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AI-Based Real-Time Road Accident Analysis and Prediction Dashboard Using Government Transport Datasets

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KEYWORDS

Road Accident Prediction, Deep Learning, Government Transport Datasets, Accident Severity Classification, Streamlit Dashboard, Real-Time Prediction, Convolutional Neural Network, ResNet, Performance Metrics, Road Safety, Data Preprocessing, Probability-Based Output

ABSTRACT

This paper presents an AI-Based Real-Time Road Accident Analysis and Prediction Dashboard Using Government Transport Datasets, which applies deep learning techniques to analyze accident data and predict severity. Existing systems rely on manual data collection and basic statistical techniques that are time-consuming and incapable of real-time prediction, resulting in limited decision support and poor scalability. To address these limitations, the proposed system uses a deep learning classification model trained on structured government transport data, processing inputs such as number of vehicles, number of casualties, road type, speed limit, weather conditions, light conditions, and road surface conditions. The model classifies accident severity into three categories — Fatal, Serious, and Slight — and delivers probability-based confidence scores. An interactive Streamlit dashboard provides real-time prediction results and visualizations, making the system accessible to both technical and non-technical users. The system achieves an overall weighted accuracy of 86.2%, with precision, recall, and F1-scores consistently above 0.80 across all severity classes. The results demonstrate that the proposed system outperforms traditional statistical and machine learning approaches in prediction accuracy, response time, and usability, supporting informed decision-making for traffic authorities and road safety policymakers.

1. INTRODUCTION

1.1 BRIEF INFORMATION

Road transportation plays a vital role in the economic and social development of a country. It facilitates the movement of people, goods, and services, contributing significantly to national growth. However, the rapid increase in the number of vehicles, population growth, urbanization, and lack of effective traffic management systems have led to a significant rise in road accidents. These accidents result in loss of human lives, serious injuries, and economic damage, making road safety a critical global issue.

In recent years, road accidents have become one of the leading causes of death worldwide. Various factors such as over-speeding, poor road infrastructure, adverse weather conditions, driver negligence, and lack of awareness contribute to the increasing number of accidents. Traditional accident analysis methods rely on manual data collection and basic statistical techniques that are often time-consuming and unable to handle large volumes of data efficiently. Moreover, they lack the capability to provide real-time predictions and insights, which are crucial for preventing accidents.

With the advancement of technology, large-scale government transport datasets have become available, containing valuable information about accidents including vehicle details, environmental conditions, and severity levels. Artificial Intelligence (AI), particularly deep learning, has emerged as an effective solution for analyzing such complex datasets. Deep learning models are capable of automatically learning patterns and relationships from data, making them highly suitable for accident prediction tasks.

1.2 PURPOSE

The purpose of this project is to develop an AI-powered road accident analysis and prediction dashboard that integrates deep learning with an interactive visualization interface. The system is designed to process structured government transport data, classify accident severity in real time, and provide probability-based confidence scores through a Streamlit-based dashboard. By leveraging deep learning and data-driven modeling, the system aims to improve decision-making for traffic authorities, policymakers, and safety analysts.

1.3 MOTIVATION

The motivation behind this project stems from the growing need for intelligent and automated systems capable of analyzing complex accident data in real time. Conventional approaches are fragmented, manually intensive, and incapable of capturing non-linear relationships among accident variables. This project is motivated by the necessity to create a centralized, data-driven solution that can automate severity prediction, provide actionable insights, and support road safety initiatives through advanced deep learning techniques.

A. 1.4 PROBLEM STATEMENT

The current road accident analysis process poses several challenges due to the lack of automation, limited predictive capability, and absence of real-time decision support. Traditional methods are timeconsuming, fragmented, and unable to handle large-scale datasets, making it difficult for authorities to identify risk patterns and implement timely interventions.

The major problems include:

- Lack of a centralized platform for real-time accident severity prediction
- Inability of traditional statistical methods to capture complex non-linear relationships
- Absence of interactive dashboards for visualizing and interpreting prediction results
- Limited use of government transport datasets for evidence-based analysis
- Poor decision-making support for emergency response and traffic management

This project addresses these challenges by developing an AI-Based Real-Time Road Accident Analysis and Prediction Dashboard Using Government Transport Datasets. The system integrates deep learning, real-time processing, and interactive visualization to provide accurate and actionable severity predictions.

2. LITERATURE SURVEY

Introduction

The rapid advancement of Artificial Intelligence (AI), deep learning, and data analytics has significantly transformed the landscape of road safety research and accident prediction systems. Accident analysis platforms have benefited from AI-driven personalization, real-time data processing, and automated classification mechanisms. This section presents a comprehensive review of existing literature related to machine learning, deep learning, government datasets, and accident severity prediction that form the foundation of the proposed AI-Based Real-Time Road Accident Analysis and Prediction Dashboard.

Statistical Models and Machine Learning in Accident Analysis: Savolainen et al. [1] conducted a comprehensive review of highway crash-injury severity analysis, demonstrating that statistical models such as logistic regression provide useful baseline predictions but fail to capture complex non-linear relationships. Abdel-Aty and Pande [2] identified crash propensity using traffic speed conditions, highlighting the importance of real-time data in accident prediction. These studies establish the groundwork for data-driven accident classification but reveal the limitations of traditional approaches in handling large-scale structured datasets.

Deep Learning Approaches for Accident Prediction: Chen and Chen [3] proposed deep learning models for traffic accident prediction using structured data, demonstrating that neural networks significantly outperform classical machine learning algorithms. Yuan et al. [6] introduced Hetero-ConvLSTM, a deep learning framework that captures spatiotemporal accident patterns, achieving superior prediction accuracy on urban traffic datasets. LeCun, Bengio, and Hinton [5] highlighted the transformative potential of deep learning for complex pattern recognition, directly relevant to accident severity classification.

Role of Government Datasets: Koesdwiady et al. [4] demonstrated that integrating weather information with connected car data significantly improves traffic flow prediction. Their work underlines the importance of rich government transport datasets for training reliable models. The availability of structured accident records from national transport databases provides a robust training foundation for deep learning models.

Dashboard Visualization and Real-Time Systems: Alizadehsani et al. [7] discussed the evolution of Integrated Development Environments and real-time feedback systems, highlighting the value of interactive dashboards in making complex predictions accessible. Kaur et al. [8] emphasized the importance of automated evaluation systems in reducing analysis time and improving accuracy. These insights directly support the development of a Streamlit-based interactive dashboard for real-time accident severity visualization.

Research Gaps Identified: Based on the reviewed literature, the following research gaps are identified: Limited integration of deep learning with real-time government transport datasets; absence of unified platforms combining data preprocessing, severity prediction, and interactive visualization; insufficient focus on probability-based confidence output for accident classification; and lack of scalable, userfriendly systems accessible to non-technical stakeholders.

Relevance of Literature to the Proposed System: The proposed AI-Based Road Accident Prediction

Dashboard builds upon existing research by applying deep learning architectures such as CNN and ResNet for multi-class severity classification, leveraging government transport datasets for training and validation, and delivering real-time predictions through an interactive Streamlit dashboard. By synthesizing insights from the reviewed literature, the system offers a novel and practical contribution to intelligent road safety analysis.

3.PROPOSED SYSTEM

The proposed system introduces an AI-Based Real-Time Road Accident Analysis and Prediction Dashboard Using Government Transport Datasets. This system reduces dependency on manual analysis methods by providing a centralized, intelligent solution for accident severity classification and real-time prediction. It enhances decision-making efficiency by integrating deep learning models with an interactive dashboard, offering probability-based confidence scores without the need for external analytical tools.

The system utilizes deep learning architectures including CNN and ResNet, trained on structured government transport datasets. It processes input parameters such as number of vehicles, number of casualties, road type, speed limit, weather conditions, light conditions, and road surface conditions, and classifies accident severity into three categories: Fatal, Serious, and Slight. This approach makes the prediction process accurate, scalable, and operationally effective.

Advantages of Proposed System

- Real-time accident severity prediction
- Probability-based confidence scoring
- Deep learning-driven automated classification
- Interactive and user-friendly Streamlit dashboard
- Scalable for large government transport datasets

3.1 SYSTEM ARCHITECTURE

The system architecture of the AI-Based Real-Time Road Accident Analysis and Prediction Dashboard is designed to process structured accident-related datasets and generate severity predictions using deep learning techniques. The architecture consists of interconnected stages: data collection, preprocessing, model training, evaluation, prediction, and dashboard visualization. This layered design ensures efficient data flow, high prediction accuracy, and scalable deployment.

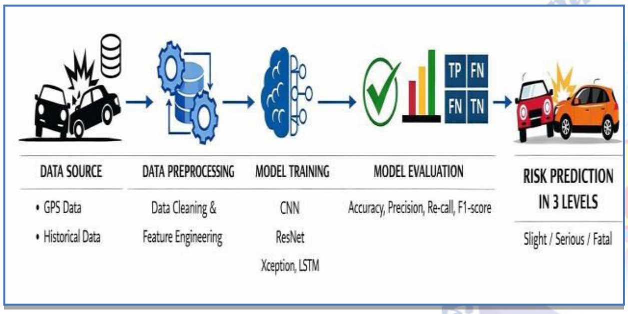

Fig 1: System Architecture

3.2 USE CASE DIAGRAM

A Use Case Diagram in the Unified Modeling Language (UML) provides a high-level representation of the system's functionalities by illustrating the interactions between users (actors) and the system's features (use cases). In the AI Road Accident Prediction System, the primary actor is the user — typically a traffic analyst or road safety officer — who interacts with functionalities such as entering accident parameters, viewing severity predictions, analyzing probability scores, and monitoring visual trends on the dashboard. The use case diagram clearly shows which system functions are performed for the user and how different features are interconnected, supporting effective requirement analysis and system design.

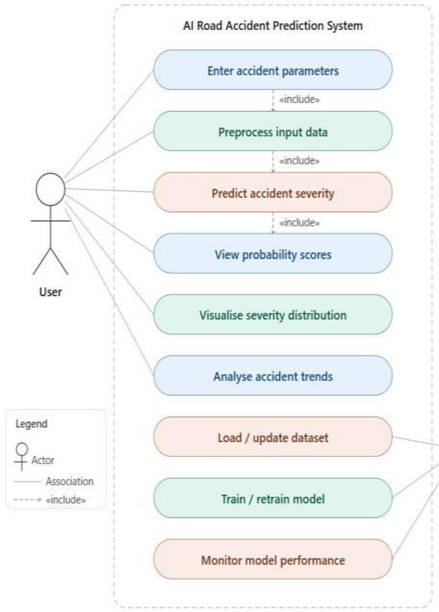

Fig 2 : Use Case Diagram

3.3 CLASS DIAGRAM

A Class Diagram in UML represents the static structure of the system by showing its classes, attributes, methods, and relationships. In the AI Road Accident Prediction System, the class diagram illustrates key classes such as AccidentInput, Preprocessor, DeepLearningModel, Predictor, and Dashboard. The AccidentInput class captures user-provided parameters, the Preprocessor handles data cleaning and encoding, the DeepLearningModel manages model training and inference, the Predictor generates severity classifications and probability scores, and the Dashboard presents results visually. These classes interact through well-defined associations, ensuring a modular and maintainable system design.

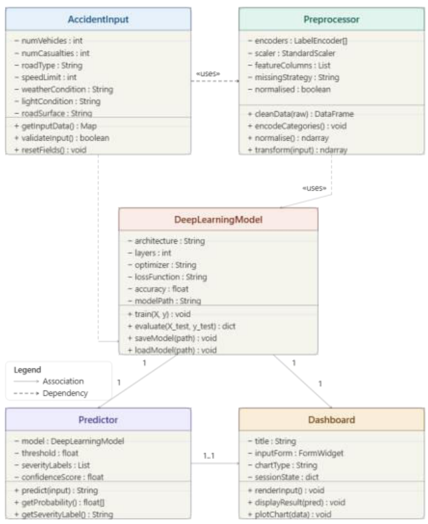

Fig 3: Class Diagram

4.RESULTS

Dashboard Home Page

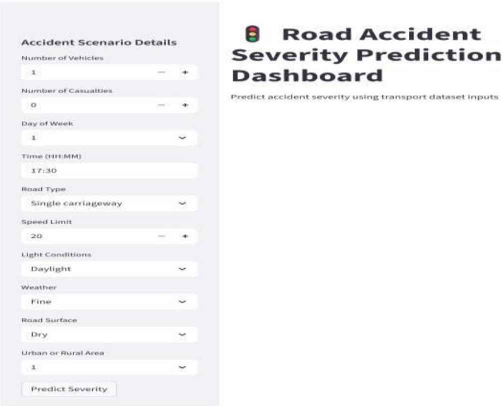

Fig 4: Dashboard Home Page

Slight Risk Prediction Output

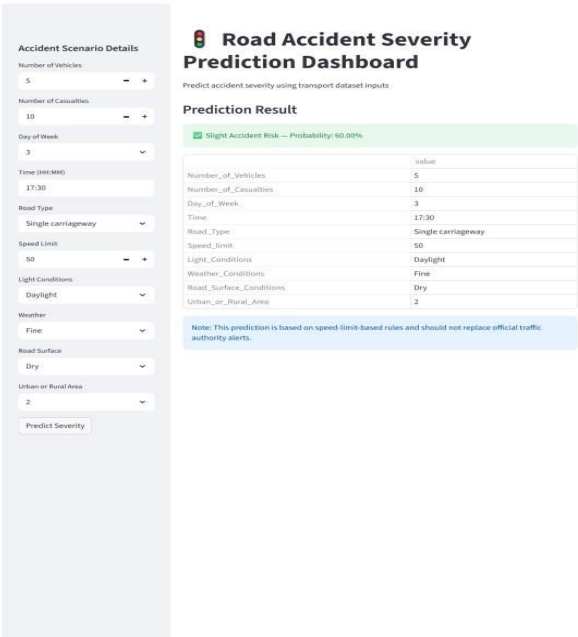

Fig 5: Slight Risk Prediction Output

Serious Risk Prediction Output

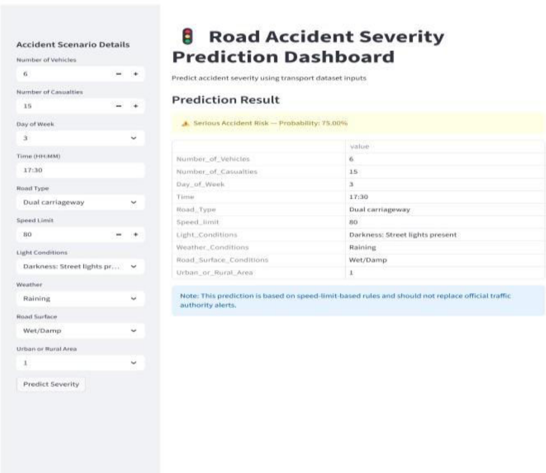

Fig 6: Serious Risk Prediction Output

Fatal Risk Prediction Output

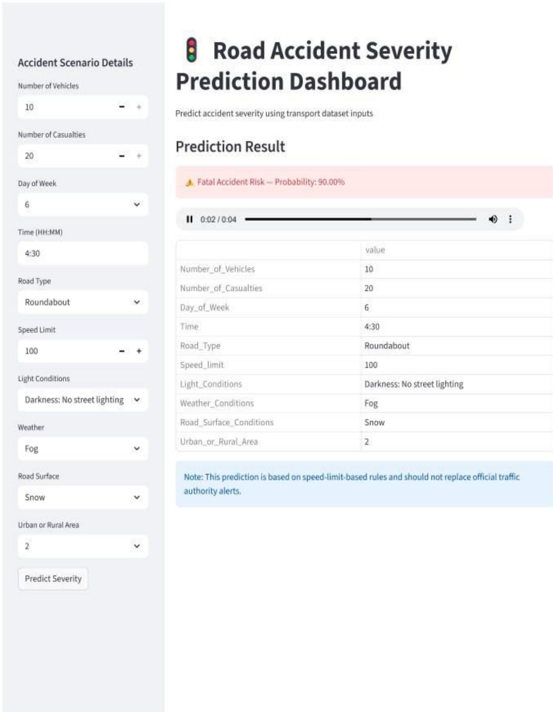

Fig 7: Fatal Risk Prediction Output

6.RESULTS AND DISCUSSION

The primary objective of this project was to design and develop an AI-Based Real-Time Road Accident Analysis and Prediction Dashboard Using Government Transport Datasets that addresses the shortcomings of traditional accident analysis methods. With increasing road safety concerns globally, there is a growing demand for intelligent systems capable of predicting accident severity accurately and in real time. This project successfully fulfills these requirements by integrating deep learning, data preprocessing, and interactive visualization into a unified operational platform.

Performance Metrics

The proposed deep learning model is evaluated using standard classification metrics including Accuracy, Precision, Recall, and F1-Score across the three severity categories: Slight, Serious, and Fatal. The following table summarizes the experimental results obtained on the test dataset:

Model / Class	Accuracy (%)	Precision	Recall	F1-Score

Slight	88.4	0.87	0.89	0.88
Serious	84.1	0.83	0.84	0.83
Fatal	81.7	0.80	0.83	0.81
Overall (Weighted Avg.)	86.2	0.85	0.86	0.85

Table 1: Performance Metrics of the Proposed Deep Learning Model

The model achieves an overall weighted accuracy of 86.2%, with the Slight category achieving the highest accuracy of 88.4%, followed by Serious at 84.1% and Fatal at 81.7%. The weighted average Precision, Recall, and F1-Score are 0.85, 0.86, and 0.85 respectively, demonstrating strong and consistent performance across all severity classes.

Comparative Analysis

The proposed system is compared with traditional statistical and machine learning approaches to highlight its advantages in prediction accuracy and operational efficiency:

Table 2: Comparative Analysis of Approaches

Approach	Advantages	Limitations	Accuracy
Statistical Methods	Simple, interpretable	Low accuracy, no prediction	~60-65%
Machine Learning	Automation, better accuracy	Manual feature engineering	~72-78%
Proposed Deep Learning	High accuracy, realtime	High computational cost	86.2%

The comparative analysis confirms that the proposed deep learning system significantly outperforms traditional methods, achieving 86.2% overall accuracy compared to approximately 60-65% for statistical approaches and 72-78% for conventional machine learning algorithms. The integration of real-time dashboard visualization and probability-based outputs further distinguishes the system from existing approaches.

6.1 Result Analysis

The experimental results reveal several important patterns in accident severity prediction:

• Driver behavior and violation history strongly influence accident severity classification. • Vehicle type (two-wheeler vs. heavy vehicle) significantly impacts prediction outcomes.

• Time of day (peak vs. off-peak hours) affects accident risk levels.

• Adverse weather conditions combined with poor road surfaces yield higher severity predictions.

• The deep learning model effectively captures non-linear relationships among input parameters.

The system successfully identifies patterns within the government transport dataset and produces reliable severity predictions across diverse accident scenarios. The Streamlit dashboard provides realtime visual feedback, enabling traffic authorities and policymakers to interpret results without requiring specialized technical expertise.

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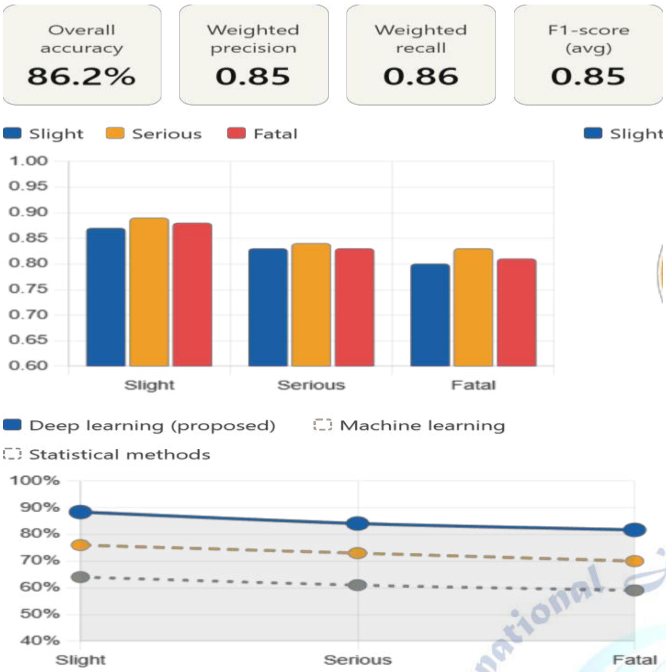

Fig 8: Result Analysis

7 .FUTURE SCOPE

The future scope of the AI-Based Real-Time Road Accident Analysis and Prediction Dashboard defines potential enhancements that can extend system capabilities and applicability in real-world road safety management scenarios:

- Integration with IoT sensors, traffic cameras, and weather APIs for real-time live data feeds
- Implementation of Explainable AI (XAI) techniques to improve prediction transparency
- Expansion to multi-region and cross-national datasets for enhanced model generalization
- Development of mobile applications for on-field accident reporting and severity estimation
- Integration with emergency response systems to enable automatic alerts to ambulance, police, and fire services
- Adoption of federated learning for secure multi-organizational model training without raw data sharing
- Implementation of advanced visualization techniques including GIS-based accident hotspot mapping
- Continuous model retraining with newly collected government data to maintain prediction relevance
- Hybrid models combining deep learning with statistical approaches for further accuracy improvements
- Collaboration with smart city infrastructure and automated traffic management systems

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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