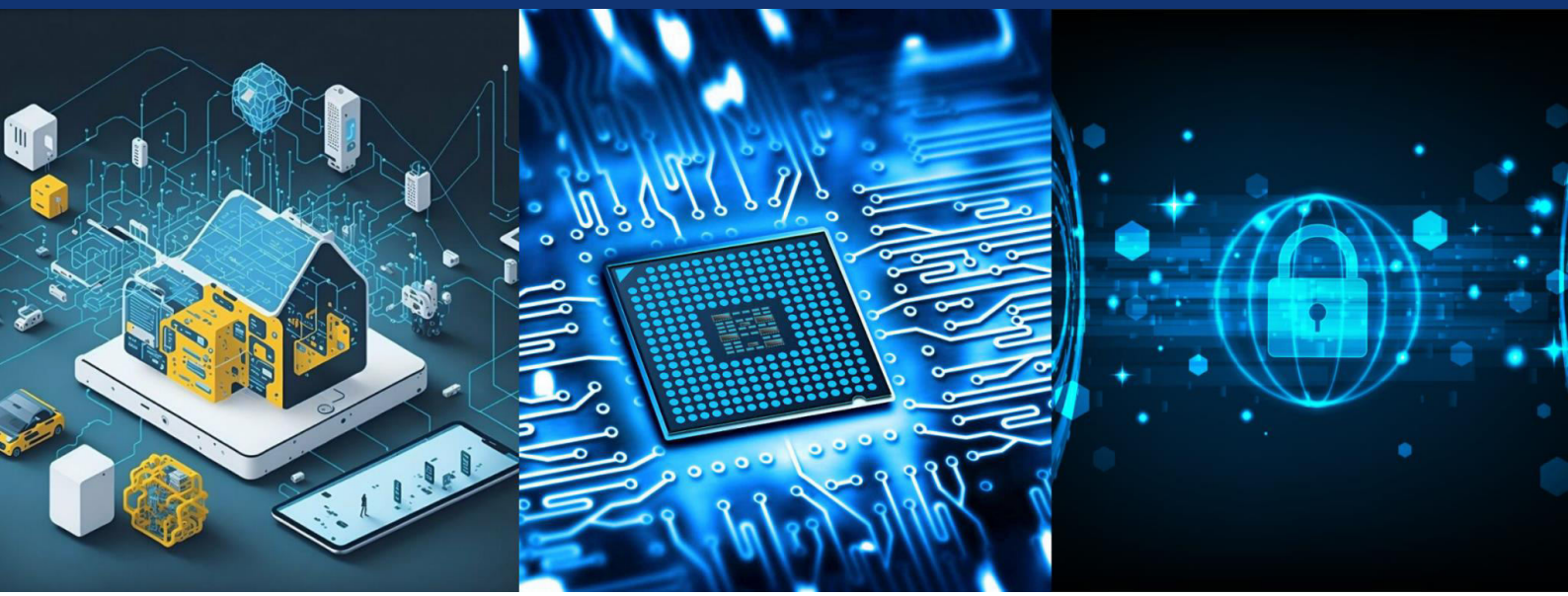
IJIRCCE

ISSN(O): 2320-9801

ISSN(P): 2320-9798



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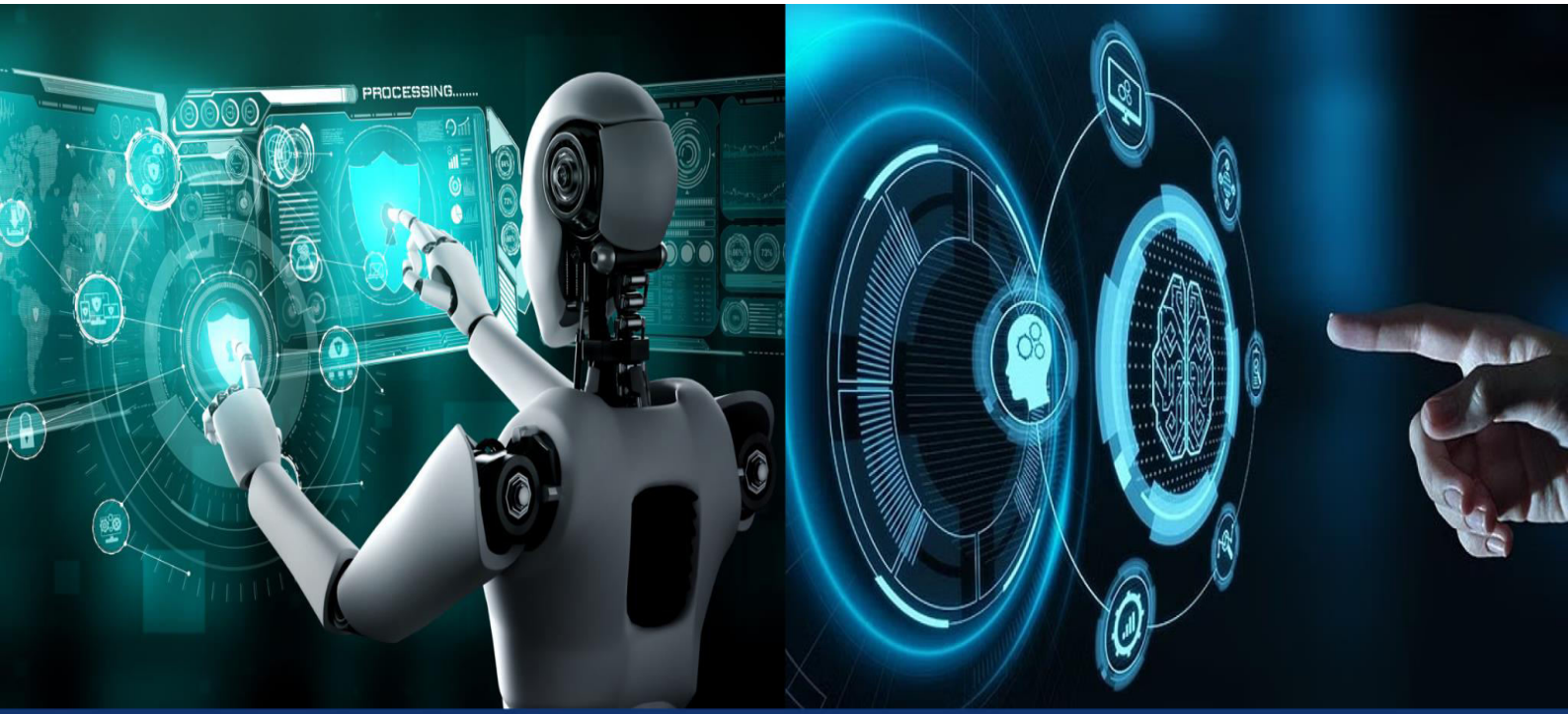

Impact Factor: 9.927

Volume 14, Issue 7, July 2026

© 2026 IJIRCCE | Volume 14, Issue 7, July 2026 DOI: 10.15680/IJIRCCE.2026.1407011

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Black Spot Detection using Machine Learning (GPS)

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ABSTRACT: Road accidents remain one of the leading causes of injuries and fatalities worldwide. Many accidents occur repeatedly at specific road locations known as accident black spots due to poor road conditions, traffic congestion, sharp curves, or inadequate infrastructure. This project proposes a **Black Spot Detection System using Machine Learning and GPS** to identify accident-prone locations by analyzing historical accident data, GPS coordinates, traffic density, weather conditions, and road characteristics. Machine learning algorithms are used to detect patterns in accident occurrences and classify high-risk areas. GPS technology enables accurate geographical mapping of accident locations, allowing authorities to visualize black spots on digital maps. The proposed system helps government agencies, traffic police, and road safety departments prioritize road improvements and implement preventive measures. By providing real-time insights and predictive analysis, the system contributes to reducing accidents, improving traffic management, and enhancing overall road safety.

KEYWORDS: Black Spot Detection, Machine Learning, Global Positioning System (GPS), Road Accident Analysis, Accident Prediction, Traffic Safety, Geographical Information System (GIS), Data Mining, Predictive Analytics, Road Safety Management.

I. INTRODUCTION

Road transportation is one of the most widely used modes of travel, but it also contributes significantly to traffic accidents. Every year, thousands of people lose their lives due to road crashes caused by speeding, poor road design, weather conditions, and driver negligence. Identifying accident-prone areas manually is time-consuming and often inaccurate.

With advancements in **Machine Learning (ML), Global Positioning System (GPS), Geographic Information Systems (GIS), and data analytics**, accident data can be analyzed automatically to detect dangerous road segments. Machine learning algorithms identify hidden patterns from historical accident records and predict potential accident hotspots.

GPS technology provides precise latitude and longitude coordinates of accident locations, enabling accurate mapping of black spots. The integration of ML and GPS helps traffic authorities monitor road safety, optimize resource allocation, and take preventive actions before accidents occur.

II. LITERATURE REVIEW

several researchers have proposed different approaches for accident black spot detection.

- Traditional methods rely on statistical analysis of historical accident records collected by traffic departments.
- Geographic Information Systems (GIS) have been widely used for mapping accident locations and identifying accident clusters.
- Machine Learning techniques such as Decision Tree, Random Forest, Support Vector Machine (SVM), and K-Nearest Neighbours (KNN) have improved prediction accuracy.
- Deep Learning models have recently been applied to analyze large-scale traffic datasets for accident prediction.

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- GPS-based systems enable precise location tracking and visualization of accident hotspots on digital maps.

Although existing systems provide useful insights, many suffer from limited real-time capability, poor scalability, and dependence on manual data processing. The proposed system overcomes these limitations by integrating GPS data with machine learning algorithms for accurate black spot detection.

III. SYSTEM OVERVIEW

The proposed system collects accident data containing GPS coordinates, accident severity, weather conditions, traffic density, road type, and vehicle information. The data is preprocessed to remove duplicate records, handle missing values, and prepare it for machine learning analysis.

Machine learning algorithms analyze the processed data to identify accident-prone locations (black spots). The detected black spots are visualized on a GPS-based map, enabling users to monitor high-risk areas and support decision-making for road safety.

System Features

- GPS-based accident location tracking
- Machine learning-based black spot detection
- Risk level classification
- GPS map visualization
- Report generation

Implementation Technologies

- **Programming Language:** Python
- **Libraries:** Scikit-learn, Pandas, NumPy
- **Visualization:** Matplotlib, Folium
- **Database:** MySQL / SQLite
- **Development Environment:** Jupyter Notebook, Visual Studio Code

Machine Learning Algorithms

- Random Forest
- Decision Tree
- K-Nearest Neighbours (KNN)
- Support Vector Machine (SVM)

Workflow

1. Collect accident data.
2. Preprocess the dataset.
3. Select important features.
4. Train and evaluate machine learning models.
5. Detect accident black spots.
6. Visualize black spots on a GPS-based map.
7. Generate reports for traffic authorities.

Outcome

The system accurately identifies accident-prone locations and assists traffic authorities in improving road safety through data-driven decision-making.

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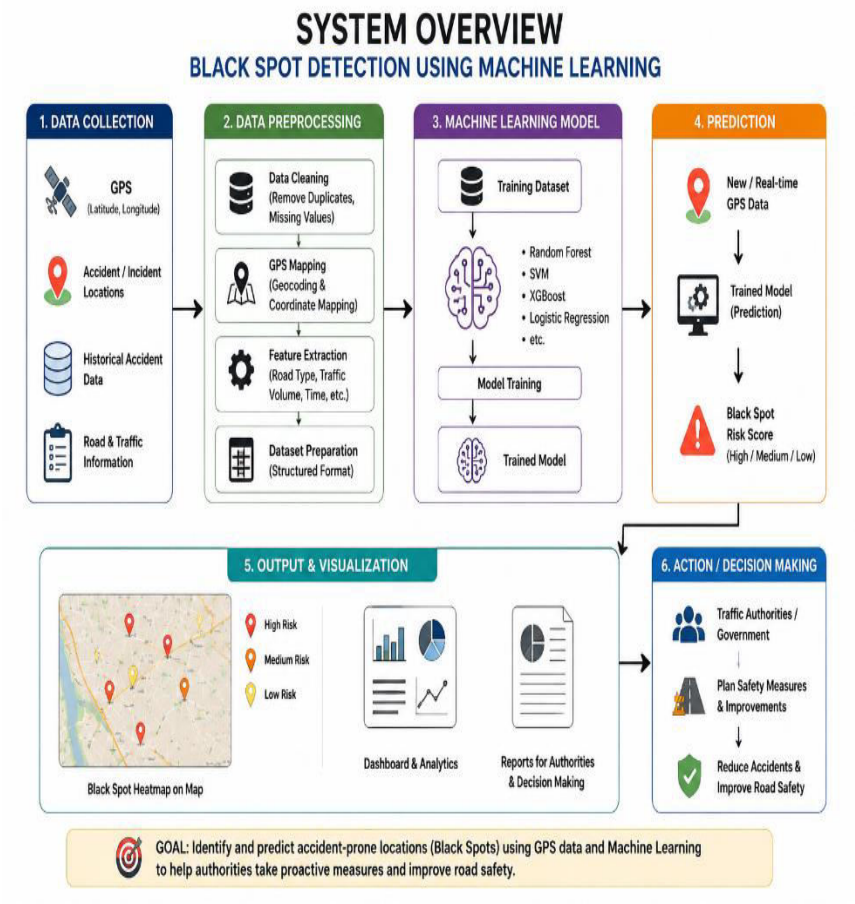

IV. METHODOLOGY

The proposed methodology consists of the following stages:

Step 1: Data Collection

Collect historical accident data, GPS coordinates, traffic information, weather conditions, and road characteristics from reliable sources.

Step 2: Data Preprocessing

Clean the dataset by removing duplicates, handling missing values, normalizing numerical features, and encoding categorical variables.

Step 3: Feature Selection

Select important features such as GPS Latitude, GPS Longitude, Accident Severity, Road Type, Weather Condition, Traffic Density, Vehicle Speed, and Time of Accident.

Step 4: Machine Learning Model Training

Train machine learning models such as Random Forest, Decision Tree, K-Nearest Neighbors (KNN), and Support Vector Machine (SVM).

Step 5: Black Spot Detection

Use the trained model to identify accident-prone (black spot) locations based on learned patterns.

Step 6: GPS Mapping

Display the detected black spots on a GPS-based map using Google Maps or a GIS platform.

Step 7: Performance Evaluation

Evaluate Evaluate the model using Accuracy, Precision, Recall, F1-Score, and the Confusion Matrix.

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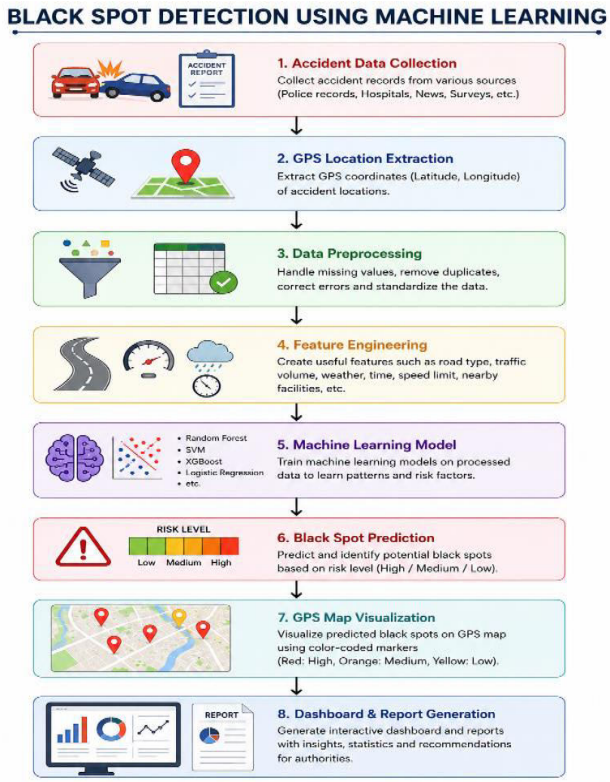
V. SYSTEM ARCHIETCTURE

The system architecture consists of the following components:



VI. MODULES

Module 1: Data Collection Module
Collects accident records from traffic departments, GPS devices, and public datasets.
Module 2: Data Preprocessing Module
Cleans and prepares the dataset by removing inconsistencies and handling missing values.
Module 3: Machine Learning Module
Trains predictive models to identify accident-prone areas using historical accident data.
Module 4: GPS Mapping Module
Plots detected black spots on digital maps using GPS latitude and longitude.
Module 5: Visualization Module
Displays accident density, risk levels, heat maps, and statistical reports through interactive dashboards.
Module 6: Report Generation Module
Generates detailed reports containing black spot locations, accident frequency, and recommendations for road safety improvements.

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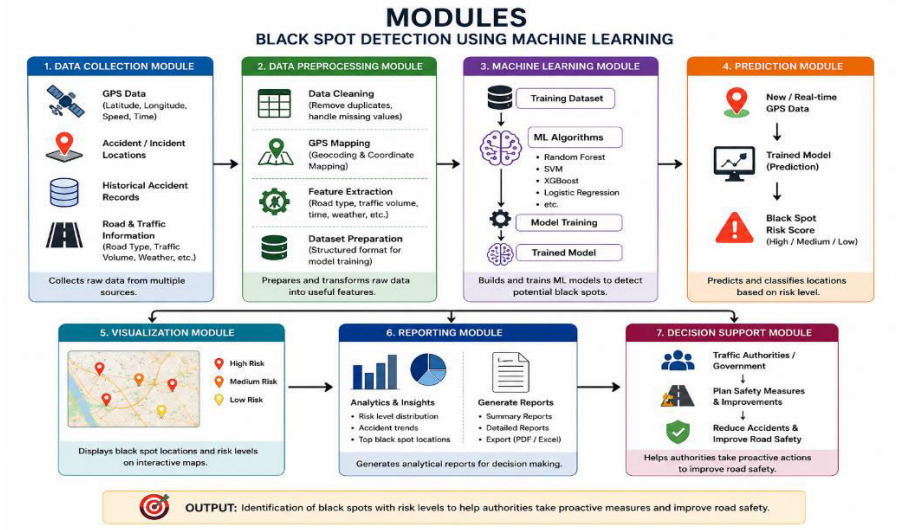

VII. IMPLEMENTATION DETAILS

The proposed system is implemented using Python and popular machine learning libraries.

Programming Language

- Python

Machine Learning Libraries

- Scikit-learn
- Pandas
- NumPy

Visualization Tools

- Matplotlib
- Seaborn
- Folium (GPS Map Visualization)

Database

- MySQL or SQLite

Development Environment

- Jupyter Notebook
- Visual Studio Code

Machine Learning Algorithms

- Random Forest
- Decision Tree
- K-Nearest Neighbours (KNN)
- Support Vector Machine (SVM)

VIII. WORKFLOW

1. Collect accident data with GPS coordinates.
2. Preprocess and clean the dataset.
3. Extract important features.
4. Train and test machine learning models.
5. Predict accident black spots.
6. Display detected locations on a GPS-based map.
7. Generate reports and safety recommendations.

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This implementation enables accurate identification of accident-prone road segments and provides decision support for traffic authorities, helping reduce road accidents and improve public safety.

IX. EXPERIMENTAL DETAILS AND RESULTS

Experimental Details: The proposed Black Spot Detection System was evaluated using historical road accident data containing GPS coordinates, accident severity, weather conditions, traffic density, road type, vehicle speed, and time of occurrence. The dataset was pre-processed by removing duplicate records, handling missing values, normalizing numerical features, and selecting relevant features.

Machine learning models including Random Forest, Decision Tree, K-Nearest Neighbours (KNN), and Support Vector Machine (SVM) were trained and tested using an 80:20 train-test split. The models were evaluated using Accuracy, Precision, Recall, F1-Score, and Confusion Matrix. The detected accident-prone locations were visualized on a GPS-based digital map.

Results: The experimental results showed that the proposed system effectively identified accident-prone locations with high prediction accuracy. Random Forest achieved the best performance among the evaluated models.
The system successfully:

- Detected accident black spots using historical accident data.
- Classified locations into Low, Medium, and High-risk levels.
- Visualized black spots on GPS-based maps.
- Generated reports for traffic authorities.

X. APPLICATIONS

The proposed system has several practical applications in road safety and traffic management, including:

- Identification of accident-prone road locations.
- Smart city traffic management systems.
- Road safety planning by government agencies.
- Highway maintenance and infrastructure improvement.
- Emergency response and ambulance route planning.
- Traffic police surveillance and monitoring.
- Accident risk analysis for transportation departments.
- Integration with Intelligent Transportation Systems (ITS).
- Support for autonomous and connected vehicles.
- Research and analysis of road accident patterns.

XI. LIMITATIONS

Although the proposed system offers significant improvements, it has certain limitations:

- Prediction accuracy depends on the quality and completeness of accident data.
- GPS location errors may affect the accuracy of black spot identification.
- Limited historical data can reduce model performance.
- Weather and traffic conditions may change dynamically, affecting predictions.
- Real-time accident data integration may not always be available.
- Machine learning models require periodic retraining with updated datasets.
- Different geographical regions may require customized models due to varying road conditions.

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XII. FUTURE ENHANCEMENT

The proposed system can be further improved in the following ways:

- Integrate real-time GPS and traffic sensor data for live black spot detection.
- Use Deep Learning algorithms for higher prediction accuracy.
- Incorporate weather forecasting data to improve accident risk prediction.
- Develop a mobile application for drivers to receive real-time accident alerts.
- Integrate Internet of Things (IoT) devices for continuous traffic monitoring.
- Implement cloud-based data storage for large-scale accident datasets.
- Add AI-based route recommendation to avoid accident-prone roads.
- Integrate with Google Maps or other navigation platforms for live navigation assistance.
- Support predictive road maintenance based on accident frequency.
- Develop an early warning system for traffic authorities and emergency services.

XIII. CONCLUSION

The proposed **Black Spot Detection Using Machine Learning (GPS)** system provides an effective approach for identifying accident-prone road locations using historical accident data and GPS coordinates. Machine learning algorithms accurately detect black spots, while GPS-based visualization helps traffic authorities identify high-risk areas and improve road safety.

The system offers faster analysis, reliable prediction, and supports informed decision-making for accident prevention and road maintenance. Overall, the integration of **Machine Learning** and **GPS technology** provides a practical solution for enhancing road safety and reducing road accidents.

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