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VEHICLE TRAJECTORY PREDICTION USING LONG SHORT-TERM MEMORY IN V2V COMMUNICATION

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Abstract: This project presents an integrated system combining computer vision, deep learning, and IoT-based V2V (Vehicle-to-Vehicle) communication to improve road safety and enable smarter transportation solutions. The system is developed in three main stages. First, a real-time lane detection module is implemented using Python and OpenCV. It employs image processing techniques such as color thresholding, edge detection, and Hough Transform to accurately identify lane boundaries from a live camera feed, enhancing driver assistance and road alignment. Second, object detection is performed using the YOLOv3 deep learning model, which identifies surrounding vehicles, pedestrians, and other road objects from real-time video frames. YOLO's high-speed and accurate detection capability makes it suitable for safety-critical environments. The model processes input frames, applies non-maximum suppression to eliminate duplicate detections, and marks detected objects with bounding boxes and labels. Third, the V2V communication system is developed using the ESP32 microcontroller and IoT platform Blynk. This system monitors temperature and collision status using a DHT11 sensor and digital input pin. When critical conditions such as engine overheating or accidents are detected, alerts are displayed on an LCD and transmitted to a mobile application via Wi-Fi, enabling remote awareness. All three components work together to provide a robust and real-time vehicle monitoring and safety system. This approach not only aids in lane discipline and object awareness but also ensures timely communication in emergencies. The integration of vision-based detection, AI models, and IoT connectivity forms a foundation for future autonomous and connected vehicle technologies.

Index Terms - Vehicle Trajectory Prediction, Long Short-Term Memory (LSTM), Vehicle-to-Vehicle Communication (V2V), Deep Learning, Time Series Forecasting, Intelligent Transportation Systems (ITS), Autonomous Vehicles, Neural Networks, Real-time Prediction, Safety and Collision Avoidance.

I. INTRODUCTION

The rapid advancement of technology in the automotive sector has led to the emergence of intelligent transportation systems aimed at enhancing road safety, reducing accidents, and improving driving efficiency. Vehicle-to-Vehicle (V2V) communication, combined with computer vision and deep learning techniques, plays a vital role in realizing smart and autonomous vehicles. V2V communication enables vehicles to exchange real-time data such as speed, location, and environmental conditions, fostering situational awareness and cooperative decision-making among nearby vehicles. Simultaneously, vision-based systems empower vehicles with the ability to perceive and understand their surroundings using cameras and intelligent algorithms.

This project integrates three core technologies to build a comprehensive vehicle safety system: lane detection using OpenCV, object detection using the YOLOv3 deep learning model, and real-time communication through an IoT-enabled V2V module. Lane detection ensures that the vehicle stays within road boundaries and provides visual guidance to the driver. YOLOv3-based object detection identifies and tracks other road users and potential obstacles, enabling proactive responses to dynamic scenarios. The V2V communication system, built using an ESP32 microcontroller and Blynk IoT platform, monitors key vehicle parameters like temperature and collision status, sending immediate alerts to a connected mobile app.

By combining image processing, artificial intelligence, and wireless communication, this system lays the groundwork for safer and more intelligent vehicles. It addresses critical aspects of driver assistance, accident prevention, and emergency response, marking a step toward the broader adoption of connected and autonomous vehicle technologies.

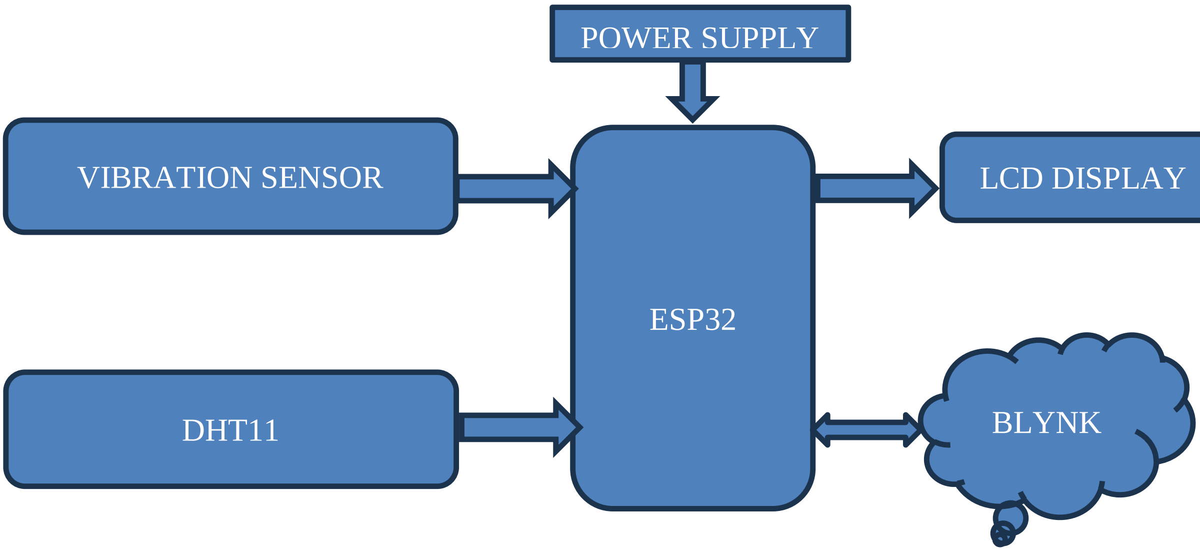
II. II. SYSTEM DESIGN

The proposed system aims to integrate multiple advanced technologies to enhance vehicle safety and assist drivers in real-time. It combines lane detection, object detection, and Vehicle-to-Vehicle (V2V) communication, creating a comprehensive safety solution. The core of the system is based on the use of the YOLO (You Only Look Once) deep learning algorithm for object detection, allowing the system to recognize nearby vehicles, pedestrians, and other road hazards in real-time. This helps prevent accidents by alerting the driver to potential collisions.

The lane detection feature, powered by computer vision techniques, assists the driver in maintaining lane discipline, ensuring the vehicle stays within the designated road lanes. Additionally, the system incorporates an onboard microcontroller, such as the ESP32, to enable V2V communication. This allows vehicles to send and receive safety-related data such as vehicle temperature, accident status, and brake failure alerts.

Using the Blynk IoT platform, the system communicates with a mobile application to send real-time notifications to the driver. If an accident or a malfunction (such as brake failure) occurs, the system immediately triggers an alert on both the vehicle's LCD screen and the mobile app, ensuring that immediate actions can be taken.

This system also integrates sensors like the DHT11 for temperature and humidity measurements and utilizes an LCD display to show relevant information to the driver. The goal of this proposed system is to improve road safety, enhance driver awareness, and provide real-time updates to prevent accidents and improve vehicle management.



Architecture diagram

III. SOFTWARE REQUIREMENT

3.1 Hardware Requirements

- CPU type : Intel core i5 processor
- Ram size : 8 GB
- Hard disk capacity : 500 GB

3.2 Software Requirement

- Operating System : Windows 10
- Language : Python
- Tool : google colab and spyder

IV. SOFTWARE REQUIREMENT

1. **Blynk (Blynk IoT Platform):**
   - Purpose: The Blynk module is used to establish communication between the ESP32 microcontroller and the Blynk IoT platform. Blynk allows users to monitor and control hardware remotely through a smartphone app.
2. Usage: This module is used to send sensor readings (temperature, humidity) and vehicle status updates (break failure, accident occurred) to the Blynk app. It also receives input from the user in case manual intervention is needed.

3. **LiquidCrystal_I2C (LCD Module):**
   - Purpose: The LCD module with I2C communication is used to display messages on a 16x2 LCD screen. It is often used in embedded systems to display real-time status information.
   - Usage: In this system, the LCD module displays critical information such as the current temperature, humidity, and vehicle status (e.g., "accident occurred," "brake failure"). It also provides immediate feedback to the user.
4. **BlynkSimpleEsp32 (Blynk Library for ESP32):**
   - Purpose: This module is part of the Blynk library designed specifically for the ESP32 microcontroller. It handles communication with the Blynk platform.
   - Usage: The BlynkSimpleEsp32 module is used to interact with the Blynk app on a smartphone, allowing the system to send sensor data, control the system remotely, and receive commands from the app.
5. **BlynkTimer (Timer Module):**
   - Purpose: The BlynkTimer module allows you to set up timed actions, enabling periodic updates or checks in your system.
   - Usage: This module is used to schedule periodic updates to the Blynk app (such as sending temperature and humidity data every second) and perform other repetitive tasks without blocking the main program flow.

V.SYSTEM TESTING

System testing for the "Vehicle Monitoring System Using IoT and Blynk" is essential to ensure that all components work together effectively and the system performs as expected in real-world scenarios. The testing process is divided into several phases to evaluate individual components, integration, and the overall performance of the system.

The first phase of testing is the component testing, where each hardware and software module is independently tested to verify its functionality. This involves testing the DHT11 temperature and humidity sensor to ensure it accurately reads the temperature and humidity levels within the expected range. The accident detection sensor is tested by simulating different accident scenarios, such as a sudden deceleration or collision, to ensure that it correctly triggers the system's response. Additionally, the ESP32 microcontroller is tested to ensure it is properly connecting to the Wi-Fi network and can transmit data to the Blynk app without interruptions.

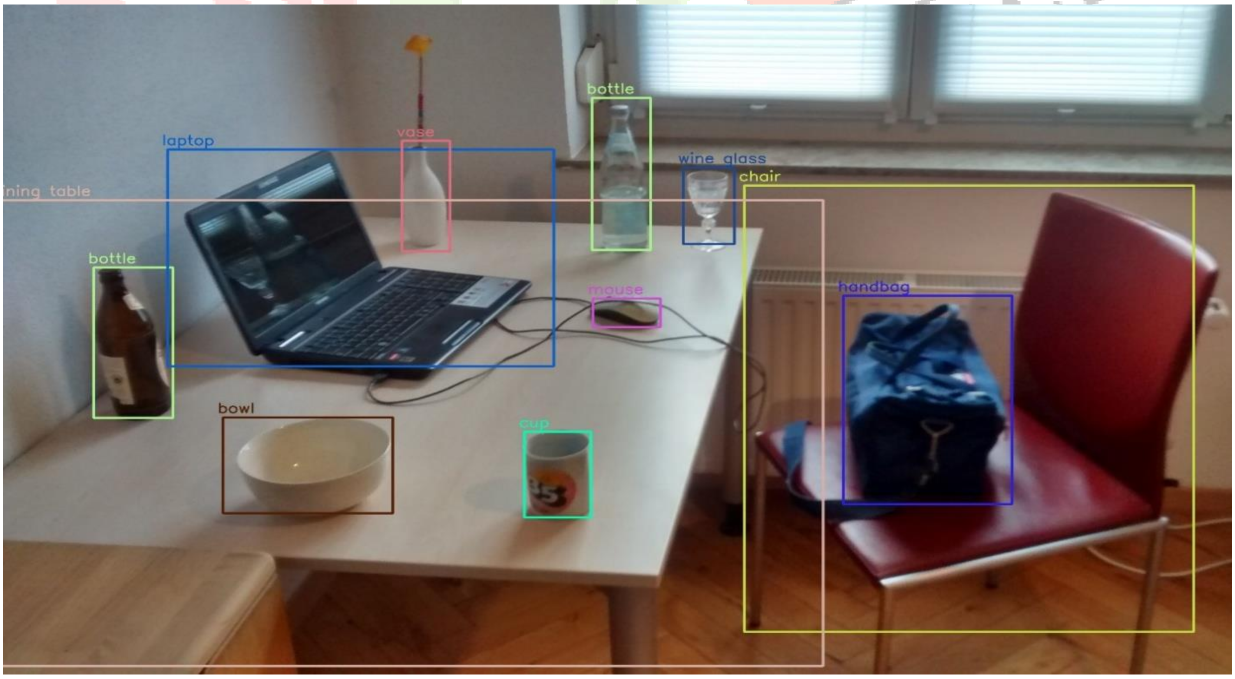
The second phase involves integration testing, where all individual components are brought together to ensure they work as a cohesive unit. The system is tested for its ability to send data from the DHT11 sensor to the ESP32, which is then sent to the Blynk app. Testing focuses on the accuracy of data transfer, ensuring that the temperature and humidity readings displayed on the app match those of the physical sensor

The third phase is functional testing, where the system's overall functionality is evaluated. The system's response to different scenarios, such as an increase in temperature or the detection of an accident, is tested. For example, the system should trigger a "brake failure" alert if the temperature exceeds 40°C, and it should send a notification to the Blynk app indicating that an accident has occurred if the accident detection sensor is triggered. The functional testing phase also evaluates the system's ability to reset after sending alerts.

Finally, stress testing is conducted to ensure that the system can handle extended usage under varying environmental conditions. This involves running the system for long periods to see how well it manages continuous data collection, sensor readings, and communication. Stress testing helps identify any potential issues related to power consumption, Wi-Fi connectivity, or data transfer, especially in scenarios where the system is expected to operate over a long duration without failure.

Overall, the system testing phase ensures that the "Vehicle Monitoring System Using IoT and Blynk" is reliable, efficient, and capable of providing real-time monitoring and alerts. It verifies that the system meets all functional and non-functional requirements and is robust enough for deployment in real-world environments.

landline detection



object detection

VI.CONCLUSION

In conclusion, the "Vehicle Monitoring System Using IoT and Blynk" provides an innovative and efficient solution for monitoring the critical parameters of a vehicle in real-time. By leveraging IoT technology and the Blynk platform, the system enables continuous tracking of temperature, humidity, and accident-related incidents, providing essential alerts and information to the user. The use of sensors like the DHT11 for environmental monitoring, coupled with an accident detection sensor, ensures that the system can react to changes and potential hazards promptly. The integration of the system with the Blynk mobile app allows for easy access to vehicle status and notifications, making it a practical tool for vehicle owners, fleet managers, and maintenance teams. Additionally, the LCD display provides immediate visual feedback, enhancing the usability of the system.

The successful implementation of this system demonstrates the power of combining IoT with real-time monitoring and data analytics. It offers significant improvements over traditional vehicle monitoring systems by enabling remote access, immediate alerts, and data logging, which can lead to improved safety and maintenance practices. By monitoring critical parameters and providing instant feedback, the system can help prevent accidents, reduce vehicle downtime, and enhance the overall driving experience.

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