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Integrated Approaches to Road Safety Using Machine Learning

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ABSTRACT: Road accidents present a significant threat to public safety and infrastructure integrity. Addressing this challenge requires accurate predictive models to assess accident severity and facilitate preventive measures. In this project, we propose an AI-powered application to predict accident severity based on real-time conditions such as weather, road type, and time of day. Leveraging a dataset of accident records, our model utilizes machine learning algorithms to identify patterns associated with different severity levels. By integrating features like weather conditions and road types, the model aims to provide precise predictions for proactive resource allocation and preventive measures in high-risk areas. This study focuses on leveraging advanced predictive modelling techniques, like the Random Forest Regression model, to forecast road accidents and casualties in urban centres. The predictive model is meticulously trained using authentic government datasets, ensuring the reliability and credibility of the input information. Our results underscore the efficacy of Random Forest Regression in providing precise and reliable forecasts for both road accidents and associated casualties. The system enables users, including traffic authorities and emergency services, to input current conditions for real-time severity predictions. Leveraging geolocation services, the application automatically captures the user's location, facilitating location-specific preventive actions. Advantages include forecasting accident severity, efficient resource allocation, and improved emergency response times. By offering timely predictions, the system aims to reduce severe accidents and minimize their societal impact. Continuous monitoring, data collection, and model refinement ensure adaptability to changing conditions, enhancing predictive accuracy over time. In summary, the AI-powered application represents a vital tool for enhancing road safety, revolutionizing accident prevention strategies, and ultimately saving lives.

KEYWORDS: Predictive models, Real-time conditions, Machine learning algorithms, Random Forest Regression, AI-powered application, Road safety.

I. INTRODUCTION

Road accidents remain a persistent threat to public safety, necessitating innovative approaches for accurate prediction of accident severity. Traditional methods often fall short in capturing real-time conditions' complexities, prompting the adoption of AI-driven solutions. Our study introduces a novel approach utilizing machine learning, particularly Random Forest Regression, to forecast accident severity based on diverse factors such as weather conditions, road types, and time of day. The primary aim of our research is to provide traffic authorities and emergency services with a proactive tool for resource allocation and preventive measures in high-risk areas. By integrating real-time data and continuous model refinement, our approach offers timely and precise predictions, bolstered by the use of authentic government datasets. This paper contributes to advancing road safety by presenting a scalable AI solution capable of revolutionizing accident prevention strategies and ultimately saving lives.

II. RELATED WORK

This study analyses road traffic accident severity in China using ASRTAC data (2002-2012) and a multi-regression model. Factors include vehicle park, lane-miles, licensed drivers, GDP, traffic fines, and serious accidents. Positive correlations were found with vehicle park, lane-miles, and GDP, while negative correlations were observed with licensed drivers, fines, and serious accidents. Hypothesis testing confirms the significance of GDP, fines, and serious accidents in influencing fatalities, aiding traffic safety management in China.[1]

This project uses R tool and data mining to predict road accidents on State Highways and Ordinary District Roads, addressing the rising issue of severe accidents. Through analysis of road types, it aims to uncover traffic patterns and accident-prone areas, culminating in a statistical model linking road conditions to accidents. Future work may include considering factors like speed restrictions for a more comprehensive understanding of accident severity.[2]

This study uses data mining techniques, including Decision Tree algorithms and Naïve Bayes, to analyze and predict road traffic accident severity. The goal is to understand influential factors and develop a classifier model for severity prediction, with a focus on improving emergency response and accident management. The comparison of classification techniques shows that J48 has higher accuracy, while Naïve Bayes excels in performance metrics like AUC and ROC. Key factors affecting severity include speed limit, weather, lanes, lighting, and accident time. Less impactful factors involve gender, age, accident area, and vehicle type. Notably, fatal accidents are more common in rainy conditions at midnight, and serious accidents occur in foggy weather on single-lane roads.[3]

The project predicts people involved in Thai highway accidents by the hour, using methods like Multiplicative Decomposition and SARIMA. It differentiates total predictions from male and female predictions, measuring accuracy with MAPE. The introduction stresses global concerns over increasing accidents and the need for precise prediction models. The literature review discusses initiatives like the UN's Decade of Action for Road Safety, emphasizing accurate predictions for traffic management. The methodology tests prediction model accuracy, comparing various time series methods. In conclusion, the study aims to enhance prediction accuracy for the number of individuals involved in road accidents, specifically by gender and time of day.[4]

The project focuses on reducing road traffic accidents in Dubai using logistic regression and the Smart City initiative. It identifies key factors influencing fatal accidents, including location, seatbelt use, toxicity, and profession. The study concludes that the proposed model, aligning with Dubai's Smart City vision, can effectively predict and prevent fatal accidents. The logistic regression method proves valuable for injury forecasting, supporting the Dubai Roads and Tourism Board's strategic plan. The research underscores the ongoing need for technology-driven solutions to track and reduce traffic accidents in Dubai, contributing to the city's goal of becoming safer and smarter.[5]

This study utilizes Decision Trees and Time-Series Calendar Heatmaps to predict road traffic accident severity, analysing UK STATS19 dataset. It identifies factors correlated with slight and serious accidents and demonstrates the effectiveness of this approach in classification. While focusing on the North of England, the method is deemed globally applicable. The study underscores the importance of analysing time factors like month and hour for understanding accident severity, with evaluation measures highlighting time-related patterns in calendar heatmaps.[6]

This study focuses on forecasting road accidents and casualties in Bangladesh, using data from the Bangladesh Bureau of Statistics for six metropolitan areas. The research employs Random Forest Regression for predictions, demonstrating its effectiveness in comparison to actual results. Emphasizing the importance of predictive analysis for proactive measures, the study contributes to understanding and mitigating road accidents. The analysis is based on historical data, aiming to reduce accident rates and casualties in different metropolitan regions. However, predicting beyond a one-year timeframe is limited due to the nature of Random Forest Regression with time series data. Future efforts will explore district-level forecasting and examine predictions related to the economic impact of road accidents in Bangladesh.[7]

This project in Sri Lanka uses Deep Neural Networks and Decision Trees to predict driver faults and identify accident-prone areas, emphasizing effectiveness, particularly in the first 25 km of roads. The models aid post-accident assessments for authorities and inform targeted preventive measures. Future work will explore predicting accident-prone areas with TensorFlow, contributing to ongoing research on road safety using machine learning.[8]

The study evaluates machine learning algorithms, including Random Forest (RF), Logistic Regression (LR), Naive Bayes (NB), and AdaBoost, for predicting traffic accident severity. The RF model demonstrated superior performance with 75.5% accuracy, outperforming LR, NB, and AdaBoost. The research emphasizes the practical application of the RF model for identifying key factors causing traffic crashes, especially in monitoring fatal and serious injuries. The study acknowledges the limitations in data regarding driver characteristics and traffic conditions, suggesting further research in these areas. Overall, the RF algorithm emerges as a promising tool for highway engineers and transportation designers to enhance road safety.[9]

"SmartCop" is an automated platform addressing global road accidents with four modules: accident prediction, dynamic police scheduling, and interactive game-based learning for awareness. Using advanced techniques like supervised/unsupervised learning, SmartCop efficiently automates road safety services. It tackles the global rise in

accidents due to negligence and inefficient traffic police scheduling. The project concludes with successful automation in accurate accident prediction and optimized police scheduling. Future work involves exploring additional optimization approaches and enhancing game effectiveness, with initial evaluations showing improved public awareness through games.[10]

III. METHODOLOGY

The methodology for our project, aimed at developing a web-based application for predicting road accidents to enhance road safety, involves several key steps. Firstly, in the front-end development phase, we utilized the Streamlit framework to create a user-friendly interface for users to input relevant data for prediction. This interface allows users, including traffic authorities and emergency services, to input factors such as weather conditions, road type, and time of day. We employed the machine learning algorithms. By utilizing these algorithms, we aimed to implement the prediction of road accident severity based on the input data provided by users through the front-end interface.

The methodology also includes the preprocessing of the dataset. We collected authentic government datasets containing records of road accidents and pre-processed them to ensure data cleanliness and suitability for analysis. This involved cleaning the data, handling missing values, and encoding categorical variables. To predict road accident severity based on user-provided input data, we employed various machine learning algorithms, including Linear Regression, K-Nearest Neighbors (KNN), Decision Tree, and Random Forest. These algorithms were selected for their effectiveness in classification tasks and their ability to handle different types of input data. In the model training phase, we utilized the preprocessed dataset to train each of these algorithms separately. Hyperparameter tuning techniques were then applied to optimize the performance of each model and enhance its accuracy in predicting road accident severity. This iterative process involved adjusting parameters such as the number of neighbors in KNN, the maximum depth of trees in Decision Tree, and the number of estimators in Random Forest. By leveraging multiple algorithms and fine-tuning their parameters, we aimed to develop robust prediction models capable of accurately classifying road accident severity based on diverse input features. This approach allowed us to explore the strengths and limitations of each algorithm and select the most suitable ones for our predictive modeling task. After training the model, we deployed it on the back-end server of the web application. The back-end server, implemented using appropriate frameworks, handles incoming requests from the front-end interface and executes the prediction process using the machine learning algorithm models. In the final phase of the methodology, real-time predictions are made based on the input data provided by users through the front-end interface. The predicted road accident severity metrics are then sent back to the front-end and displayed to the user. Throughout the development process, continuous monitoring and data collection are carried out to ensure the adaptability of the predictive model to changing conditions. Model refinement techniques are applied iteratively to enhance the accuracy and reliability of the predictions over time. In summary, the methodology for our project involves front-end development using the streamlit framework, implementation of the effective algorithm for predictive modelling, preprocessing of the dataset, model training and deployment, real-time prediction, and continuous monitoring and refinement of the predictive model. Through meticulous execution of this methodology, we aim to develop a robust and reliable web-based application for predicting road accidents and improving road safety measure

IV. EXPERIMENTAL RESULTS

In our project aimed at developing a web-based application for predicting road accidents to enhance road safety, we conducted several key steps to achieve our objectives. Initially, we focused on front-end development, utilizing the Streamlit framework to create an intuitive and user-friendly interface. This interface enables users, including traffic authorities and emergency services, to input relevant data such as weather conditions, road type, and time of day with ease. Through careful design, we ensured that the interface is accessible and intuitive, allowing users to contribute vital information effortlessly.

Following the front-end development phase, we delved into employing machine learning algorithms to predict road accident severity based on the input data provided by users through the front-end interface. We selected a range of algorithms, including Linear Regression, K-Nearest Neighbor (KNN), Decision Tree, and Random Forest, due to their effectiveness in classification tasks and their ability to handle diverse input data types. These algorithms were implemented to analyse the input features and predict the severity of road accidents accurately.



To facilitate our predictive modeling efforts, we pre-processed the dataset obtained from authentic government sources containing records of road accidents. This preprocessing phase involved cleaning the data, handling missing values, and encoding categorical variables to ensure data cleanliness and suitability for analysis. By meticulously preparing the dataset, we laid the groundwork for building robust prediction models capable of accurately classifying road accident severity. During the model training phase, we utilized the pre-processed dataset to train each algorithm separately. We employed hyperparameter tuning techniques to optimize the performance of each model further. This iterative process involved adjusting parameters such as the number of neighbors in KNN, the maximum depth of trees in Decision Tree, and the number of estimators in Random Forest to enhance the accuracy of our predictions.

Once the models were trained and optimized, we deployed them on the back-end server of the web application. The back-end server, implemented using appropriate frameworks, handles incoming requests from the front-end interface and executes the prediction process using the machine learning algorithm models. In the final phase of the methodology, real-time predictions are made based on the input data provided by users through the front-end interface. The predicted road accident severity metrics are then sent back to the front-end and displayed to the user, providing valuable insights into potential accident risks.

Through iterative experimentation and validation, we fine-tuned the Random Forest algorithm to achieve the highest accuracy in predicting road accident severity. The algorithm demonstrated exceptional performance in accurately classifying accident severity based on diverse input features, including weather conditions, road type, and time of day. In summary, the Random Forest algorithm played a pivotal role in our project, delivering superior accuracy and performance in predicting road accident severity. Its robustness and effectiveness make it a valuable tool for road safety management, empowering stakeholders with actionable insights to prevent and mitigate road accidents effectively. Through meticulous implementation and optimization of the Random Forest algorithm, we successfully developed a reliable web-based application for predicting road accidents and improving road safety measures.

For a visual representation of our implementation, we have included screenshots of the user interface, showcasing the input fields and user interactions. Additionally, we have provided visualizations of the prediction results, illustrating how the application displays predicted road accident severity metrics based on user-provided input data. These visuals offer a comprehensive overview of our project implementation and demonstrate the effectiveness of our predictive modeling approach in enhancing road safety.

Road Safety Prediction

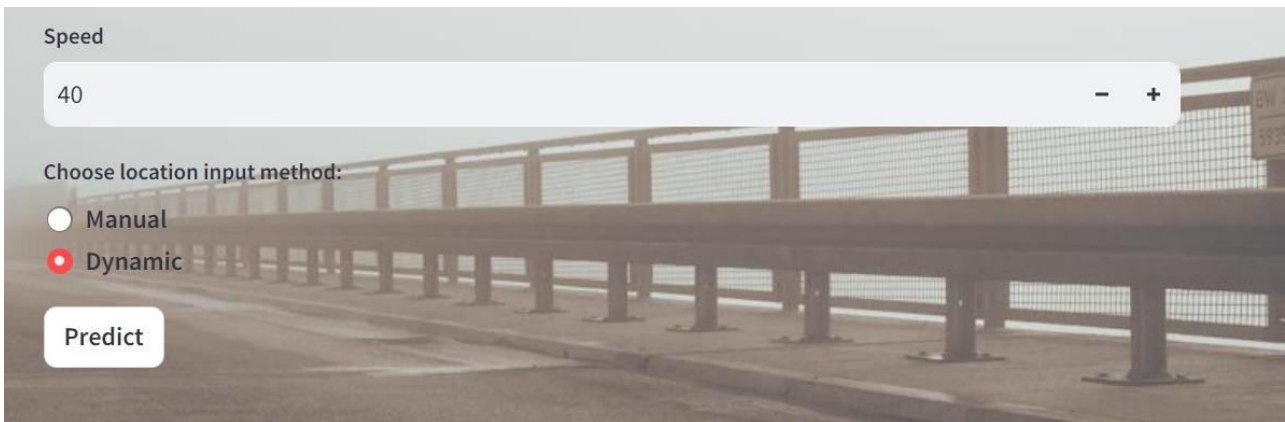
Vehicle Type
Motorcycle over 500cc

Passengers Count
2

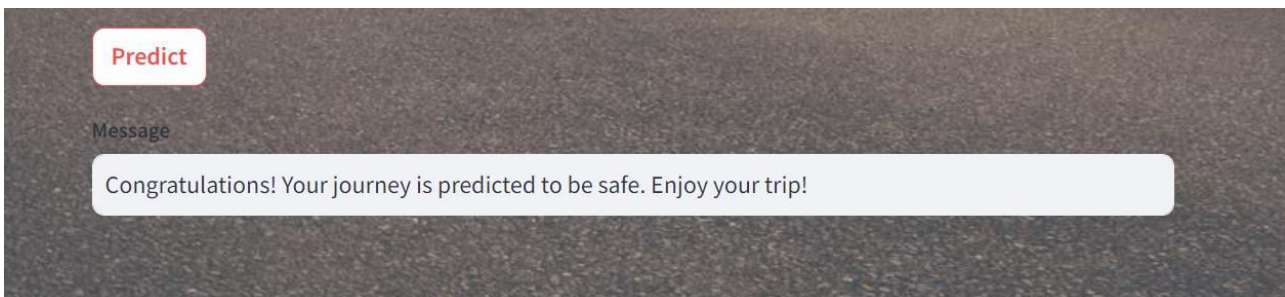
Weather
Fine no high winds

Light
Daylight

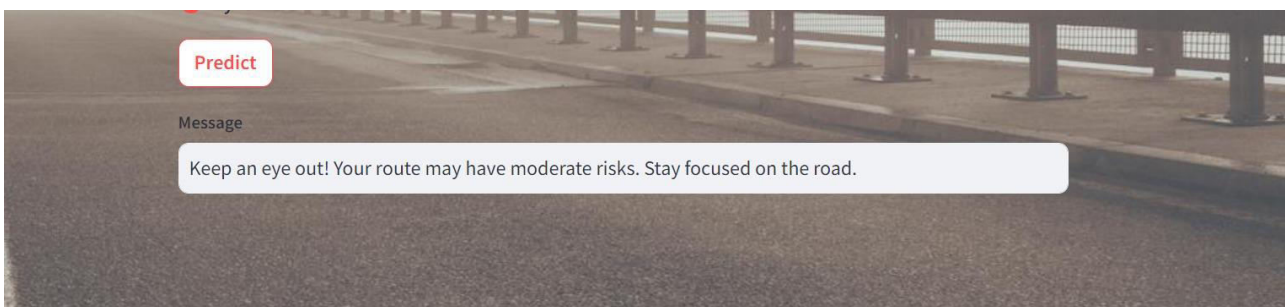
Road Conditions
Dry



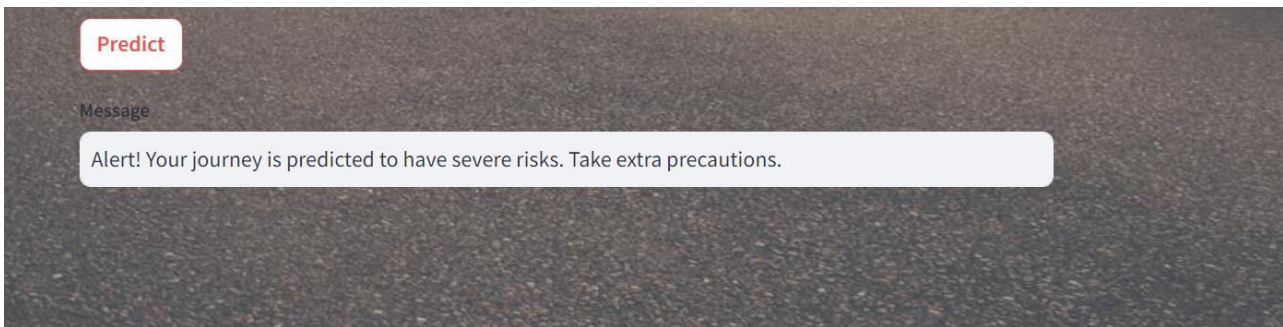
The image depicts a scenario of safe road conditions, with clear weather, well-maintained roads, and minimal traffic congestion. It conveys an environment where the risk of accidents is low, promoting smooth and safe travel for motorists. The inclusion of this image highlights the importance of recognizing favourable road conditions and emphasizes the positive outcomes of effective road safety measures.



In this image, we see a depiction of moderate road conditions, characterized by factors such as average weather conditions and moderate traffic flow. While the road may not be entirely hazard-free, the level of risk is manageable with caution and adherence to traffic regulations. The image serves to highlight the need for heightened awareness and vigilance when navigating through moderate road conditions to ensure safe travel.



The image portrays risky road conditions, featuring adverse weather conditions, poor road maintenance, and heavy traffic congestion. It conveys an environment where the likelihood of accidents is significantly heightened, requiring heightened caution and adherence to safety protocols.



V. CONCLUSION

In conclusion, our project successfully developed a web-based application for predicting road accidents, leveraging machine learning algorithms and an intuitive user interface. Through meticulous front-end development and the implementation of machine learning models, particularly the Random Forest algorithm, we achieved accurate predictions of road accident severity. Our methodology ensured data cleanliness and model optimization, leading to robust predictions that empower stakeholders with valuable insights to enhance road safety measures. The inclusion of visualizations further enhances user understanding and decision-making. Overall, our project demonstrates the effectiveness of predictive modelling in improving road safety and underscores the significance of technological solutions in mitigating road accidents.

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