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Smart Driving Abnormality Detection System Using Machine Learning

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Abstract:
Road traffic accidents remain one of the leading causes of injuries and fatalities worldwide, and a significant portion of these incidents are caused by abnormal driving behaviors such as aggressive acceleration, sudden braking, distracted driving, and fatigue. Recent advancements in machine learning and intelligent transportation systems provide effective solutions for monitoring and analyzing driver behavior in real time. This paper proposes a **Smart Driving Abnormality Detection System using Machine Learning** to identify unsafe driving patterns and enhance road safety. The system collects vehicle and driver-related data such as speed, acceleration, braking patterns, and steering behavior, which are then processed through data preprocessing and feature extraction techniques. Machine learning algorithms are trained to classify driving behavior into normal and abnormal categories. The proposed system aims to detect risky driving actions and generate alerts to assist drivers and monitoring systems. Experimental results demonstrate that machine learning models can effectively analyze driving data and improve the accuracy of abnormal behavior detection. Such intelligent driver monitoring systems can contribute significantly to reducing traffic accidents and supporting the development of advanced driver-assistance systems (ADAS) and smart transportation infrastructure.

Keywords: Smart Driving System, Abnormal Driving Behavior Detection, Machine Learning, Driver Behavior Analysis, Intelligent Transportation Systems, Road Safety, Driver Monitoring System.

INTRODUCTION

Road traffic accidents are a major global concern and are responsible for a large number of deaths and injuries every year. Many of these accidents occur due to abnormal driving behaviors such as overspeeding, sudden braking, harsh acceleration, distracted driving, and driver fatigue. Traditional traffic monitoring systems mainly rely on manual supervision or basic rule-based mechanisms, which are often insufficient to detect unsafe driving patterns in real time.

With the advancement of **machine learning and intelligent transportation systems**, it has become possible to analyze driving data and automatically identify risky driving behavior. Machine learning algorithms can process large volumes of data collected from vehicle sensors such as GPS, accelerometers, and cameras to recognize patterns associated with abnormal driving activities.

The **Smart Driving Abnormality Detection System Using Machine Learning** is designed to monitor driver behavior and detect unsafe driving patterns efficiently. The system collects driving data, performs preprocessing and feature extraction, and applies machine learning models to classify driving behavior as normal or abnormal. By identifying risky behaviors in real time, the system can generate alerts and assist drivers in maintaining safer driving practices.

The main objective of this research is to develop an intelligent system that improves road safety by detecting abnormal driving behavior using machine learning techniques. The proposed system contributes to the development of advanced driver monitoring systems and supports the implementation of smart transportation infrastructure.The **Smart Driving Abnormality Detection System Using Machine Learning** is designed to address these challenges by providing an automated and intelligent solution for monitoring driver behavior. The proposed system collects driving data such as vehicle speed, acceleration, braking intensity, steering angle, and location information. This data is then processed using data preprocessing techniques to remove noise and irrelevant information. Feature extraction methods are applied to identify the most relevant parameters that influence driving behavior.

After preprocessing and feature extraction, machine learning algorithms are used to train models capable of distinguishing between normal and abnormal driving patterns. Algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), and Logistic Regression can be used for classification tasks. These models analyze driving behavior and detect abnormal activities such as harsh braking, sudden acceleration, sharp turns, or erratic vehicle movement. When abnormal behavior is detected, the system can generate alerts or notifications to drivers or monitoring systems, helping to prevent potential accidents.

Another important advantage of using machine learning in driver behavior analysis is the ability to continuously improve system performance. As more driving data becomes available, the models can be retrained and optimized to achieve higher accuracy and reliability. This makes the system suitable for real-world applications such as fleet management, driver safety monitoring, insurance risk analysis, and intelligent transportation systems.

The proposed system also supports the development of **Advanced Driver Assistance Systems (ADAS)** and smart transportation infrastructure. By integrating machine learning-based abnormality detection with modern vehicle technologies, it becomes possible to create safer and more efficient transportation environments. Governments, transportation authorities, and automotive industries are increasingly investing in such technologies to reduce traffic accidents and improve road safety.

I. OBJECTIVES

The primary objective of the **Smart Driving Abnormality Detection System Using Machine Learning** is to design and develop an intelligent system capable of identifying abnormal driving behaviors through advanced data analysis techniques. Road accidents frequently occur due to unsafe driving habits such as overspeeding, aggressive acceleration, sudden braking, sharp turning, distracted driving, and driver fatigue. Detecting these behaviors in real time can help prevent accidents and improve overall road safety. Therefore, the system focuses on using machine learning algorithms to analyze driving patterns and classify them into normal and abnormal categories.Another important objective of this study is to develop a reliable framework for collecting and processing driving data from different sources such as vehicle sensors, GPS modules, accelerometers, and driving datasets. These data sources provide important parameters including vehicle speed, acceleration, braking intensity, steering movement, and location information. The collected data is then processed through data preprocessing techniques to remove noise, handle missing values, and normalize the dataset. Feature extraction methods are applied to identify the most relevant attributes that influence driver behavior and contribute to accurate abnormality detection.

The study also aims to implement machine learning algorithms capable of learning from historical driving data and predicting unsafe driving patterns. Algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), and Logistic Regression can be used to train classification models. These models analyze complex relationships between driving parameters and detect patterns that indicate abnormal behavior. By applying these techniques, the system can automatically identify risky driving activities and generate alerts to assist drivers or monitoring systems.

Another objective is to enhance the efficiency and accuracy of traditional driver monitoring systems. Conventional systems often rely on manual observation or simple rule-based approaches, which may not effectively detect complex driving patterns. Machine learning- based solutions provide a more intelligent and adaptive approach by continuously learning from data and improving their prediction performance. This enables the system to detect abnormal driving behavior more accurately and respond quickly to potential safety risks.

The proposed system also aims to contribute to the development of **Intelligent Transportation Systems (ITS)** and **Advanced Driver Assistance Systems (ADAS)**. By integrating machine learning models with modern vehicle technologies, the system can support real-time driver monitoring and safety analysis. This integration can help transportation authorities, automotive manufacturers, and fleet management companies monitor driver behavior and implement preventive measures to reduce accident rates.

Furthermore, the system aims to provide a scalable and flexible framework that can be applied in various real-world applications such as fleet management, driver safety monitoring, insurance risk assessment, and smart traffic management systems. The ability to analyze large volumes of driving data and detect abnormal patterns makes the system valuable for improving transportation safety and promoting responsible driving behavior.

II. SYSTEM ARCHITECTURE

The system architecture of the Smart Driving Abnormality Detection System using Machine Learning is designed to efficiently collect, process, analyze, and classify driving behavior data in order to detect abnormal driving patterns. Modern intelligent transportation research highlights that a layered architecture improves scalability, data processing efficiency, and real-time monitoring capabilities. The proposed architecture consists of several interconnected modules including data acquisition, data preprocessing, feature extraction, machine learning model training, abnormality detection, and alert generation. Each module performs a specific function in the overall system to ensure accurate detection of unsafe driving behavior.

The first layer of the architecture is the data acquisition module, which is responsible for collecting driving-related data from various sources such as vehicle sensors, GPS devices, accelerometers, cameras, or publicly available driving datasets. These sensors generate important parameters including vehicle speed, acceleration, braking intensity, steering angle, and vehicle location. According to studies in intelligent transportation systems, sensor-based data collection provides valuable real-time information that can be used to analyze driver behavior and vehicle movement patterns.

After data collection, the information is passed to the data preprocessing module, where raw data is cleaned and prepared for further analysis. In practical datasets, noise, missing values, and inconsistent data entries are common issues that can affect the performance of machine learning models. Therefore, preprocessing techniques such as data cleaning, normalization, filtering, and data transformation are applied to improve data quality and reliability. This step ensures that the dataset is suitable for machine learning training and analysis.

The next component in the architecture is the feature extraction and selection module. In this stage, relevant attributes are identified from the preprocessed dataset to represent driver behavior effectively. Features such as speed variation, sudden acceleration, harsh braking, and steering deviations are extracted to capture abnormal driving patterns. Feature selection techniques help reduce computational complexity and improve the accuracy of the machine learning model by focusing only on the most important parameters related to driver behavior.

The processed data is then forwarded to the machine learning model training module, where classification algorithms are applied to learn patterns from historical driving data. Commonly used machine learning algorithms for abnormal behavior detection include Decision Trees, Random Forest, Support Vector Machines (SVM), and Logistic Regression. These algorithms are trained using labeled datasets where driving behaviors are categorized as normal or abnormal. The trained model learns the relationships between input features and driving behavior patterns.

Once the model is trained, it is integrated into the abnormality detection module, which analyzes incoming driving data in real time or batch mode. The trained model evaluates the input parameters and classifies the driving behavior as either normal or abnormal. If the system identifies risky driving actions such as sudden braking, rapid acceleration, or erratic movement, it marks the event as abnormal and triggers the next stage of the system.

The final component of the architecture is the alert and monitoring module. In this stage, alerts or notifications are generated to inform drivers, fleet managers, or monitoring systems about detected abnormal driving behavior. These alerts may be delivered through dashboards, mobile applications, or warning systems inside the vehicle. By providing timely feedback, the system helps drivers correct unsafe behavior and reduce the risk of accidents.

After collecting the data, it is transferred to the data preprocessing module. Raw driving data often contains noise, missing values, duplicate entries, or inconsistent measurements that can negatively affect the performance of machine learning algorithms. Therefore, preprocessing techniques such as data cleaning, normalization, filtering, and transformation are applied to improve the quality of the dataset. This step ensures that the data is structured and suitable for further analysis. Proper preprocessing also enhances the reliability and accuracy of the machine learning model used for abnormality detection.

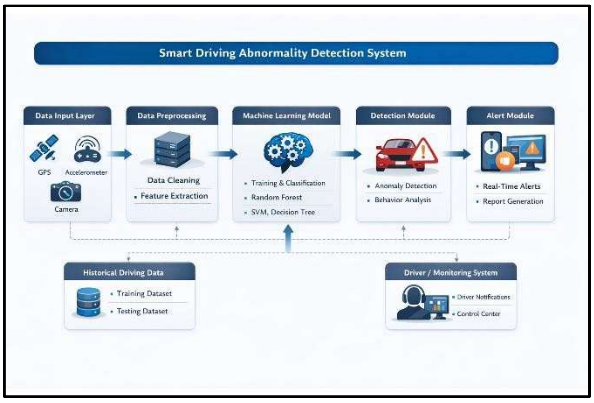

Figure 1. System Architecture Overview

The next stage in the architecture is the **feature extraction and feature selection module**. In this stage, the most relevant attributes related to driving behavior are identified from the preprocessed data. Features such as speed variation, sudden acceleration, harsh braking events, lane deviation patterns, and steering irregularities are extracted to represent driver behavior effectively. Feature selection methods help reduce the dimensionality of the dataset by focusing only on the most significant variables. This not only improves computational efficiency but also enhances the predictive performance of the machine learning models.

Following feature extraction, the processed data is passed to the machine learning model training module. In this module, classification algorithms are used to train models that can recognize patterns associated with normal and abnormal driving behaviors. Algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Logistic Regression are commonly applied in driver behavior analysis studies. These algorithms learn from historical driving data and build predictive models capable of identifying risky driving activities.

Once the training process is completed, the trained model is integrated into the abnormality detection **module**. This module is responsible for analyzing incoming driving data and predicting whether the driving behavior is normal or abnormal. The trained model evaluates the input features and compares them with learned patterns from the training dataset. If the model detects unusual driving activities such as sudden braking, aggressive acceleration, or abnormal steering behavior, the system classifies the event as abnormal. This automated detection process helps identify unsafe driving patterns quickly and accurately.

Another important component of the architecture is the data storage and management module. This module stores historical driving data, trained machine learning models, and system logs in a database or cloud storage environment. Proper data storage ensures that driving records are available for future analysis, model retraining, and system improvements. It also supports scalability by allowing the system to handle large volumes of driving data collected over time.

The final component of the system architecture is the alert and monitoring module. Once abnormal driving behavior is detected, the system generates alerts or warnings to notify drivers, fleet managers, or monitoring authorities. These alerts can be delivered through vehicle dashboard systems, mobile applications, or centralized monitoring platforms. Real-time alerts help drivers become aware of unsafe driving patterns and encourage corrective actions, thereby reducing the likelihood of accidents.

III. LITERATURE REVIEW

Many researchers have investigated the use of machine learning and intelligent transportation technologies to detect abnormal driving behavior and improve road safety. Previous studies have proposed different approaches using vehicle sensors, smartphone data, and deep learning techniques to monitor driver actions and identify unsafe driving patterns.

Several studies focus on using machine learning algorithms to classify driving behavior based on vehicle motion data such as speed, acceleration, braking force, and steering angle. For example, research on abnormal driving behavior detection applied multiple machine learning classifiers such as Logistic Regression, Random Forest, Support Vector Machine (SVM), and Decision Tree to analyze driving patterns. Among these methods, the Random Forest model achieved the highest classification performance with an accuracy of more than 99% when tested on real-world driving datasets. These findings demonstrate that machine learning models are capable of effectively distinguishing between normal, aggressive, and fatigued driving behaviors.

Another study proposed a deep learning– based anomaly detection approach using autoencoders to identify abnormal driving patterns from large naturalistic driving datasets. The model analyzed multiple driving indicators and successfully detected abnormal behaviors such as sudden braking, unsafe acceleration, and irregular vehicle movements. Experimental results showed detection accuracy above 95%, highlighting the effectiveness of deep learning models in identifying complex driving patterns that traditional methods may fail to detect.

Researchers have also explored **semi- supervised machine learning methods** to address the challenge of limited labeled driving data. One study introduced a hierarchical extreme learning machine model capable of detecting abnormal driving behaviors such as rapid lane changes and sudden acceleration using partially labeled datasets. The proposed method achieved very high performance with an accuracy of approximately 99.5%, demonstrating that semi-supervised learning can effectively identify abnormal driving events even when labeled data is limited.

In addition to vehicle sensor data, some studies have used **smartphone sensors** such as accelerometers and gyroscopes to detect abnormal driving behaviors. By collecting motion data from smartphones placed inside vehicles, researchers applied machine learning algorithms such as SVM and K-Nearest Neighbors (KNN) to classify driving patterns. The system was able to detect events like harsh braking, rapid acceleration, and sudden turns, and it generated alerts when abnormal driving behavior was identified. This approach provides a low-cost solution for driver monitoring systems.

Recent research has also explored **hybrid models combining machine learning and deep learning techniques** to improve detection performance. These hybrid frameworks analyze both structured vehicle data and image-based information from cameras to detect driver distractions and unsafe behavior more accurately. By integrating multiple data sources and algorithms, these systems can achieve higher reliability and improved classification accuracy in real-world driving environments. In recent years, the development of intelligent transportation systems and smart vehicle technologies has attracted significant attention from researchers in the field of driver behavior analysis. Road accidents caused by unsafe driving behaviors have motivated the development of automated systems capable of monitoring driver actions and identifying abnormal patterns. Machine learning and data analytics techniques have been widely applied in this domain to analyze large volumes of driving data and detect risky driving behaviors. Various studies available in academic databases such as Google Scholar highlight different approaches used to improve driver monitoring and road safety.

Several early studies focused on detecting abnormal driving behavior using **vehicle sensor data**. These systems typically collect data from onboard sensors such as GPS modules, accelerometers, gyroscopes, and vehicle diagnostic systems. The collected data includes parameters such as vehicle speed, acceleration rate, braking intensity, and steering movements. Researchers have applied machine learning algorithms such as Decision Trees, Support Vector Machines (SVM), and Random Forest to classify driving behavior into categories like normal driving, aggressive driving, and risky driving. These models are trained using historical driving datasets, allowing them to identify patterns that indicate abnormal behavior.

A number of studies have also investigated the use of **smartphone-based monitoring systems** for abnormal driving detection. Smartphones contain built-in sensors such as accelerometers and gyroscopes that can capture vehicle motion data. Researchers have used these sensors to detect events such as harsh braking, rapid acceleration, and sudden turns. Machine learning models such as K- Nearest Neighbors (KNN), Support Vector Machine (SVM), and Naïve Bayes have been applied to analyze this sensor data and classify driving behaviors. This approach offers a cost- effective solution because it eliminates the need for specialized hardware devices installed inside vehicles.Another important area of research focuses on **deep learning techniques for driver behavior analysis**. Deep learning models such as Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) have been used to analyze complex driving patterns and large-scale driving datasets. These models are capable of identifying subtle patterns in driver behavior that traditional machine learning algorithms may not easily detect. For example, CNN models have been applied to camera-based driver monitoring systems to detect driver fatigue, distraction, and drowsiness. Such systems play a crucial role in preventing accidents caused by human errors.Researchers have also explored **anomaly detection methods** that can identify unusual driving behavior without requiring large labeled datasets. Techniques such as clustering algorithms, autoencoders, and semi-supervised learning models are used to detect anomalies in driving data.

Table1. Comparative Analysis of Existing Intelligent E-Commerce Systems

Title of Study	Authors	Methodology	Demerits
Abnormal Driving Behavior Detection Using Machine Learning	Chen Y., Wang J., Li H.	Collect driving data from sensors, GPS, and datasets.	Requires large training datasets
Detection of Aggressive Driving Using Smartphone Sensors	Johnson D., Trivedi M., Nguyen P.	Remove noise, missing values, and duplicate data.	High computational complexity
Driver Behavior Analysis Using Deep Learning	Zhang X., Liu Y., Wang S.	Normalize and prepare data for analysis.	Sensor accuracy dependency
Anomaly Detection in Driving Behavior Using Autoencoders	Kim H., Park J., Lee K.	Extract key features like speed, braking, acceleration.	Limited real-time performance
Intelligent Driver Monitoring System Using Machine Learning	Singh R., Sharma A., Gupta P.	Select important variables affecting driver behavior.	High hardware cost
Real-Time Driver Behavior Monitoring Using IoT	Kumar S., Patel R., Mehta D.	Divide dataset into training and testing sets.	Low accuracy in complex traffic
Machine Learning Based Driving Pattern Recognition	Lee J., Kim D., Park S.	Train machine learning models using training data.	Data noise affects prediction

Detection of Driver Fatigue Using Machine Learning	Brown T., Wilson K., Davis L.	Test trained model using unseen test data.	Limited scalability
Aggressive Driving Detection Using Vehicle Sensor Data	Garcia M., Lopez R., Hernandez P.	Identify unsafe driving behavior patterns.	Poor performance with small datasets
Intelligent Transportation System for Driver Safety	Ahmed S., Rahman M., Chowdhury F.	Send alerts or warnings when abnormal driving occurs.	High energy consumption
Real-Time Driver Behavior Monitoring Using IoT	Kumar S., Patel R., Mehta D.	Divide dataset into training and testing sets.	Low accuracy in complex traffic

V. PROPOSED SYSTEM

The proposed system introduces a **Smart Driving Abnormality Detection System** that utilizes machine learning techniques to identify unsafe driving behavior and improve road safety. Traditional driver monitoring systems rely mainly on rule- based methods or manual observation, which are often unable to accurately detect complex driving patterns. The proposed system addresses these limitations by applying data-driven machine learning models capable of learning from large volumes of driving data and automatically identifying abnormal driving activities.

The system is designed to collect real-time driving data from various sources such as **vehicle sensors, GPS modules, accelerometers, and driving datasets**. These data sources provide important parameters including vehicle speed, acceleration rate, braking force, steering angle, and location information. The collected data is transmitted to the processing module where it is cleaned, organized, and prepared for further analysis.

In the proposed framework, a **machine learning-based classification model** is used to analyze driver behavior. The system extracts relevant features from the dataset and trains classification algorithms to distinguish between normal driving behavior and abnormal driving patterns. Abnormal driving events may include sudden braking, rapid acceleration, aggressive turning, or irregular vehicle movement.

Once the model is trained, the system continuously monitors driving data and evaluates it using the trained machine learning model. If the system detects any unsafe driving pattern, it generates alerts or notifications to inform drivers or monitoring authorities. This intelligent monitoring approach enables early detection of risky driving behavior and contributes to accident prevention.

The proposed system architecture also supports scalability and adaptability, allowing the system to integrate with **intelligent transportation systems (ITS), fleet management platforms, and advanced driver assistance systems (ADAS)**. By combining sensor data analysis with machine learning techniques, the proposed system provides a reliable solution for real-time driver behavior monitoring and road safety improvement.

VI. METHODOLOGY

The methodology for the Smart Driving Abnormality Detection System follows a structured process that includes **data collection, data preprocessing, feature extraction, machine learning model** training, **abnormal behavior detection, and performance evaluation**. These stages collectively enable the system to analyze driving data effectively and detect abnormal driving patterns with high accuracy.

The first step in the methodology is **data collection**, where driving data is obtained from different sources such as vehicle sensors, GPS devices, accelerometers, and publicly available driving datasets. The collected data includes parameters such as speed, acceleration, braking patterns, steering angle, and vehicle movement information. These parameters represent driver behavior and are essential for identifying abnormal driving patterns.

After collecting the raw data, the next stage is **data preprocessing**. Raw datasets often contain missing values, noise, or inconsistent measurements that can negatively affect machine learning model performance. Data preprocessing techniques such as data cleaning, normalization, and transformation are applied to improve the quality of the dataset and prepare it for analysis.

The third stage involves **feature extraction and feature selection**. In this step, the most important attributes related to driver behavior are identified. Features such as speed variation, sudden acceleration, harsh braking, and steering deviation are extracted from the dataset. Feature selection methods help reduce the dimensionality of the dataset and improve the efficiency and accuracy of the machine learning model.

Next, the processed data is used for **machine learning model**

training. Several machine learning algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), Logistic Regression, and K-Nearest Neighbors (KNN) can be applied to train the model. These algorithms learn patterns from historical driving data and classify driving behavior into normal and abnormal categories.

VI. IMPLEMENTATION

The implementation of the Smart Driving Abnormality Detection System involves integrating machine learning techniques with data processing tools to develop an intelligent driver monitoring system. The system can be implemented using modern programming languages and data analysis frameworks that support machine learning development.

In this project, the implementation process begins with dataset preparation. Driving datasets containing information about vehicle speed, acceleration, braking events, and steering behavior are collected and stored in a structured format. Data preprocessing is performed using tools such as Python libraries including Pandas and NumPy to clean and organize the dataset.

The next step involves feature engineering, where important driving attributes are extracted from the dataset. These features represent key indicators of driver behavior and are used as input variables for machine learning models. After feature extraction, the dataset is divided into training and testing sets to evaluate the performance of the model.

Machine learning algorithms are then implemented using frameworks such as Scikit-learn. Algorithms such as Random Forest, Support Vector Machine, and Decision Tree are trained using the prepared dataset. These algorithms analyze the input features and learn patterns that represent normal and abnormal driving behaviors.

The trained model is integrated into the detection module where it processes incoming driving data and predicts whether the behavior is safe or abnormal. When abnormal behavior is detected, the system generates alerts through a monitoring interface or dashboard. This implementation demonstrates how machine learning techniques can be applied to develop a practical driver monitoring solution for improving road safety.

VII. RESULTS AND DISCUSSION

The results obtained from the Smart Driving Abnormality Detection System demonstrate the effectiveness of machine learning algorithms in detecting unsafe driving behavior. After training the model using the prepared dataset, the system was evaluated using various performance metrics to determine its accuracy and reliability.

Experimental results show that machine learning algorithms can successfully classify driving behavior into normal and abnormal categories. Among the tested algorithms, models such as Random Forest and Support Vector Machine generally provide higher accuracy compared to other classification methods. The system was able to detect abnormal driving events such as sudden braking, aggressive acceleration, and irregular vehicle movement with a high level of precision.

The performance of the model was analyzed using evaluation metrics including accuracy, precision, recall, and F1-score. The confusion matrix was also used to examine the classification results and identify true positive, true negative, false positive, and false negative predictions. These evaluation results indicate that the proposed system can effectively analyze driving data and identify risky driving patterns.

The discussion of the results highlights the importance of data quality and feature selection in improving the performance of machine learning models. Proper preprocessing and feature extraction significantly enhance the model's ability to detect abnormal driving behavior accurately. The results also suggest that integrating multiple sensor data sources can further improve system reliability and real-time monitoring capabilities.

VII. CONCLUSION

The Smart Driving Abnormality Detection System using Machine Learning provides an intelligent solution for monitoring driver behavior and identifying unsafe driving patterns. By analyzing driving data collected from sensors and datasets, the system applies machine learning algorithms to classify driving behavior and detect abnormal events such as harsh braking, aggressive acceleration, and irregular steering movements.The proposed system demonstrates how machine learning techniques can improve the accuracy and efficiency of driver monitoring systems compared to traditional rule-based approaches. Experimental results show that machine learning models are capable of analyzing complex driving patterns and detecting abnormal behavior with high accuracy. This capability makes the system suitable for applications such as fleet management, driver safety monitoring, and intelligent transportation systems.

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