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IOT-BASED SCHOOL BUS MONITORING SYSTEM USING GSM AND GPS MODULE

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Abstract

Student safety during school transportation is a major concern for parents and educational institutions. Conventional school bus tracking systems provide only location-based monitoring and lack visual verification of on-board conditions. This paper presents an enhanced IoT-based school bus monitoring and security system that integrates real-time GPS tracking, driver alcohol detection, emergency alert mechanisms, and live video streaming using an ESP32-CAM module. The proposed system employs an Arduino Uno as the main control unit for sensor interfacing and GSM communication, while the ESP32-CAM operates as an independent edge device to provide real-time video surveillance over Wi-Fi. In emergency situations, alerts are transmitted to parents and school authorities through SMS, and live video streaming enables visual confirmation of events inside the bus. Experimental results demonstrate reliable location tracking, timely alert delivery, and stable live video streaming, making the **system suitable for smart transportation applications in smart cities.**

Keywords—Internet of Things (IoT), School Bus Monitoring, Arduino Uno, ESP32-CAM, Live Video Streaming, GPS, GSM, Smart Transportation.

I. Introduction

The rapid growth of urban populations and increasing traffic density have significantly raised concerns regarding the safety of school children during daily transportation. Parents often remain anxious due to the absence of real-time information about the location and condition of school buses. Although GPS-based vehicle tracking systems are widely used, they provide limited insight into on-board safety conditions such as driver behavior or emergency situations involving students.

Recent advances in the Internet of Things (IoT) have enabled the integration of sensors, communication modules, and embedded controllers to create intelligent transportation systems. However, most existing school bus monitoring solutions focus primarily on location tracking and lack real-time visual monitoring. Visual surveillance can play a critical role in confirming emergencies, monitoring driver behavior, and ensuring student safety.

This paper proposes a modified IoT-based school bus monitoring and security system that integrates live video streaming using an ESP32-CAM module along with conventional GPS tracking and safety mechanisms. The system aims to enhance transparency, reduce response time during emergencies, and provide parents and school authorities with real-time visual and location-based information.

II. Related Work

Vehicle tracking and monitoring systems have been widely studied in the context of fleet management, anti-theft applications, and intelligent transportation systems. GPS-GSM based vehicle tracking systems enable real-time location updates and alert generation. Several IoT-based solutions have incorporated mobile applications to visualize vehicle positions.

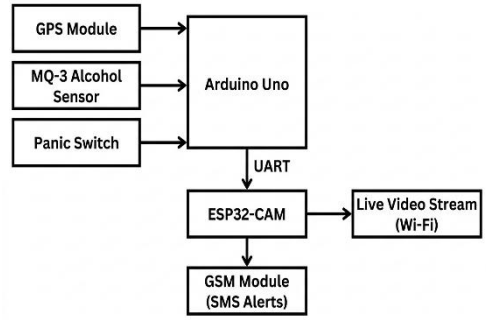
Driver behavior monitoring using alcohol sensors has also been explored to reduce accident rates caused by drunk driving. Emergency alert mechanisms such as panic switches have been proposed to allow immediate communication during critical situations. However, limited research has focused on integrating live video surveillance with school bus monitoring systems due to hardware and bandwidth constraints.

Recent developments in low-cost embedded cameras and Wi-Fi-enabled microcontrollers have made real-time video streaming feasible in IoT applications. The ESP32-CAM module, with its integrated camera and Wi-Fi capability, offers a cost-effective solution for edge-based video streaming. This work builds upon existing vehicle monitoring systems by incorporating live video streaming to provide a comprehensive school bus safety solution.

III. Proposed System Architecture

The proposed system adopts a dual-controller architecture to efficiently handle sensing, communication, and video streaming tasks. The Arduino Uno serves as the primary controller for sensor data acquisition and GSM-based alert communication, while the ESP32-CAM functions as an independent video streaming unit.

A. System Overview



The system consists of the following major subsystems: 1. Location tracking subsystem using a GPS module 2. Safety monitoring subsystem using an alcohol sensor and panic switch 3. Communication subsystem using GSM and Wi-Fi modules 4. Live video surveillance subsystem using ESP32-CAM

The Arduino Uno continuously monitors sensor inputs and controls the GSM module to send SMS alerts. The ESP32-CAM connects to a Wi-Fi network and streams live video from inside the bus to authorized users.

B. Block Diagram Description

The GPS module provides real-time latitude and longitude data to the Arduino Uno. The MQ-3 alcohol sensor monitors the driver's breath alcohol concentration, while a panic switch allows manual triggering of emergency alerts. The Arduino Uno processes these inputs and sends notifications via the GSM module. The ESP32-CAM independently captures and streams video **data over Wi-Fi, enabling live monitoring through a web interface.**

IV. Hardware Implementation

A. Arduino Uno

The Arduino Uno acts as the central control unit for sensor interfacing and decision-making. It reads GPS coordinates, monitors the alcohol sensor output, detects panic switch activation, and communicates with the GSM module using AT commands.

B. ESP32-CAM Module

The ESP32-CAM module integrates an ESP32 microcontroller with an OV2640 camera. It supports Wi-Fi connectivity and can function as a standalone web server for MJPEG video streaming. The module is powered using a regulated 5 V supply capable of delivering sufficient current.

C. GPS Module

A NEO-6M GPS module is used to obtain real-time location information. The module communicates with the Arduino Uno through serial communication and provides accurate latitude and longitude data.

D. Alcohol Sensor

The MQ-3 alcohol sensor detects the presence of alcohol vapors in the driver's breath. When the detected level exceeds the permissible threshold, the Arduino Uno triggers an alert message to school authorities.

E. Panic Switch

A simple push-button switch is installed inside the bus to allow students or staff to trigger an emergency alert in case of danger. Upon activation, an SMS alert is sent to parents and authorities.

F. GSM Module

The GSM module enables SMS-based communication. It sends alert messages containing emergency notifications and driver status to predefined phone numbers.

V. Software Design and Algorithm

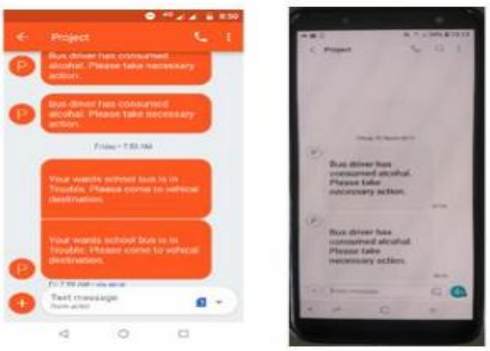
A. Arduino Uno Algorithm

1. Initialize GPS, GSM, and sensor interfaces
2 Continuously read GPS coordinates
3. Monitor alcohol sensor values
4. Check panic switch status
5. If alcohol level exceeds threshold, send SMS alert
6. If panic switch is pressed, send emergency SMS
7. Repeat monitoring process

B. ESP32-CAM Algorithm

1. Initialize camera and Wi-Fi connection
2. Start embedded web server
3. Capture video frames
4. Stream live video to connected clients
5. Maintain continuous streaming

VI. Results and Discussion



The proposed system was implemented and tested under real-time conditions. GPS tracking provided accurate and continuous location updates. The GSM module successfully transmitted SMS alerts during alcohol detection and panic switch activation. The ESP32-CAM delivered stable live video streaming over Wi-Fi, allowing real-time visualization of bus interiors.

The integration of video streaming significantly enhances system reliability by providing visual confirmation of events. Although video streaming depends on network availability, the system performs effectively within Wi-Fi coverage areas.

VII. Conclusion

This paper presented an enhanced IoT-based school bus monitoring and security system integrating live video streaming using an ESP32-CAM module. The dual-controller architecture ensures efficient handling of sensing, communication, and video processing tasks. The system improves student safety by combining real-time location tracking, emergency alerts, driver behavior monitoring, and visual surveillance. The proposed solution is cost-effective, scalable, and suitable for deployment in smart transportation systems.

Future work includes cloud-based video storage, AI-based behavior analysis, and secure access control for video streams.

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