Driver Safeguard System: A Real Time IoT Based Safety Monitoring Solution Using Computer Vision and Sensors

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ABSTRACT

This project presents a real time Driver Safeguard System designed to enhance road safety by monitoring driver behavior using an integrated IoT framework. The system detects signs of distraction, drowsiness, mobile phone usage and smoking while driving. It utilizes deep learning models (YOLOv11x and YOLOv11l-face), MediaPipe for facial landmark analysis, and environmental sensors (MQ2 and temperature sensors). Alerts are provided through LEDs and a buzzer, while a Blynk app allows for remote monitoring and control. The system activates only when a driver's face is detected, optimizing performance and reliability.

INTRODUCTION

Driver inattention is a leading cause of road accidents. This system aims to proactively detect risky driver behavior and environmental hazards using modern AI techniques and IoT components. The integration of computer vision, real time alerts, and a mobile dashboard ensures a comprehensive and user-friendly safety solution.

MAIN OBJECTIVES

- Detect and alert on driver distraction, drowsiness, mobile phone use and smoking.
- Monitor in car temperature and smoke levels.
- Activate the system only when a driver is present.
- Provide real time alerts through buzzer and LEDs.
- Allow remote system control and monitoring via the Blynk mobile app.

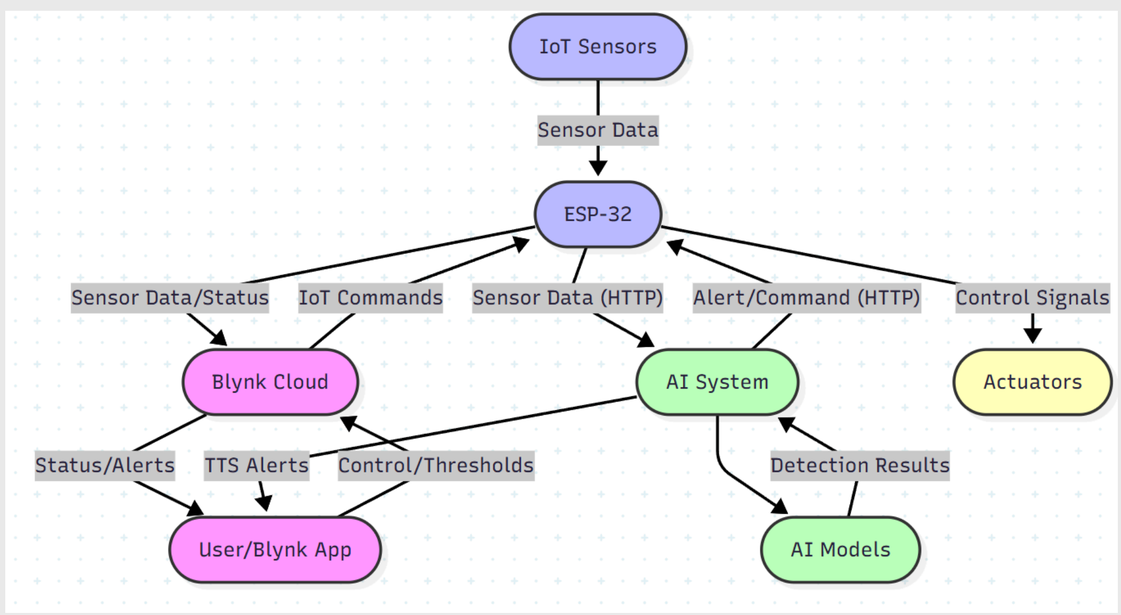
RESEARCH METHOD

- **Face Detection:** yolov11l face.pt activates the system only when a driver's face is detected.
- **Mobile Phone Detection:** yolov11x.pt identifies mobile phone use through object detection.
- **Drowsiness & Distraction Detection:** MediaPipe is used for head pose estimation and eye closure tracking.
- **Smoking Detection:** MQ2 gas sensor detects elevated smoke levels inside the vehicle.
- **Temperature Monitoring:** DS18B20 digital temperature sensor is used to monitor the vehicle's internal temperature accurately.
- **Alert Mechanism:** Multi color LEDs and a buzzer provide immediate visual and auditory warnings.
- **Mobile App Integration:** The Blynk app allows users to toggle the system, change smoke thresholds and view live data for smoke level and temperature.

BLYNK APP FEATURES

- ⭕ System ON/OFF toggle
- 🔧 Adjustable smoke threshold
- 📊 Real time smoke level graph
- 🌡️ In car temperature display

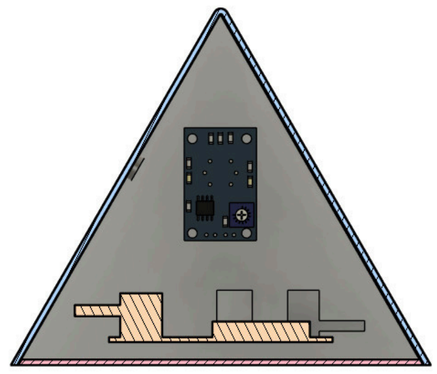
SYSTEM ARCHITECTURE DIAGRAM



- Sensors collect data (smoke, temperature) and send it to the ESP32.
- ESP32 processes data, controls LEDs/buzzer for alerts and sends info to the Blynk app for user monitoring.
- AI system analyzes sensor and camera data, detects risks and sends commands to the ESP32 to trigger alerts.
- Users can monitor and control the system remotely via the Blynk app.

HARDWARE DESIGN & ENCLOSURE INTEGRATION

External 3D Enclosure View



Internal Cross Section View

Our custom designed 3D printed enclosure ensures both functionality and compact integration of the Driver Safeguard System hardware. It is designed for stable dashboard placement, secure internal mounting and optimal component alignment.

EXTERNAL VIEW (LEFT IMAGE)

The outer shell includes:

- A top hole for the MQ2 sensor
- A row of LED indicators for alert notifications.
- A side grill for buzzer sound output or ventilation.
- A sloped surface for improved driver facing orientation.

INTERNAL STRUCTURE VIEW (RIGHT IMAGE)

The internal cross-sectional view shows:

- Component mounts for the ESP32 and Temperature sensor.
- Secure slots to prevent movement during driving.
- Organized layout for easy wiring and airflow.
- Compact triangle shape, ideal for minimal space usage.

CHALLENGES & LIMITATIONS

1. **Model Accuracy**
   - Machine learning models like YOLOv11x and MediaPipe do not guarantee 100% accuracy in real-world scenarios due to varying conditions and unseen data.
2. **Internet Dependency**
   - A stable internet connection is required between the ESP32 and the Blynk cloud. If the connection is lost, remote control and monitoring features will not function.
3. **Processing Power Requirement**
   - Running deep learning models requires significant computational resources. While CPU execution is possible, it's not ideal for real time performance.
4. **Lighting Conditions**
   - Subtle driver distractions may be difficult to detect under poor or inconsistent lighting, which can affect the model's reliability.
5. **Camera Angle Sensitivity**
   - The effectiveness of detection heavily depends on the proper camera angle and clear visibility of the driver's face.
6. **Environmental Influence on Smoke Sensor**
   - The MQ2 sensor can produce false positives or fail to detect smoke accurately in the presence of other gases or strong ventilation.

REAL WORLD APPLICATIONS

This system has high potential for real-world deployment in the following areas:

Commercial Fleet Monitoring
- Improve safety and reduce accidents in logistics and transportation.

School and Public Transport
- Ensure the safety of students and passengers by monitoring driver attentiveness.

Personal Vehicle Safety
- Assist personal car drivers in maintaining alertness and avoiding distractions.

Emergency & Government Vehicles
- Ensure optimal behavior from drivers of critical services under high-stress conditions.

CONCLUSION

The Driver Safeguard System successfully combines AI powered computer vision, IoT sensor integration and mobile app connectivity to detect and respond to critical driver behaviors in real time. It effectively monitors driver distraction, drowsiness, mobile phone usage and smoking, and alerts the driver through LEDs and a buzzer. The system's activation based on face detection ensures optimized performance and resource usage. With remote control and monitoring enabled via the Blynk app, this solution offers a scalable, real world ready approach to enhancing road safety in both personal and commercial vehicles.