Design and Implementation of Vehicle Tracking System Using Esp32

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***Abstract*—The system entails the development of a comprehensive multi-sensor geared towards real-time vehicle tracking, employing an ESP32 microcontroller alongside GPS and GSM SIM808 modules to ensure high precision. This system facilitates continuous monitoring of vehicle movements regardless of location or time, enhancing overall security and operational efficiency. Beyond basic tracking functionalities, the system integrates additional sensor capabilities to detect crucial parameters such as fuel levels, accidents, distance measures between the vehicles, over-speeding, and passengers/students' headcounts. Notably, alerts are promptly issued upon detection of critical events like low fuel levels, over-speeding, or accidents, ensuring timely intervention and mitigating potential risks. Central to its operation is a microcontroller which governs system functionalities and data processing. Through GSM communication, data collected by the sensors are efficiently transmitted to users via SMS and live data are displayed in web GUI and mobile application, enabling real-time monitoring and decision-making. Overall, the proposed multi-sensor system offers a robust solution for comprehensive vehicle monitoring, encompassing not only tracking but also vital safety and operational aspects, thereby contributing to enhanced security and efficiency in transportation systems.**

***Index Terms*—ESP32 microcontroller, vehicle tracking, GPS, GSM SIM808, real time monitoring, web GUI, mobile application**

I. INTRODUCTION

The project introduces a multi-sensor system designed for real-time vehicle tracking, leveraging ESP32, GPS and GSM SIM800C technologies to achieve high accuracy. It aims to provide seamless monitoring of vehicle movements regardless of location or time, ensuring enhanced security and operational efficiency. In addition to tracking, the system integrates sensors for detecting fuel levels, accidents, distance measures between the vehicles, over-speeding, and passenger/student headcounts. Prompt alerts are issued upon detecting critical events such as low fuel levels or accidents. Governed by a microcontroller, the system transmits collected data via GSM communication for real-time monitoring and live data displayed, offering a comprehensive solution for vehicle tracking, safety and decision making.

In vehicle tracking system combines LiDAR and mmWave Radar for precise positioning, managed by GPS/GSM modules. However, it suffers from high costs, complexity, limited accuracy, power consumption, data latency, and challenges in integrating and processing sensor data. Additionally, its coverage is limited and reliant on external factors, necessitating a more efficient and cost-effective solution.

The proposed solution aims to revolutionize vehicle tracking through a comprehensive system employing ESP32 microcontroller, GPS, GSM SIM800C, and an array of sensors for real-time monitoring. Building upon the shortcomings of the existing system, which suffers from high costs, complexity, and limited accuracy, this solution presents a low-cost, power-efficient alternative with enhanced functionality.

Central to the proposed system is the ESP32 microcontroller, which serves as the backbone for processing data from various sensors and controlling system operations. This microcontroller facilitates seamless integration of GPS and GSM SIM800C modules for accurate location tracking and communication with users. By combining these modules with additional sensors such as fuel level, vibrational, and IR sensors, the system achieves comprehensive monitoring capabilities beyond basic tracking functionalities.

One of the key advantages of the proposed solution is its ability to detect crucial events such as accidents, distance measures between the vehicles, over-speeding, and passenger headcounts in real-time. The integration of sensors enables the system to promptly alert users upon detection of these events, facilitating timely intervention and mitigating potential risks. This proactive approach to monitoring enhances overall security and safety in transportation systems. The proposed system addresses the limitations of the existing system by offering improved data accuracy and reliability. While the existing system relies solely on GPS and GSM modules for tracking, the proposed model incorporates additional sensors to provide a more holistic view of vehicle operations. This multi-sensor approach enhances the system's ability to gather and process data, resulting in more accurate and actionable insights for users.

The proposed solution is designed for seamless integration with mobile devices, enabling users to access real-time tracking information and receive alerts on-the-go. This mobile integration enhances user accessibility and convenience, empowering them to monitor vehicle movements and respond to critical events from anywhere at any time. The system offers a robust, user-friendly, and cost-effective solution for comprehensive monitoring of vehicle movements. By leveraging advanced technologies and addressing the limitations of the existing system, it contributes to enhanced security, safety, and operational efficiency in transportation systems. With its low-cost, power-efficient design and multi-sensor capabilities, the proposed solution represents a significant advancement in the field of vehicle tracking and monitoring.

II. RELATED WORKS

A lot of researches have been done for vehicle tracking system depend mainly on GPS and to predict the vehicle location but the difference between them is the way the GPS information collected and sent to the monitor and control unit.

X. Wang, H. Yu, C. Lu, X. Liu; et al describes Accurate position tracking of the leader vehicle stands as a crucial aspect of vehicle-following technology for unmanned ground vehicles (UGVs), yet implementing it in unstructured environments, particularly amidst challenging weather conditions and rough terrain, presents numerous hurdles. This paper introduces a multi-sensor fusion system (MSFVT) designed to address these challenges. The system aims to achieve real-time and robust detection and tracking of the leader vehicle by integrating data from LiDAR, millimeter-wave Radar (MMW Radar), and an inertial navigation unit (IMU)/Global Navigation Satellite System (GNSS) fusion. The implementation of this system unfolds in three steps: Firstly, the LiDAR point cloud undergoes separation into distinct clusters using an adaptive threshold clustering method, and these clusters are classified through a support vector machine (SVM) to discern the leader vehicle, thereby initiating the tracking process and ensuring continuous tracking thereafter. Secondly, validated detection results from MMW Radar, acquired post multiple data filters, furnish the position information of the leader vehicle during UGV movement. Lastly, the position of the tracking target in each sensor is mapped to a global coordinate system utilizing IMU/GNSS information and processed through a Kalman filter to estimate the target's motion. To validate the effectiveness of this method, extensive experiments are conducted across diverse unstructured environments. The experimental findings demonstrate that the proposed method yields a smaller target position estimation error alongside an average processing frame rate surpassing 40Hz. This indicates the system's robustness and capability to accurately track leader vehicles in varied and challenging environmental conditions, offering promising prospects for advancing vehicle-following technology in UGV applications.

Most of researchers had gone toward the use of embedded system that can operate stand alone, this embedded system is mainly depends on a microcontroller as system core such as Arduino, ARM Processors, etc. GPS maps via the Internet or specialized software.

M. S. Rudramurthy; et al describes development of A vehicle tracking system is a valuable tool for monitoring the movement of a vehicle from any location at any time. The proposed system utilizes widely used technologies by integrating a smartphone system with a compact controller. This automotive device operates through the integration of the Global Positioning System (GPS) and mobile communication systems. By utilizing the Google Maps API, the system displays the vehicle's location on a map within a smartphone application, enabling users to continuously monitor the vehicle's movement. Users can determine the minimum distance and time required to reach a specific destination by tracking the vehicle's progress. Furthermore, the system incorporates geofencing technology, whereby users receive notifications when the vehicle enters or leaves a predefined geographical area. For instance, upon entering a geofenced area, users with the application installed will receive a notification, providing updates on the vehicle's status. Additionally, notifications are sent when the GPS-enabled smartphone associated with the vehicle enters or exits the geofenced area, enabling users to track the vehicle's activities in real-time. Moreover, users have the capability to view the smart city car's location and access precise distance information by tapping on the vehicle's icon within the application. Beyond vehicle tracking functionalities, users can utilize the program to browse news, update their profiles, and register grievances, enhancing the versatility and utility of the system. Overall, this comprehensive vehicle tracking system not only provides real-time monitoring capabilities but also offers additional features to cater to diverse user needs, ensuring enhanced convenience and functionality.

A. -S. T. Hussain, M. Fadhil, T. A. Taha, O. K. Ahmed, S. A. Ahmed and H. Desa explains Leveraging the adaptable PIC microcontroller as its foundation, this innovative system seamlessly integrates GPS and GSM technologies alongside a practical and efficient implementation circuit. Through this approach, our project aims to provide an affordable and effective solution, enhancing vehicle security while reducing reliance on external assistance. By doing so, we seek to offer peace of mind to vehicle owners as they navigate the complexities of vehicle theft and recovery, ensuring greater autonomy and control over the safety of their valuable assets.

III. PROPOSED SYSTEM

In today's fast-paced world, the need for efficient and reliable vehicle tracking systems has become paramount. Whether it's for fleet management, personal security, or logistics optimization, real-time monitoring of vehicle movements has emerged as a critical requirement. To address this demand, the proposed project introduces a cutting-edge multi-sensor system designed to revolutionize vehicle tracking and safety. The cornerstone of this system lies in its utilization of advanced technologies such as the ESP32 microcontroller and the GPS, GSM SIM800C module. By seamlessly integrating these components, the system enables real-time monitoring of vehicle locations with unparalleled accuracy and reliability. This capability is pivotal not only for ensuring the security of valuable assets but also for optimizing operational efficiency across various sectors, including transportation, logistics, and public safety.

At the heart of the system is the ESP32 microcontroller, renowned for its versatility and robust performance in IoT applications. Leveraging the power of this microcontroller, our system orchestrates the seamless integration of multiple sensors and communication modules, thereby enabling a holistic approach to vehicle tracking and monitoring. This integration ensures that the system is not only capable of pinpointing the exact location of a vehicle but also of providing real-time insights into various operational parameters critical for effective management.

One of the key features of our system is its ability to detect and report fuel levels in real-time. By incorporating a fuel level sensor into the system architecture, we empower users with invaluable insights into the fuel consumption patterns of their vehicles. This functionality not only facilitates proactive maintenance scheduling but also enables optimized route planning to minimize fuel wastage, thereby leading to substantial cost savings and environmental benefits.

In addition to fuel level monitoring, our system is equipped with sensors designed to detect accidents and over-speeding incidents. These sensors serve as crucial safety mechanisms, enabling prompt identification of potentially hazardous situations and facilitating immediate intervention. Upon detecting such critical events, the system issues instant alerts to designated stakeholders, thereby ensuring timely response and mitigating the risk of serious consequences.

Furthermore, our system incorporates innovative technology for passenger/student headcount monitoring, thereby catering to a diverse range of applications, including school buses, public transportation, and corporate shuttles. By accurately tracking the number of passengers/students on board, the system enhances safety and accountability, while also enabling efficient resource allocation and capacity planning.

The seamless integration of these advanced functionalities underscores the versatility and effectiveness of our multi-sensor vehicle tracking system. By harnessing the power of embedded IoT technologies, we aim to redefine the standards of vehicle tracking and safety, offering a comprehensive solution that meets the evolving needs of modern society.

The proposed project represents a significant leap forward in the field of vehicle tracking and safety. By leveraging cutting-edge technologies such as the ESP32 microcontroller, GPS and GSM SIM800C communication modules, we have developed a sophisticated multi-sensor system capable of delivering real-time insights into vehicle movements and operational parameters. With features such as fuel level monitoring, accident detection, distance measures between the vehicles and passenger headcount, our system offers unparalleled versatility and reliability, empowering users with the tools they need to enhance security, optimize efficiency, and drive sustainable growth.

A. Block Diagram of Proposed System

The block diagram of the vehicle tracking system illustrates a well-coordinated integration of various components to achieve efficient monitoring and management capabilities. At its core is the ESP32 microcontroller, acting as the central processing unit. Connected to it are the GPS, GSM module (SIM800C), fuel level sensor, force sensor, IR sensor and Ultrasonic sensor, forming the sensory network for data acquisition.

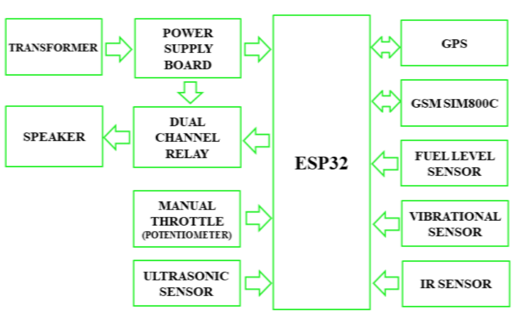


Fig. 1. Block Diagram of Proposed System

Data collected by these sensors undergo processing by the ESP32, which then communicates relevant information to the user via the SIM module. This architecture embodies a robust design optimized for dependable and efficient vehicle monitoring across various scenarios. By leveraging these interconnected components, the system provides real-time insights into vehicle location, fuel levels, and environmental conditions, empowering users with actionable data for enhanced operational efficiency and security.

B. Circuit Diagram of Proposed System

The circuit diagram of the vehicle tracking system presents an intricate integration of electronic components, facilitating the efficient monitoring and management of vehicles. At the core of the diagram is the ESP32 microcontroller, assuming the pivotal role of the control unit. It interfaces with various modules, including the GPS, GSM SIM800C, fuel level sensor, force sensor, IR sensor, and Ultrasonic sensor.

These modules are interconnected with the ESP32 to establish a comprehensive sensory network dedicated to data acquisition and processing. The ESP32 serving as the central processing hub, assimilates incoming data from these sensors and executes corresponding actions based on predefined information. These actions may involve generating alerts for unusual events detected by sensors or updating the user regarding the vehicle's status through the GSM module and web GUI.

This sophisticated integration of components empowers the vehicle tracking system with real-time monitoring capabilities, enabling users to track the vehicle's location, assess fuel levels, head count, and various parameters. By leveraging the synergy among these electronic elements, the circuit diagram embodies a robust architecture designed to ensure reliable and effective vehicle management in diverse operational scenarios.

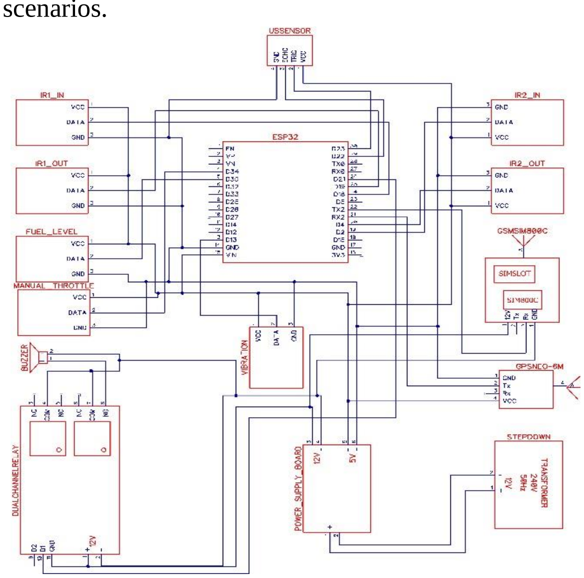


Fig. 2. Circuit Diagram of Proposed System

The circuit diagram illustrates a well-designed system architecture tailored for accurate tracking, efficient monitoring, and timely response capabilities in various vehicular scenarios.

IV. IMPLEMENTATION AND RESULT

We have implemented the IOT based technology in our proposed model of Vehicle Tracking System. This circuit board is seen to be the heart of the vehicle tracking system which consists of all the sensors and electronic components used in our project.

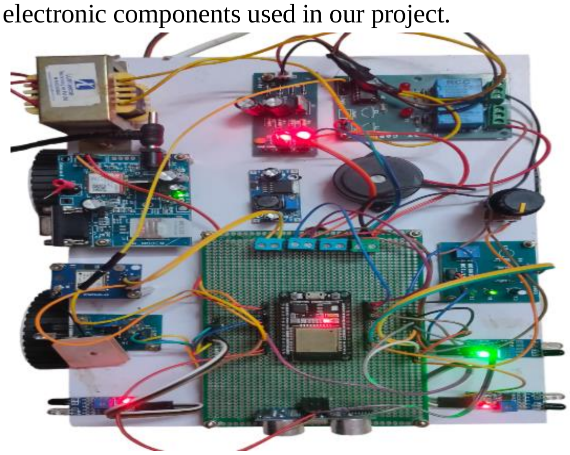


Fig. 3. Hardware of Proposed System

Here ESP32 microcontroller is used for controlling the actions of the system. We have selected ESP32 microcontroller for better performance and 30 pins are there in it which is used to connect all the sensors and other components directly to the controller. It is a 32-bit × 2 core controllers with clock speed of 240MHz and flash memory of 4MB for storage purpose with RAM of 512 KB. It has its own WIFI module working at 2.4GHz.

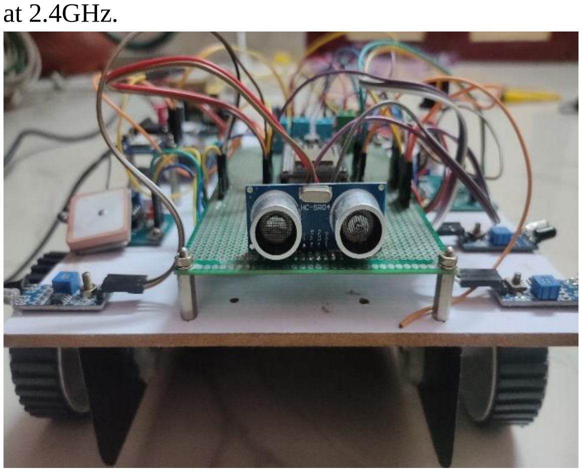


Fig. 4. Front view of Proposed System

We have also added IR sensor for count the number of passengers, fuel level sensor for measure the fuel level, ultrasonic sensor for detect the distance between the vehicle and vibration sensor for detect the accident as a additional feature to the vehicle tracking system.

When the accident detects, fuel level reaches its minimum and detects over speed reaches its maximum the system will alert the driver by making beep sound using the buzzer. The alert message will be also sent to the user as a text message. At the same time, live location co-ordinates also sent to the user.

We have added a GSM 800C module which is a sim card module with the 2G support for the purpose of sending the alert message and measured values periodically as a text message (SMS). This will help the user to monitor the vehicle even when the internet is disconnected. It will reduce the risk of interrupted internet connection to the system.

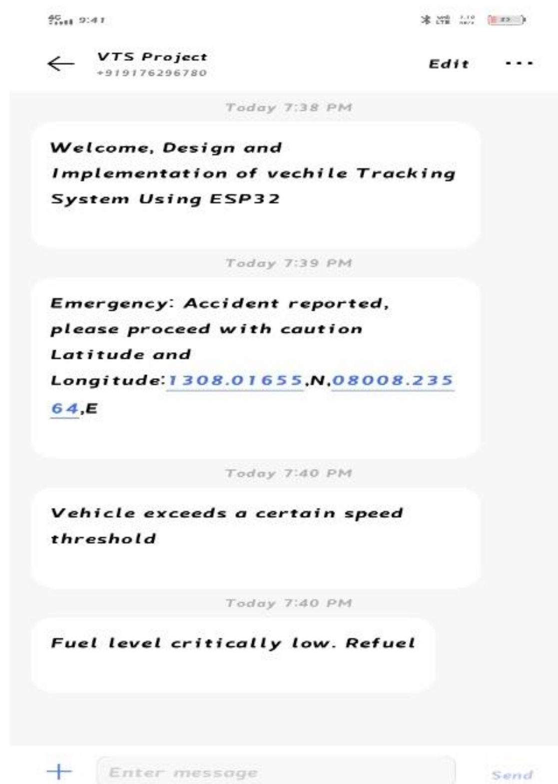
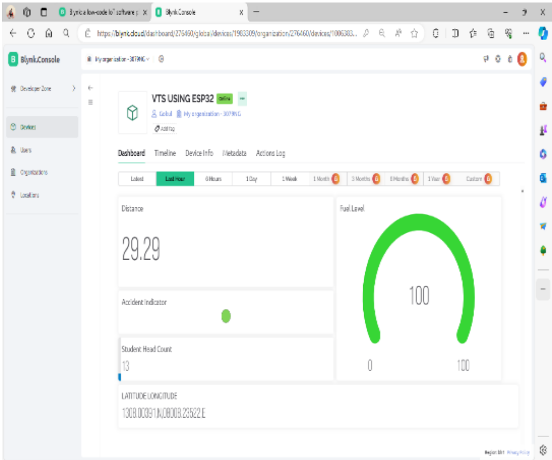
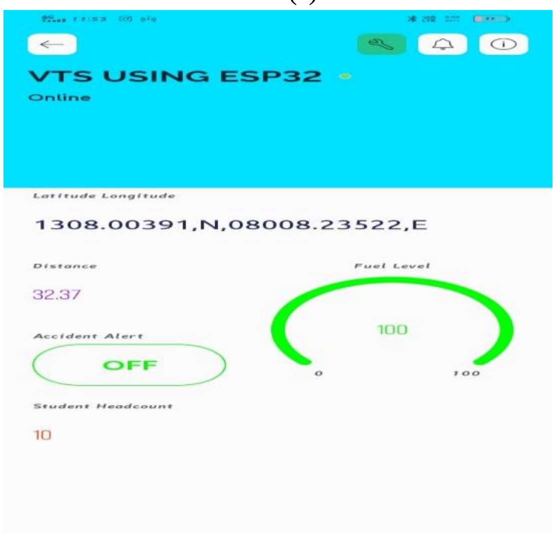


Fig. 5. Alert Messages from the Vehicle

In addition to Blynk IoT, we develop a web GUI and mobile app. Utilizing Wi-Fi, these platforms display real-time data on both the web dashboard and mobile interface, enhancing accessibility and providing comprehensive project monitoring capabilities.



(a)



(b)

Fig. 6. Live Data Shown in Web GUI & Mobile Application

V. CONCLUSION AND FUTURE SCOPE

The proposed multi-sensor vehicle tracking system represents a significant advancement in the realm of vehicle monitoring and safety. By leveraging state-of-the-art technologies including the ESP32 microcontroller, GPS, GSM SIM800C module, and a range of sensors, the system offers unparalleled capabilities for real-time tracking, monitoring, and management of vehicles in diverse scenarios. Such features as fuel level monitoring, accident detection, distance between the vehicle, over-speeding alerts, and passenger/student headcount functionality enhance the safety of the system.

It integrates with user-friendly web GUI and mobile application ensure easy access to live data and remote system control, empowering users with comprehensive oversight and proactive decision-making capabilities. Implementation of Internet of Things (IOT) technology makes it smart and makes it capable of doing the all above mentioned actions.

A. Future Scope

We have planned to enhance our project adding sensors, AI integration, blockchain for security, autonomous vehicle support, smart city integration, and improved user interface.

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