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SafePathAI: An Intelligent Safety Heatmap and Secure Route Recommendation System using AI and Web Development

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Abstract:

Safety is one of the most significant concerns that individuals may experience while travelling, particularly within city areas due to the risks and incidents that can arise. It is common for navigation apps to provide the shortest or fastest route in terms of distance or time. However, in regards to SafePath AI system, the concept was thought of to be an efficient guide in which safer paths can be taken while travelling.The system will be designed to gather and process all relevant data concerning safety such as crime, amount of accidents, light density, congestion, and others reported or collected by users. The data would then be processed to depict the safety percentage and will be colour-coded to show the level of safety. Multiple routes will then be provided from the pick-up to destination location for the user to choose from in which certain routes were chosen based on the safety level they provide.Safe path is anticipated to become a successful system in providing safety to individuals as they travel from one place to another. Through its incorporation of Artificial Intelligence, route-finding, data processing, and web application development, SafePath is expected to be an alternative for travellers to ensure a safe and reliable travel experience. Ultimately, SafePath AI system, through certain aspects and features being utilised, will become a guide for all road users to make it easier for them to get to their desired destination.The system recommends multiple routes and provides the best possible path according to the safety and traveler's choice. The system has been designed using Artificial Intelligence, data analytics, and web technologies to ensure the safety of the traveler and the current scenario of different locations.

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I. INTRODUCTION

With the rapid growth of the cities and the rise in population, it has become essential to ensure safe travel. The majority of the users opt for digital sources for getting directions. However, the problem with such systems is that they prioritize shortening the distance or saving time, whereas safety should be the priority. Such navigation devices do not incorporate safety aspects like crime-jail areas, dimly or unsafe lit locations, and other hazardous places.

The recent advances in technology open new doors for innovation and improvements in various fields of human activity. Artificial Intelligence is a sphere of technology that has the potential to transform the existing systems and make them highly efficient and accurate.

It was analyzing and interpreting the data related to the crime rate users' feedback, topography, and other factors to come up with an efficient and reliable safe path.

The proposed system, SafePath AI, will address the problem of existing navigation systems not considering the safety aspects while providing directions to the users. It will gather relevant data to build a safe path algorithm that will be utilized for identifying the safest route between the source and the destination. The system will offer a safety heatmap that will highlight the unsafe and safe zones. The SafePath AI will rely on artificial intelligence, routing techniques, and web technologies to offer better performance. Safe path recommendation systems will become essential as the world continues to grow and develop at a rapid pace

Human beings are dependent on transportation systems for a wide range of activities and purposes. They use the various modes of transit to get to their places of work, education, and other purposes. Such systems have become more advanced and efficient with the introduction of digital technologies. However, the reliance on such systems is compromised as the majority of them do not consider or prioritize safety measures while providing directions to the users. It is essential to consider the safety aspects of travel, especially when in unfamiliar territory or places.

The world continues to grow and densify, the aspect of security has become a significant concern in most urban centers. People who travel through these areas are exposed to high risk, particularly when walking alone or even at night. Most navigation systems do not offer such features that can alert the users on time about the possible risks or dangers they could encounter. Therefore, it is essential to develop a safe path recommendation system that as offers more reliable and safe routes rather than the short and time-saving ones. With AI, Machine Learning, and Data Analytics, it has become possible to come up with better and safer navigation systems.

Furthermore, SafePath AI will be beneficial for women, students, tourists, and people going to work because it provides location and safety insights, and it recommends smart destinations based on route safety analysis. It will help them find the safe paths before arriving at their destination. It will be possible by utilizing route safety insights, route ranking system, and the application of AI to predict the safety of a route.

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II.RELATED WORK

The conducted literature survey demonstrated that recent studies significantly improved the road safety, accident prediction, crime-aware navigation, women safety, and intelligent route recommendation systems based on Artificial Intelligence and Machine Learning methods. However, most of the solutions address separately particular safety problems, crime prediction, telematics data mining, or emergency response, while fewer studies attempt to combine several factors influencing transportation safety. According to the reviewed articles, it was found that the majority of the tested machine learning algorithms demonstrate a good prediction performance level for various safety-related outcomes, while the system's ability to perform real-time safety analysis and assess the overall safety level of a specific road section is limited. Thus, considering the survey results, the SafePath AI solution introduces the advanced navigation model that estimates the road safety level based on crime rate, accident rate, traffic density, population

density, environment-related factors, zone pressure index, and time-based conditions.

Chai et al [1] in 2024 conducted a comprehensive survey on machine learning techniques for road accident prediction using non-visual data. The review analyzed 95 research papers collected from major scientific databases. The study compared machine learning, deep learning, statistical, ensemble, and hybrid approaches, highlighting their strengths, limitations, and future research directions..The study found that ensemble and deep learning techniques performed better overall, but also emphasized the need for high-quality data, interpretable models, and real-time prediction systems.

Berhanu et al. [2] in 2024 proposed a road traffic accident prediction framework integrated with spatial network analysis for safer route planning. The research used historical accident data (2014–2019) and GIS-based road network data from Addis Ababa. A Random Forest model combined with GIS spatial analysis was employed to identify accident-prone areas and recommend safer routes. The proposed framework successfully identified accident-prone locations and improved the accuracy of recommending safer travel routes.

Tei et al. [3] in 2024 presented a safe vehicle routing system that balances travel efficiency and road safety using telematics information. The study utilized telematics data, road network data, driver information, delivery locations, and estimated road risk values. K-Means clustering and a Genetic Algorithm (GA) were used to optimize safer delivery routes. The system mainly depends on accurate telematics and road risk information, so missing or incorrect data may reduce the effectiveness of the recommended safe delivery routes.The routing system generated safer delivery routes with lower risk while keeping travel time efficient.

Agrawal et al. [4] in 2024 have proposed AI-based women safety system which can classify the safe and unsafe region and create safety heatmaps based on the data. The research study has used crime against women dataset, police personnel dataset, demographics dataset, literacy dataset and infrastructure dataset from data.gov.in as the main datasets. The researchers have used K-Means clustering, GMM, PCA and correlation analysis for classifying the safe and unsafe regions. The system effectively identified unsafe areas and produced useful safety heatmaps to support safer travel decisions.

Thilagavathi et al [5] in 2025 proposed an explainable AI framework for transport logistics that predicts road accident riskand recommends safer routes. The system collected data from Google Maps, OpenStreetMap, OpenWeatherMap, TomTom APIs, and synthetic crime-risk data. Decision Tree, Random Forest, Gradient

Boosting, and Deep Neural Networks (DNN) were evaluated, with DNN providing the best performance. The system relies on data collected from multiple sources, so inaccurate or outdated information from these sources may affect the accuracy of risk prediction

Meivel et al. [6] in 2025 have proposed IoT-based wearable system for women safety which can detect emergency situations and inform the guardian and police about the situation. The research study has used GPS, heartbeat sensor data, body temperature data, accelerometers data and camera data for detecting emergency situations. The system has used rule-based emergency detection system along with GPS, GSM and LoRaWAN modules instead of ML algorithms. The wearable safety system detected emergency situations in real time and quickly sent location-based alerts to guardians and police.

Vignesh et al. [7] in 2025 have proposed crime prediction model for improving accuracy of the prediction process by considering time lag of submission of crime reports. The research study has used USA government dataset of 2020-present as the main dataset. The researchers have used Deep Learning, XGBoost, KNN models for making prediction about occurrence of crime. Among the models, XGBoost model has shown better performance in terms of prediction accuracy.

Kollu et al. [8] in 2025 have proposed hybrid framework for crime aware route optimization by using classification and clustering techniques. The research study has used UK police dataset and open route service route data as the main datasets. The researchers have used K-Means clustering and Random Forest classification for hotspot analysis and route optimization task respectively. The system mainly depends on past crime data and may not accurately respond to real-time changes in crime patterns or road conditions, which can affect the reliability of route recommendations

Atterkar et al. [9] in 2025 have proposed AI-based women safe route navigation system for detecting hotspots and

suggesting safe route for women. The research study has used Pune Police crime dataset of 2018-2023 as the main dataset. For hotspot analysis task, the researchers have used K-Means clustering, XGBoost and Random Forest classifier. The system mainly uses past crime data for prediction, so it may not always handle sudden changes in crime patterns or real-time safety conditions effectively.The proposed system effectively identified crime hotspots and recommended safer routes, with XGBoost and Random Forest achieving strong prediction performance.

Yashodha et al. [10] in 2025 have proposed smart city navigation system for suggesting safe route by using crime datasets, street light information and GIS analysis. The research study has used openstreetmap road data, crime dataset, street light data, road data and Bengaluru road data. The study has used random forest, A pathfinding algorithm and GIS based spatial analysis for suggesting safe routes. The system depends on the quality and availability of existing crime and streetlight data, so outdated or incomplete information may reduce the accuracy of the recommended safe routes.

Singh et al. [11] in 2025 have proposed women safety platform for making prediction about safe route with assistance of crime information and emergency service. For the prediction task, the researchers have used historical crime dataset, location based crime dataset, GPS information and user location. The study has compared the performance of various machine learning classifiers for making prediction about safe route and random forest classifier has shown better performance.The system relies heavily on historical crime and location data, so changes in real-time situations or missing information may affect the accuracy of the recommended safe routes

Kudale et al. [12] in 2026 have proposed real-time smart path recommendation system for recommending safe path by considering historical accident datasets and GPS information. The research study has used historical accident dataset, openstreetmap road data, GPS location and Bengaluru Road data. The modified risk aware A algorithm and machine learning based risk prediction model have been used for recommending safe route with SOS services. The system depends on accurate and updated accident and road information, so incomplete data or sudden changes in road conditions may affect the reliability of the recommended safe paths.

III. PROPOSED SYSTEM

Fig 3.1 outlines the proposed system, SafePath AI, is a machine learning-based route recommendation tool that aims to improve travel safety by examining various risk factors. Unlike traditional navigation systems that mainly focus on distance and travel time, SafePath AI looks at the safety of different routes before suggesting them to users. The goal is to help travelers make informed choices by identifying safer paths and reducing exposure to potential risks.

SafePath AI gathers and combines safety information from several sources, such as crime data, accident records, traffic conditions, population density, environmental factors, and time-related risk indicators. The collected information is processed and analyzed using machine learning methods to find patterns linked to safe and unsafe road segments. This allows the system to predict the safety level of different routes under different conditions.

From the analyzed data, the system creates a safety score for each road segment and calculates an overall safety score for complete travel routes. These scores help evaluate and compare different route options. The route with the highest safety score is recommended to the user while also considering travel efficiency to find a practical balance between safety and convenience.

The proposed system includes an interactive map-based navigation platform that enables users to see route safety information through safety indicators and route comparisons**.** By presenting safety-focused navigation suggestions in an easy-to-understand way, SafePath AI offers a more secure travel experience, which is especially beneficial for daily commuters, travelers, and concerned about safety.

Fig 3.1 The proposed system

IV.METHODOLOGY

Fig : 4.1 Outlines SafePath AI helps users travel more safely by identifying and recommending the safest route available. By considering factors such as crime rates, accidents, traffic conditions, and environmental risks, the system guides users through safer paths while also ensuring reasonable travel time and distance.

User Input:

This represents the information provided by the user to the system. The user provides information such as source, destination or provide feedback about the unsafe locations to the system. This acts as the input to the system.

Web Interface (UI):

The system runs on a web interface which allows the user to enter the source and destination and view the results such as directions and safety heatmap conveniently.

API Communication:

The API is the link between the front end and the backend of the system. Once the user provides input via the web interface, the API takes this information and processes it on the server and provides the output back to the user via the web interface.

Data Collection & Storage:

The system gathers safety-related data from multiple sources such as user reports, historical records, and location data. This information is stored in a database and used for analysis.

Preprocessing: Module:

Once the data is collected, it is preprocessed to remove any inconsistencies and missing values in the data thus making it easier for the machine learning algorithm to analyse the data and predict the results accurately.

AI Safety Analysis:

This module represents how the system uses Artificial Intelligence and Machine Learning to predict the safety scores of different locations and determine safe and unsafe zones.

Route Generation Module:

This module represents the route finding algorithms such as Dijkstra's algorithm or A algorithm which help the system determine how many possible routes exist between the given source and destination.

Safety Heatmap Generation:

This is the module that creates a safety heatmap using the safety scores predicted by the AI Safety Analysis module.

Decision Making:

The possible routes and selects the route which provides maximum safety to the user.

Output Display:

The system then displays the most safe and convenient route along with the safety heatmap to the user on the web interface as an output.

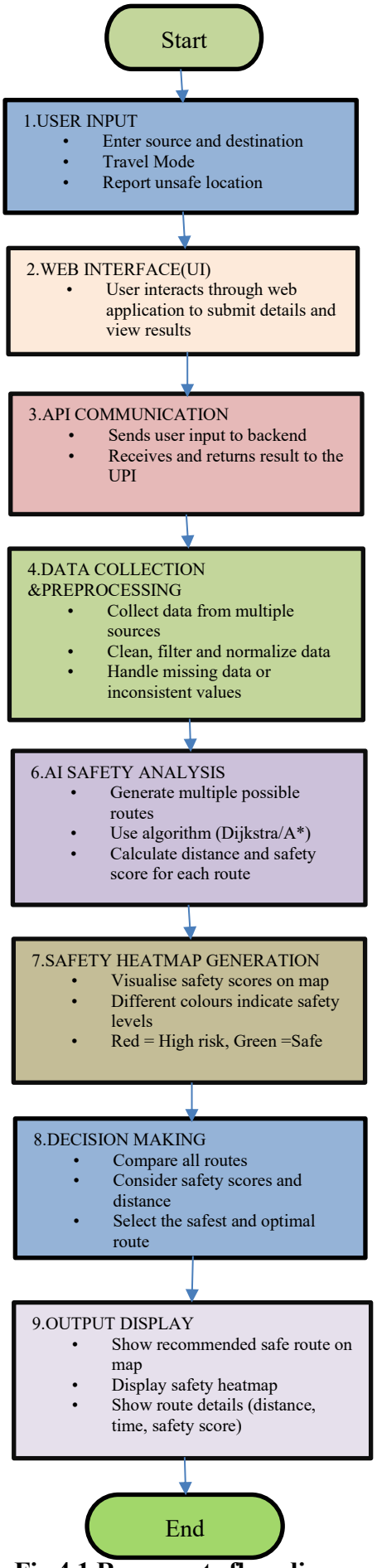

Fig 4.1 Represents flow diagram

V. SYSTEM FEATURES

1. Safety-Aware Route Recommendation

Recommends the safest route between source and destination.

Considers safety in addition to distance and travel time.

2. Machine Learning-Based Safety Prediction

Uses the Extra Trees Regressor algorithm to predict route safety scores.

Evaluates routes based on multiple safety-related factors.

3. Multi-Factor Risk Assessment

Considers crime rate, accident rate, traffic density, population density, environmental factors, zone pressure index, and time-risk factors.

4. Multiple Route Analysis

Analyzes multiple route alternatives generated by Google Maps.

Compares and ranks routes according to predicted safety levels.

5. Safety Score Generation

Generates a quantitative safety score for each route.

Helps users make informed travel decisions.

6. Interactive Map Visualization

Displays source, destination, and recommended routes on an interactive map.

Provides route details such as safety score, distance, and travel duration.

7. User-Friendly Interface

Simple web-based interface for entering locations and viewing route recommendations.

VI. EXPECTED RESULTS AND OUTCOMES

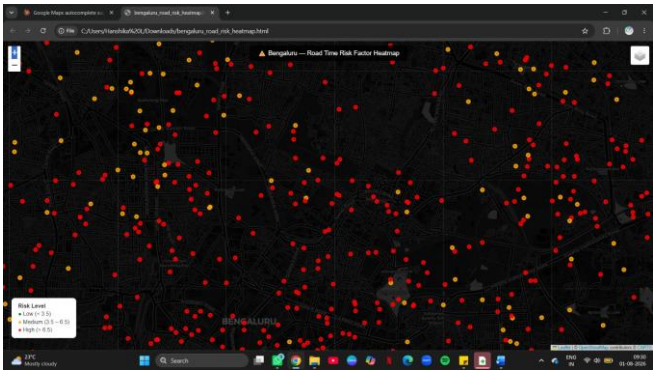

Fig 8.1 SafePath AI Risk Heatmap Visualization

The Fig 8.1 outlines the SafePath AI system was successfully developed and tested using various safety parameters such as crime rate, accident rate, traffic density, population density, environmental factors, zone pressure index, and time-risk factors. All these parameters were combined into a single dataset to predict the safety scores of various road segments in Bengaluru.

The Extra Trees Regressor was used to predict the safety scores of the routes. The algorithm was trained using the relationship between the various safety parameters and the historical risk patterns in order to predict the safety scores of different road segments. This algorithm was preferred because of its ability to handle multiple variables, reduce overfitting, and capture nonlinear relationships.

The Google Maps Directions API was used to generate multiple routes between the given destination and source. The distance, time, and coordinates of the different routes were extracted. Unlike the standard route recommendation systems, the safest routes were recommended based on the predicted safety scores of the different routes between the given destination and source.

The Nearest Road Matching Method was used to match the coordinates of the routes generated using Google Maps Directions API and the available safety data of different road segments. This helped in generating safety attributes of different road segments based on their traffic density, accident rate, and crime rate. The matched route coordinates were then used to generate the safest route between the given destination and source.

The results of the experiment were finally visualized using a road risk heatmap. The heatmap showed that the routes with high-risk scores were majorly concentrated in regions with high crime rates, accident rates, and traffic density. On the other hand, the routes with low-risk scores were mainly located in the regions with low traffic density, accident rates, and crime rates. The heatmap was used to recommend the safest routes between the given destination and source.

It is evident from the experiment that using a machine learning model to predict the safety scores of different routes and using the results to generate the safest route is more efficient than the standard route recommendation systems. This is because the Extra Trees Regressor, Google Maps Directions API, and the Nearest Road Matching Method were efficient in predicting the safety scores of different road segments, generating multiple routes between the given destination and source, and recommending the safest route based on the predicted safety scores, respectively.

So, the SafePath AI system was able to predict the safety scores of different routes, generate safety scores heatmaps, and recommend the safest routes between the given destination and source. The proposed solution is efficient in generating route safety scores and recommending the safest routes based on the generated scores.

VII. FUTURE SCOPE

1. Real-Time Data Integration

Incorporate live traffic updates, accident reports, and crime alerts for dynamic route recommendations.

2. Mobile Application Development

Develop Android and iOS applications for wider accessibility and real-time navigation support.

3. Emergency Assistance Features

Integrate SOS alerts, emergency contacts, and nearby police station or hospital information.

4. Advanced AI Models

Explore deep learning and hybrid machine learning models to improve prediction accuracy.

5. Expansion to Multiple Cities

Extend the system beyond Bengaluru to support multiple cities and regions.

6. Personalized Safety Recommendations

Provide customized route recommendations based on user preferences, travel history, and risk tolerance.

7. IoT and Smart City Integration

Integrate with smart city infrastructure, surveillance systems, and IoT sensors for enhanced safety monitoring.

8. Explainable AI Support

Provide explanations for route recommendations to improve transparency and user trust.

VIII. CONCLUSION

It was proposed to develop SafePath AI, which would offer a safe and intelligent route recommendation system that accounts for safety aspects. The system is different from existing navigation systems because, in addition to the distance and travel time, it considers crime, accident rate, traffic, population density, environment, zone pressure index, and time-risk factor. The heat map helps the user visualize the safest and most dangerous areas and avoid dangerous routes. The experiments prove that SafePath AI can predict the safety of the route and help users make the right choice when deciding which road to take. In summary, the proposed route recommendation system is helpful in predicting the route safety and informing the users about the safest way to accomplish their travel plans. The system offers an advanced visualization method to represent the safety of different road segments, which increases situational awareness. SafePath AI would help commuters make safer decisions and reduce overall exposure to danger while providing a convenient alternative to the existing route recommendation systems. In the future, it would be possible to add additional features to SafePath AI, such as real-time crime and accident data, user feedback, and mobile application version.

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