DriveAlert: A Smart Driving Assistance

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***Abstract*——This Intelligent Driver Assistance System enhances road safety by integrating real-time signboard detection, speed monitoring, and 3D map visualization. Utilizing a YOLO-based deep learning model, it processes images from a vehicle's front-facing camera to identify traffic speed signs, with a FastAPI-based backend handling detection and returning real-time results. The Flutter-based front-end provides an intuitive interface with visual and auditory alerts for detected signs and speed limits, ensuring drivers receive timely notifications. Additionally, the system features an over-speed monitoring mechanism that warns drivers if they exceed speed limits, promoting safer driving. To enhance spatial awareness, a 3D map visualization powered by Mapbox offers custom styles for improved navigation and situational awareness. Unlike high-end Advanced Driver Assistance Systems (ADAS) that require expensive hardware, this project delivers a cost-effective solution by leveraging machine learning, computer vision, and interactive UI components, making it accessible for a wider range of vehicles. By offering real-time detection, intelligent notifications, and enhanced road visibility, this system significantly contributes to reducing road accidents and improving driver assistance.**

***Index Terms*—Driver assistance, road safety, sign- board detection, speed monitoring, object recognition, YOLOv8, machine learning, computer vision, real-time alerts, FastAPI, Flutter, mobile application, 3D mapping, Mapbox, over-speed warning, visual alerts, auditory alerts, intelligent driving, smart navigation, traffic sign recognition, driving assistance, road hazard detection, accident prevention, cost-effective ADAS.**

I. INTRODUCTION

Road safety is a growing concern as traffic congestion, driver distractions, and excessive speeding contribute to numerous accidents worldwide. While Advanced Driver Assistance Systems (ADAS) offer solutions with real-time alerts and automated assistance, they remain expensive and are typically found in high-end vehicles. This leaves many drivers without access to essential safety features that could help prevent accidents. To bridge this gap, DriveAlert has been developed as an affordable and efficient solution for road sign detection and speed monitoring, aiming to enhance driver awareness and improve overall traffic safety.At the heart of DriveAlert is a deep learning-powered YOLO (You Only Look Once) model, enabling accurate, real-time detection of road signs. The system utilizes a vehicle-mounted camera to capture images, classifies detected traffic signs, and provides instant feedback to the driver. A FastAPI-based backend ensures seamless data processing, while a Flutter-powered mobile application delivers real-time alerts in a simple and user-friendly interface. The system provides both visual and auditory notifications, ensuring that drivers stay informed without being overly distracted.

DriveAlert features an over-speed monitoring system that continuously tracks the vehicle's speed and compares it to detected speed limits. If the vehicle exceeds the prescribed limit, an alert is triggered, encouraging safer driving practices and minimizing speed-related accidents—particularly in high-risk, high-traffic zones.To further improve situational awareness, DriveAlert integrates interactive 3D mapping using Mapbox, providing drivers with a visual representation of their surroundings. This feature allows users to anticipate upcoming road signs and speed limits, improving navigation and spatial awareness. Customized map styles enhance visibility, making it easier to recognize road-specific details.Unlike traditional ADAS solutions, which depend on expensive proprietary hardware, DriveAlert is designed as a cost-effective and scalable alternative that can be deployed across various vehicle types. By leveraging machine learning, computer vision, and real-time notifications, it offers an effective and accessible driving assistance system.With real-time road sign detection, speed monitoring, and instant driver alerts, DriveAlert plays a key role in promoting safer driving habits. Its affordability and seamless integration make it a practical tool for improving road safety, providing essential driving assistance without requiring costly hardware upgrades.

II. LITERATURE SURVEY

Karrary et al. [3] discuss the increasing reliance on Advanced Driver Assistance Systems (ADAS) to enhance road safety and ensure adherence to traffic

regulations, given the alarming number of road traffic fatalities reported by WHO. A crucial aspect of ADAS is automated speed limit recognition, which involves detecting and classifying speed signs using various techniques. Methods like Haar Cascade filtering refine the accuracy of sign detection by eliminating unnecessary visual data, enabling efficient real-time recognition of road signs, even in dynamic environments.

Chaising et al. [1] highlight the growing need for driver safety and traffic compliance amid increasing road traffic. Modern ADAS use real-time road sign detection and speed monitoring to reduce human error and enhance responsible driving. These systems provide alerts when speed limits are exceeded and often include an override function for critical situations, minimizing distractions. By integrating real-time detection, monitoring, and adaptive alerts, ADAS improve driver awareness, adherence to traffic rules, and overall road safety.

Mishra et al. [4] propose an RF-based signboard detection system to enhance driver awareness by wirelessly transmitting sign information to an in-car display. Using an Arduino ATmega 2560, the system ensures timely alerts, especially in low-visibility conditions. Unlike traditional driver assistance systems, it proactively detects road signs, improving safety. Future enhancements may integrate smartphone apps for real-time alerts, promoting safer driving and better situational awareness.

Rassaruka et al. [6] emphasize the role of real-time driver assistance systems (ADAS) in improving road safety through image processing and machine learning. These systems use front-mounted cameras and deep learning models like YOLOv5 and Faster R-CNN for accurate road sign and speed limit detection. Real-time alerts help drivers respond quickly to traffic conditions, reducing accident risks. Additionally, override mechanisms allow drivers to disable alerts in emergencies, ensuring a balance between safety and minimal distraction.

Javed et al. [2] propose a solid rotary inverter sensor for vehicle speed measurement in Intelligent Driver Assistance Systems (IDAS). By converting DC to three-phase AC, the sensor measures speed without traditional mechanical components, enhancing accuracy and reliability. This innovation improves real-time speed monitoring and road safety.

Shao et al. [7] present a driver assistance system integrating vehicle speed sensors and machine learning. The system converts rotational speed into electrical signals, analyzed by the ECU to provide real-time speed alerts. It utilizes regression techniques to analyze speed-related features and offer personalized feedback. The study reports efficient operation with a total harmonic distortion (THD) of -28.9778 dB and suggests optimizing sensor materials to enhance performance in intelligent driver assistance systems (IDAS).

Nassar et al. [5] propose an Intelligent Signboard Detection and Speed Monitoring System to enhance road safety using machine learning. Inspired by accident detection systems, it leverages CNN-SVM models for accurate sign recognition and speed monitoring. Real-time alerts improve driver awareness, while an override button ensures focus in emergencies. Integrating proven techniques from related research strengthens its effectiveness as a driver assistance tool.

Yin et al. [8] analyze adaptive speed control using C-V2X communication to enhance road safety. Their approach adjusts vehicle speeds based on congestion and inter-vehicle distances, reducing collision risks. Integrating these insights into the Intelligent Signboard Detection and Speed Monitoring System enables real-time speed recommendations and improved situational awareness. Adaptive algorithms and inter-vehicle communication enhance responsiveness, while an override feature balances safety and flexibility.

III. METHODOLOGY

The DriveAlert methodology outlines the development of an AI-powered device designed to enhance driver safety by integrating advanced sensors, real-time hazard detection, audio alerts, and navigation support. It combines machine learning and computer vision techniques to detect and interpret traffic signs, providing immediate feedback to drivers. The system also monitors vehicle speed, issuing alerts when speed limits are exceeded to encourage safer driving behavior. By ensuring real-time processing and adaptability to diverse road conditions, DriveAlert aims to deliver an intuitive and responsive solution that minimizes driver distractions while maximizing road awareness.

The methodology follows a structured approach covering design, implementation, and testing phases. It involves extensive data validation, real-world simulations, and iterative improvements to optimize performance. The system is developed with a user-friendly interface, ensuring seamless integration into mobile or embedded platforms. Additionally, considerations such as system efficiency and cost-effectiveness make DriveAlert a practical alternative to high-end Advanced Driver Assistance Systems (ADAS), providing an accessible and reliable solution for everyday drivers.

A. System Architecture

The project is primarily divided into six key modules.

1) Image Processing Module:

- **Purpose**: Processes video feed from the vehicle's front camera to detect and classify traffic signs, specifically speed limit signs.

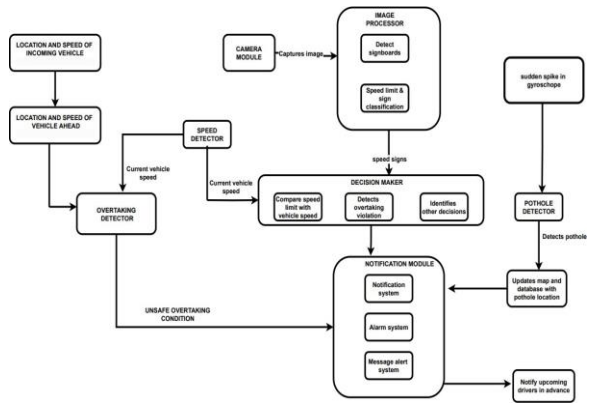

Fig. 1. System Architecture

- **Components**:

1. **Camera Interface** - Manages raw video input from the vehicle's front camera. - Controls frame capture rate.
2. **Sign Detection** - Implements object detection algorithms. - Identifies traffic signs in video frames.
3. **Sign Classification** - Categorizes detected signs. - Focuses on speed limit signs. - Uses a machine learning model for classification.
4. **Speed Limit Extraction** - Extracts numerical values from speed limit signs. - Validates extracted values. - Handles different speed limit formats.

2) Speed Detector Module:

- **Purpose**: Monitors and tracks vehicle speed using GPS data, comparing it with detected speed limits.
- **Components**:

1. **GPS Interface** - Retrieves real-time location and speed data.
2. **Speed Calculation** - Processes GPS data for speed calculation. - Ensures accuracy of speed measurements.
3. **Speed Comparison** - Compares current speed with detected limits.
4. **Violation Detection** - Identifies speeding violations. - Applies violation criteria. - Records violation details. - Triggers alert system.

3) Overtaking Detector Module:

- **Purpose**: Identifies unsafe overtaking using real-time camera feed and alerts the driver.
- **Components**:

1. **Vehicle Detection** - Recognizes nearby vehicles for safe overtaking.
2. **Overtaking Violation Check** - Flags risky overtaking situations.
3. **Alert System** - Warns the driver in case of unsafe overtaking.

4) Notification and Alarm Module:

- **Purpose**: Manages real-time alerts for speed violations, sign recognition, and overtaking warnings.
- **Components**:

1. **Driver Alerts** - Generates real-time speed warnings. - Manages alert priority. - Controls alert frequency.
2. **Violation Counting** - Tracks the number of violations. - Maintains violation history. - Implements counting rules. - Handles reset conditions.

5) Database Module:

- **Purpose**: Stores and manages all system data, including vehicle and violation records.
- **Components**:

1. **Vehicle Database** - Stores vehicle information. - Registration details. - Vehicle type. - Owner information. - Handles data updates.
2. **Driver Database** - Maintains driver records. - Personal information. - License details. - Contact information. - Violation history. - Ensures data privacy.
3. **Violation Database** - Records violation details. - Date and time. - Location coordinates. - Speed recorded. - Speed limit.
4. **Overspeeding Users Table** - Logs all instances of overspeeding violations. - Stores driver ID, ve- hicle details, and violation timestamp. - Helps in tracking repeat offenders. - Provides data for gen- erating reports and insights.

6) Map Module:

- **Purpose**: Provides navigation assistance and enhances driving safety with route guidance and haz- ard detection.
- **Components**:

1. **Route Navigation** - Displays the route to a selected destination when tapped.
2. **Super-Safe Mode** - Suggests the least risky route to the destination.
3. **Pothole Detection** - Identifies and marks potholes on the map.
4. **Incident Reporting** - Allows users to report road hazards and incidents.

IV. RESULTS AND DISCUSSION

The DriveAlert system underwent testing across mul- tiple modules, including user authentication, over-speed detection, live vehicle tracking, and navigation assis- tance. Figures 2, 3, and 4 illustrate key features designed to enhance road safety.

Fig. 2. Over-speed detection

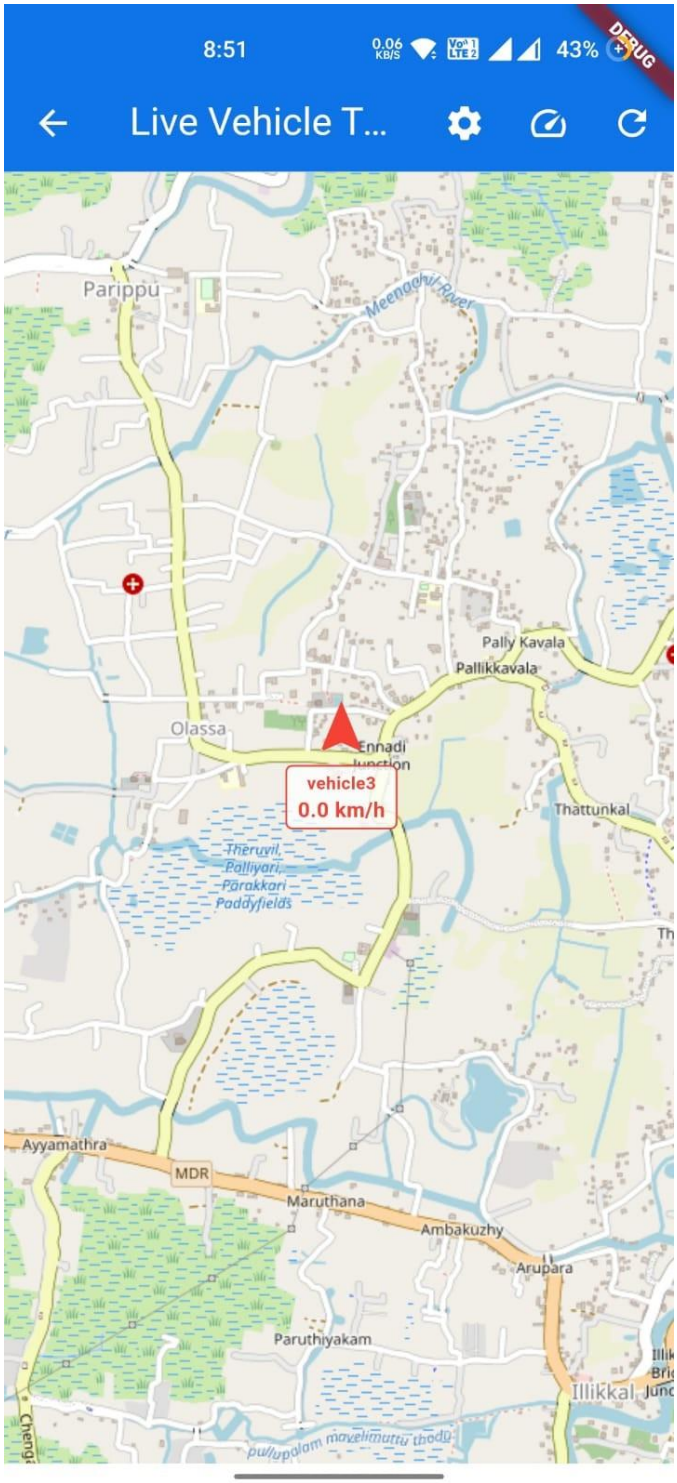

Fig. 3. Live vehicle tracking

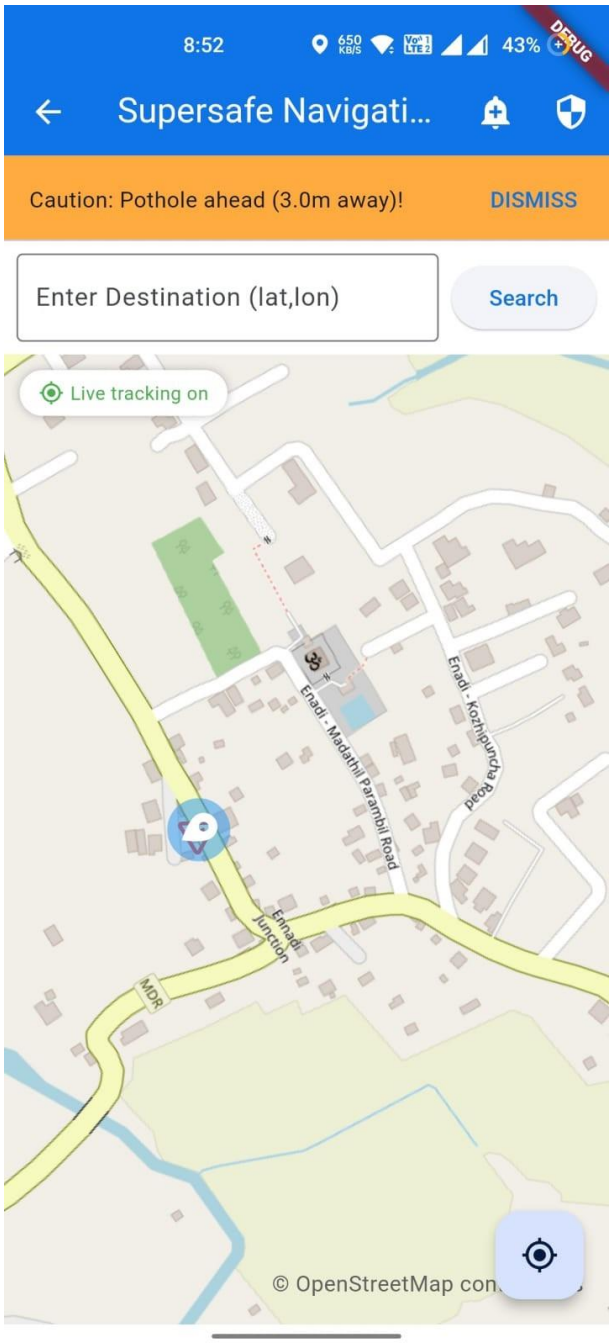

Fig. 4. Pothole Detection

Figure 2 depicts the system's over-speed detection capability, which warns drivers when they surpass designated speed limits, reducing the risk of speed-related accidents. Figure 3 presents real-time vehicle tracking, ensuring continuous location updates for improved security and effective fleet monitoring. Figure 4 highlights the pothole detection feature, which helps drivers avoid hazardous road conditions by identifying potholes and recommending alternative routes.

By combining AI-driven alerts, GPS tracking, and real-time monitoring, DriveAlert enhances driving safety and awareness. Future upgrades could incorporate predictive hazard detection, voice-guided alerts, and broader system compatibility for enhanced performance across various vehicle types.

V. CONCLUSION

In conclusion, DriveAlert addresses the growing concern of road safety by offering an innovative and cost-effective solution to enhance driver awareness and prevent accidents. As traffic congestion, driver distractions, and speeding continue to contribute to a high number of road incidents globally, DriveAlert bridges the gap between advanced safety technologies and the majority of drivers who lack access to premium systems. Unlike traditional ADAS solutions, which are often expensive and limited to high-end vehicles, DriveAlert utilizes an affordable combination of deep learning, computer vision, and real-time notifications, making it accessible to a wider range of vehicles.

The integration of a YOLO-based deep learning model for real-time traffic sign detection, an over-speed monitoring system, and a seamless backend powered by FastAPI ensures that drivers are constantly informed without unnecessary distractions. Additionally, the system's interactive 3D mapping through Mapbox improves spatial awareness, allowing drivers to anticipate road conditions ahead and make more informed decisions. By providing both visual and auditory alerts, DriveAlert ensures that important safety messages are communicated effectively without overwhelming the driver.

DriveAlert's ability to track speed limits and issue warnings in real-time plays a crucial role in preventing speed-related accidents, particularly in high-traffic and urban areas where speed compliance is vital. The system's scalability and ease of integration also make it a practical solution for a wide range of vehicles, offering a significant improvement in road safety without the need for expensive hardware installations.

Overall, DriveAlert offers a comprehensive, user-friendly solution that brings together machine learning, real-time processing, and effective notification systems to address critical safety concerns. Its accessibility, combined with the power of modern technology, makes it a game-changer in promoting safer driving habits, enhancing road safety for all. By making advanced road safety features available to a broader audience, DriveAlert has the potential to significantly reduce accidents, improve driver behavior, and contribute to the overall safety of the transportation ecosystem.

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