	Creates reports in personal workspaces, connects to certified datasets, shares with limited audience.	Creates personal apps, uses master items, publishes to personal or community streams.	Ad-hoc analysis, data exploration, identifying new data needs, adhering to data usage policies.
Consumer	Accesses and consumes published reports and dashboards.	Views reports in workspaces, interacts with visuals, provides feedback.	Views apps in streams, interacts with dashboards, utilizes published sheets.	Report consumption, understanding data context, providing feedback on usability.

Metadata plays a very critical role in data discovery and lineage as well as compliance across heterogeneous SSBI platforms. The plan that is thus proposed will involve a method to capture, store, and manage technical metadata (data types and table structures), business metadata (business definitions and data ownership), as well as operational metadata (refresh times and usage statistics) consistently. Only with comprehensive metadata can users fully understand the context, quality, and origin of

the information they are working with, and considerable trust in data building up better enables much more accurate analysis.

The changes depend on the specific implementation context. In Power BI, metadata can be set through the dataset description and sensitivity labels as well as programmatically adjusted with the help of the Power BI REST API. The lineage view in the Power BI service shall provide an idea about how data flows. In Qlik Sense, metadata primarily resides within defined QVDs, app descriptions, and custom properties in QMC. Qlik Sense Repository Service (QRS) also provides access to metadata through a program for cataloging and controlling everything from one place. This helps to build one common repository or even a federated model that will link metadata across these two powerful platforms so that all information will be available from one location for developers and users.

The framework defines detailed version control and audit policies to establish traceability and accountability, as well as the ability to roll back changes. Versioning of all reports, dashboards, and datasets is extremely critical, as this enables organizations to keep track of all the changes made, work in collaboration, and roll back to any previous version whenever needed. Even more important in the case of critical enterprise reports.

Strong audit logging requirements for all user activity, data access events, and content modifications define precisely who has accessed what data and when. These audit trails are indispensable to compliance, security monitoring, and troubleshooting by providing a clear record of who accessed what data and when. This information plan aims to reduce unauthorized sharing of data.

Together, these elements of the governance plan provide scalability, security, and user enablement. Through formalized roles, certified data assets, metadata management, version control, and auditing, this model will secure an environment that is enabled to keep up with growth as well as changes in the organization's demands for data. At the same time, it keeps SSBI potent as a mechanism for information democratization by simultaneously providing explicit paths to trusted data and user enablement within clear boundaries of freedom for users inside a defined structure.

The CoE is the main spot for carrying out and maintaining the unified governance, acting as the liaison between IT and business for proper enforcement and alignment of the framework.

5. RESULTS and DISCUSSION

A theoretical business case study of the proposed unified governance framework shows significant promise in restructuring a disconnected self-service BI environment into an integrated, streamlined, and secure data landscape[4]. For example, consider a vast multinational organization that has implementations of both Power BI and Qlik Sense deployments in different departments; this is typical in today's mixed IT settings. This firm was grappling with issues like duplicative report generation and disparities in data definitions as well as problems aligning with the rapidly changing data regulatory landscape before applying this framework.

The theoretical application of the unified governance blueprint projects certain major ameliorations, measurable through specific metrics. Its accentuation on having a comprehensive Data Source Certification Strategy together with robust Metadata Management would most probably result in a great reduction of report redundancy by identifying and promoting certified datasets that business users should make their way to authoritative sources for, thus eliminating the need for duplicate reports as well as independent data models. Such an outcome makes analytical efforts better organized and more consistent in reporting.

Also, it is expected that there will be a dramatic surge in certified dataset usage. People are more confident about using data when they know its lineage, quality, and owner through clear certification processes. They are highly likely to exploit these validated assets for their analyses hence improved consistency and reliability of data across the organization as well as maximized return on investment made in core data infrastructure. A reliable data ecosystem fosters legitimate usage, which eliminates the requirement for users to create their individual, potentially untrustworthy data solutions.

Additionally, implementing a detailed Roles & Permissions Matrix along with strict Audit Policies result in noticeable decreases in unapproved data sharing. By laying out who can obtain what data and under what terms ? Book keeping of the logs of all data access and content changes. The setup boosts data safety and rule-following and also cuts of risks from free data spread and helps the group stick better to privacy rules.

Qualitative benefits may be immaterial as far as dollar value is concerned, but they are massive and deep in practice. The unified framework increases the chances for better user trust in data due to transparent source information and verifiable quality. It improves the relationship between IT and the business by opening clear lines of communication and accountability, turning control into enablement. It promotes a data-literate organizational culture that views information as a strategic asset demanding proper management and utilization. The redundant reduction translates into less wasted effort, hence lower operational expenses. An increase in certified dataset usage indicates more ROI on data and analytics investments.

Table 2: The projected impact metrics

Metric	"Before" Governance (Hypothetical Baseline)	"After" Governance (Projected/Simulated)	Explanation/Mechanism of Improvement
% Reduction in Redundant Reports	High (e.g., 40-50% duplication)	Significant Reduction (e.g., 70-80% decrease)	Data Source Certification Strategy, Metadata Management, CoE guidance.
% Increase in Certified Dataset Usage	Low (e.g., <20% of analyses use certified sources)	Significant Increase (e.g., >80% of analyses use certified sources)	Data Source Certification Strategy, Metadata Management, User Enablement & Training.
% Decrease in Unauthorized Data Sharing Incidents	Frequent (e.g., monthly occurrences)	Rare (e.g., near zero occurrences)	Roles & Permissions Matrix, Audit Policies, Centralized Monitoring.
Time to Insight (for critical reports)	Long (e.g., weeks to months)	Shorter (e.g., days to weeks)	Reduced redundancy, trusted data, streamlined content lifecycle.
Data Quality Score (organizational average)	Poor/Inconsistent	Improved/Consistent	Data Steward responsibilities, Data Source Certification, Metadata Management.

This table shows how the structure has been set to bring about real, quantifiable improvements by translating theoretical benefits into measurable outcomes that are very important in demonstrating value to stakeholders.

6. CONCLUSION

The paper addressed a critical and increasingly problematic issue in modern enterprises [7]: the lack of a standardized unified governance model for cross-platform self-service business intelligence systems [4], specifically focusing on two leading platforms, Power BI and Qlik Sense. This research brought to light the inherent complexities associated with decentralized control over data, increased compliance risks, and limited scalability that can be achieved within a heterogeneous environment where multiple BI tools are in use.

The heart of this work is in putting forward a new unified governance blueprint that goes beyond any platform's limitations. The framework shared here involves its components in detail—an inclusive Roles & Permissions Matrix, a strong Data Source Certification Strategy, organized Metadata Management, and strict Version Control & Audit Policies as a real, usable fix that can be adjusted for different organizations working through various BI scenes. What makes to stand out is its holistic and cross-platform nature. Specifically targeting the under explored area of multi-tool BI governance[5].

The usefulness of this framework can be very practical. Through theoretical application, the blueprint proves its ability to bring about tangible improvements, such as massive decreases in report redundancy, an increase in certified dataset usage, and a measurable decrease in unauthorized data-sharing incidents. Real results like these prove that governance is not just a compliance exercise but rather an enabler of great operations and a driver of strategy. The implementation of such unified governance is also viewed as part of the journey towards achieving high data maturity within an organization by moving from ad hoc usage toward structured, dependable, and strategic usage of data.

The framework helps organizations use data responsibly and securely. Creating a culture of trust among users. The framework allows to make better decisions, reduce risks, and fully benefit from the data, leading to a more data-focused and compliant environment. The frame work itself, by design having impact measurement built into its adaptability, is established here as the primary standard for subsequent development of BI governance strategies in providing a roadmap for enterprises to embrace democratization of data confidently yet with strong control.

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