Proceedings of the International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC 2024)
IEEE Xplore Part Number: CFP24OSV-ART; ISBN: 979-8-3503-7642-5

IoT-BASED PASSENGER OVERLOAD MONITORING AND REPORTING SYSTEM

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2024 8th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC) | 979-8-3503-7642-5/24/$31.00 ©2024 IEEE | DOI: 10.1109/I-SMAC61858.2024.10714724

Abstract*— This research study addresses the critical issues of passenger overcrowding and safety in public transportation. The objective is to tackle overloading by employing sensors to count passengers and detect obstacles, complemented by automated doors for efficient entry and exit control. Additionally, an alcohol sensor ensures the bus driver's sobriety. Notably, the project integrates with an open-source cloud platform, utilized to transmit real-time data about overloading and the driver's sobriety. This integration enhances monitoring and protection by providing a central hub for data storage and analysis. When the passenger count exceeds the preset limit, an automated alert is sent to the nearby Regional Transport Office for swift intervention and safety compliance. By harnessing cutting-edge technologies, the project aims to significantly enhance safety and reduce the likelihood of accidents in public transportation.

Keywords—Public Transportation, Overloading, Infrared sensors, Ultrasonic sensor, Automated doors, Alcohol sensor, ThingSpeak, Arduino Uno, Sim 800 Global System for Mobile Communications, Alerting, Safety.

I. INTRODUCTION

In today's busy era, the issue of overloading in public transport vehicles has become more prevalent. This project aims to provide a solution for overcrowding by utilizing advanced technologies and sensors, enhancing passenger safety and preventing rule violations. The vehicle is preset with a limit for passenger count; when the count exceeds this limit, an alarm is triggered, and a message is sent to nearby authorities.

The cornerstone of this innovation is the detection of passenger count, where strategically placed Infrared (IR) sensors near the bus doors efficiently monitor passenger numbers. These sensors ensure that passenger numbers remain within predefined limits, enabling automated bus door operations based on passenger presence. The collected data, transmitted to the central control unit, Arduino, forms the foundation for real-time monitoring and prevention of overcrowding.

A key feature of the system is its ability to alert authorities in real-time. When the passenger count exceeds the preset limit, the Node MCU processes this data, triggering a burglar alarm and initiating an alert to nearby authorities. The simultaneous deployment of a SIM800 GSM module ensures that an SMS alert is sent to the relevant authorities, providing immediate notification and facilitating prompt intervention in case of overloading.

Additionally, the project incorporates data storage to add sophistication. As SMS alerts are dispatched, critical information regarding overloading is securely stored in the cloud platform ThingSpeak. This cloud-based data repository captures details such as the number of passengers boarded, timestamps, and dates, forming a valuable resource for future analysis and decision-making.

Beyond the core features, the project integrates additional elements to enhance passenger safety and convenience. Automated bus doors facilitate seamless entry and exit, while an ultrasonic sensor at the bus's front serves as an obstacle detection system. Furthermore, the integration of an MQ3 sensor actively monitors the bus driver's breath, triggering alarms and notifying authorities if alcohol levels exceed predefined limits.

This innovative embedded system represents a comprehensive solution to the multifaceted challenges faced by the current bus transportation system. It aims to redefine safety standards, prevent overcrowding, and introduce a new era of efficiency and accountability in public transportation. By focusing on passenger safety and maintaining overcrowding data on a cloud platform, this system seeks to enhance passenger safety and reduce the risk of accidents and injuries.

II. RELATED WORKS

The innovative approach of the project has been made possible by an examination of previous endeavors and technological advancements. In the current work, the preset limitation is counted by the PIR sensor [1]. When the limit is exceeded, a message is automatically sent to the bus station via the GSM modem, and the driver is subsequently penalized.

Each passenger will receive an RFID tag, which will allow the bus to track the number of people entering and departing. A microprocessor such as an Arduino or Raspberry Pi is used to manipulate and record the count. The GSM module is used

to send an alert or warning message [2] to the local traffic police if the count is higher than the advised range.

Microcontrollers, load sensors, load cells, and sensors [3] were utilized to measure and track the weight of the bus in order to detect instances of vehicle overloading. To access the internet and offer GPRS services, the SIM900A GPRS/GSM shield is used. The bus weight data is recorded, entered into the central database server, and kept safe. Before the data is sent to the fog layer in [4], the edge layer, which is connected to the sensor, aggregates it. The cloud layer receives the results from the fog layer's seat-belt check, passenger count, and speed estimation algorithms. After receiving data from every vehicle, the cloud layer checks it again for infractions and sends reports to the traffic stations.

An image of a passenger is taken by a camera [5], and this image is sent to the Arduino microcontroller, which counts the number of passengers to decide and act appropriately.

The vehicle is stopped, and the fuel is eventually cut off [6] by the potentiometer load sensor, which also detects the load and issues a warning. Given the importance of safety, truck overloading is also detected [7] based on the ITMD system configuration that uses SSD detection and classification modalities to automatically identify and categorize trucks in videos. Using the current detection algorithms as a foundation, a reliable passenger detection system is designed. As the identified passengers move through a virtual line of interest (LOI), the system [8] counts them automatically. The suggested method's methodology is built around four primary steps: preprocessing, passenger detection, passenger tracking, and passenger counting.

Every bus stop has its barcode [9], which the reader scans to trigger the door to open automatically. By determining the time at which the bus arrives at the previous stop, it also indicates the arrival time of the bus at each stop. Passengers will find it useful to know when the bus is expected to arrive. The passenger will find it useful to know whether there are any seats available before boarding the bus thanks to the LCD outside the vehicle.

A Weigh-In-Motion (WIM) system was integrated with the toll system [10] for more efficient operation to shield the roads from needless damage. The toll system can now collect fares based on both vehicle classification and weight thanks to the addition of WIM. This prevents drivers from overloading their cars.

The car will make a buzzing sound if the driver is trying to maneuver it with too much power, which will cause the engine to cut off fuel [11–14] and cause the vehicle to stop moving. Like this, the suggested mechanism seizes the battery and prevents the user (truck driver) from starting the engine once the weight surpasses the allowed weight limit.

Arduino signals the fuel in if the weight limit is allowed; if not, the fuel cut-off is completed. The Arduino Uno will be calibrated each time it is reset, making it available for use in various scenarios. A DC motor is used to simulate the fuel cut-off that occurs in real-time applications, while a buzzer is interfaced to provide a sound notification to alert the driver.

When lightweight is loaded on a load cell. LCD shows the weight and no penalty. RP enables the ignition of the underloaded vehicle and gives a green indicator. Heavy weight is placed on the load cell, with the LCD displaying the weight and penalty. The ignition of the overloaded vehicle is disabled by the RP, and a red indicator and buzzer are activated.

Blockchain integration with Artificial Intelligence and the Internet of Things [15] addresses the future integration of various industries namely, healthcare, transportation, and finance for finding solutions for security concerns about the data and automating the existing process.

III. PASSENGER OVERLOAD MONITORING AND REPORTING SYSTEMS

The proposed IoT-Based Passenger overload monitoring and reporting embedded system is developed to revolutionize the current bus transportation system, introducing advanced monitoring and safety features that prioritize passenger well-being. It not only deals with passenger safety it also faces the long-standing issue of overcrowding by combining the sensors and technologies.

A. Detection of Passenger count

Infrared (IR) sensors are strategically placed near the bus doors for efficient passenger count monitoring. It serves as the base for this system as it monitors overcrowding. These sensors detect passengers as they board and alight, allowing for automated bus door operations based on passenger presence, ensuring that passenger counts remain within a predefined limit. IR sensors send the collected data to the Arduino. These data act as the backbone of this project, as the system is about monitoring overloading and alerting. This IR sensor acts as a vital element in this project. As this sensor is placed near the door it automatically increases and decreases the count of the passenger by sensing the people's presence. The count displayed by the LCD is the data detected by the IR sensor. The count of the passenger will be displayed on the LCD display. Also, the Burglar alarm will be triggered and alarm by so the driver will alerted that the bus has overloaded.

B. Alerting the authorities

NODE MCU, which plays a vital role in this project acts as a message processor which is the receiver of the data of overloading from the Arduino (central control unit). Arduino collects those data from the Infrared (IR) Sensor. When the count of the passenger exceeds the actual limit, those data are processed in the Node MCU. As the limit exceeds, the Burglar alarm will be triggered equipped with the alarm. This alarm alerts both the passengers and the driver about the overloading situation, which helps to take immediate action. Node MCU initiates the act of alerting the relevant authorities through messages. This alert is in the form of an SMS, which has information on whether the bus is full. When the message is sent to the Regional Transport Officer, they will take the appropriate action. By doing so, the violation of laws, along with the occurrence of accidents and unfortunate injuries, can be reduced.

C. Sending Alert

Communication is facilitated by the SIM800 GSMmodule. When there is a situation of overloading in the vehicle, Node MCU processes the data, it triggers the GSM module to send an SMS (Short messaging service) to alert the authorities. This real-time communication plays a vital role in this system.

This helps address safety concerns. When the respective authorities are informed about the overloading issue in the bus, immediate action will be taken and resolve the issue. This aspect of the system is fundamental in maintaining safety compliance in the transportation sector and enhancing the safety measures of passengers.

D. Storing of the Data

The system sends SMS alerts to authorities while storing critical data and bus congestion information on an opensource cloud platform called ThingSpeak. This cloud service acts as a secure repository of a wealth of critical information, including the number of passengers boarding the bus, precise timestamps, and corresponding data measured and stored. This data is not only a valuable source of information for real-time decision-making but also serves as a resource for future analysis. This also helps further improve the system's monitoring and security capabilities. Cloud-based storage is a pioneering approach to data management that allows for a deeper understanding of transportation system performance.

E. Additional features

In addition to its core functionality, the system introduces additional features to improve passenger comfort and safety. Automatic bus doors that open and close as passengers board and exit streamline the boarding and alighting process, increasing both efficiency and safety. By installing an ultrasonic sensor for obstacle detection at the front of the bus, potential obstacles within a certain area are actively detected. This feature significantly reduces the risk of accidents and collisions, further emphasizing the safety of the system. Additionally, an MQ3 sensor is integrated into the system to continuously monitor the bus driver's breathing. If this sensor detects that the alcohol content exceeds a pre-set limit, it will sound an alarm and immediately notify the relevant authorities. This proactive safety measure plays an important role in ensuring driver sobriety and passenger safety.

F. Passenger Safety System

The proposed embedded system marks a significant advancement in bus transportation, aiming to transform safety and efficiency. This project integrates advanced monitoring and safety features to prioritize passenger well- being and address the persistent issue of overcrowding. Utilizing strategically positioned Infrared (IR) sensors near bus doors, the system monitors passenger counts and automates door operations to adhere to predefined limits. The Node MCU analyzes the data, initiating a Burglar alarm to promptly alert both passengers and the driver. Concurrently, it communicates with the SIM800 GSM module to send real-time SMS alerts to authorities, facilitating prompt intervention. Notably, the system utilizes ThingSpeak, a cloud platform, to store critical data on passenger counts and bus congestion, improving real-time decision-making and providing insights for future analysis. Features such as automated bus doors, ultrasonic obstacle detection, and the MQ3 sensor for driver sobriety underscore the system's commitment to safety and efficiency in public transportation.

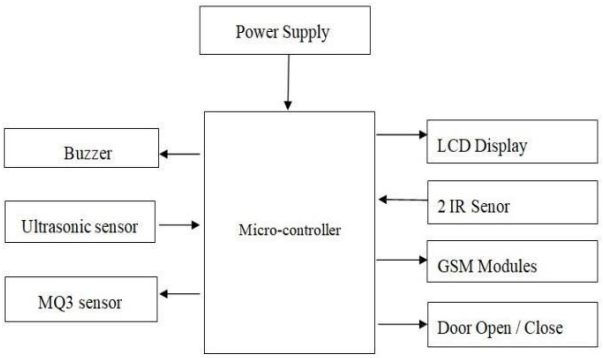

Fig. 1. Block Diagram of IOT-Based Passenger Overload Monitoring And Reporting System

Fig 1. Shows the block diagram illustration of the proposed system. The process of each component of the Passenger Overload Monitoring and Reporting System is explained below.

Microcontroller (Arduino Uno)

The Arduino Uno is selected as the central control unit for passenger overload monitoring system due to its balanced combination of processing power, ease of use, and cost-effectiveness. The ATmega328P microcontroller provides sufficient power with a 16 MHz clock speed, while the user-friendly Arduino IDE and extensive community support facilitate rapid development and integration. Its broad compatibility with various sensors and actuators, coupled with its affordability, makes it an ideal choice for efficient and scalable system implementation.

Power Supply

The power supply unit ensures a stable and reliable source of energy to sustain the operation of the entire system, especially the microcontroller and associated components.

Buzzer

The buzzer acts as an audible alarm, designed to alert passengers and the driver in critical situations, providing a clear and immediate signal in response to potential safety concerns.

Ultrasonic Sensor

Responsible for obstacle detection, the ultrasonic sensor enhances the safety of bus navigation by identifying and signaling the presence of obstacles in the vehicle's path.

MQ3 Sensor

The MQ3 sensor plays a crucial role in continuous monitoring of the bus driver's sobriety, contributing to enhanced safety measures by ensuring the driver's fitness to operate the vehicle.

LCD Display

The LCD display serves as a real-time information panel for passengers, presenting alerts, and providing a visual representation of the current passenger count, contributing to transparent communication within the bus.

IR Sensor

The IR sensor efficiently counts passengers as they board or disembark, and it actively contributes to the automation of the bus door operations based on the presence or absence of passengers, streamlining the boarding process.

GSM Module

The GSM module enables real-time communication with authorities, facilitating the transmission of SMS alerts during instances of overloading. This feature ensures prompt intervention and compliance with safety regulations.

Door Open/Close Mechanism

The automated bus door system, controlled by the microcontroller, ensures the safe and efficient boarding of passengers. This mechanism adds an extra layer of safety and convenience to the overall transportation experience.

TABLE I. Comparison of Proposed Model and Traditional Model

Feature	Proposed Model	Traditional Model
Data Storage	Cloud storage of details for future analysis	No data storage or prediction
Overload Detection	Real-time with automated alerts	Manual Visual monitoring

IV. RESULT

The IoT-Based Passenger Overload Monitoring and Reporting System addresses critical issues of passenger safety and overloading in public transportation by providing real-time communication with authorities and cloud-based data storage for future analysis and decision-making. The system was validated through simulated overload scenarios, where IR sensors accurately counted passengers, with data processed by the Arduino Uno and displayed on the LCD. Upon exceeding passenger limits, the system triggered a buzzer and sent real-time SMS alerts via the GSM module. Data was stored in the ThingSpeak cloud, confirming the system's reliability in handling overload situations efficiently.

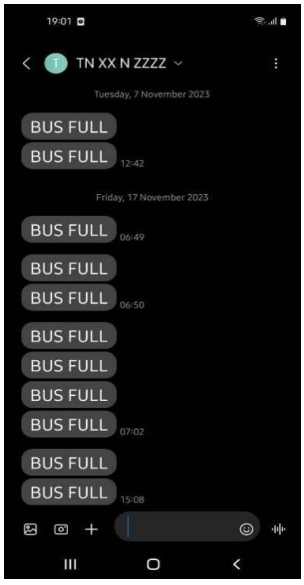

Fig. 2. Sending SMS to Authorities

The results shown in Fig. 2 utilizes infrared sensors to monitor real-time passenger counts. When the limit is breached, a crucial "BUS FULL" signal is triggered and swiftly communicated to relevant authorities through the SIM800 GSM module. This real-time alert mechanism ensures prompt action, enhancing passenger safety and compliance with capacity standards. Committed to revolutionizing public transport for improved safety and efficiency, the "BUS FULL" SMS remains a key component of this transformative initiative. ThingSpeak cloud platform efficiently stores real-time data, encompassing passenger count, date, and timestamp. This open-source system ensures data security, accessibility and establishes a foundation for future research. Emphasizing contemporary data management, the project enhances monitoring and supports well-informed decisions on public transport safety. Additionally, the stored data proves valuable for predictive analysis, contributing to providing high numbers of transport facilities.

Fig. 3 Chart Represents Overloading

Fig. 3 visually displays peak days of bus overloading, complete with specific time and date labels. This graphical representation allows for a quick evaluation of patterns in overloading incidents, providing authorities with a valuable tool to pinpoint high-demand periods. The chart improves monitoring capabilities and aids in data-driven decision-making to enhance both efficiency and safety within the bus transportation system.

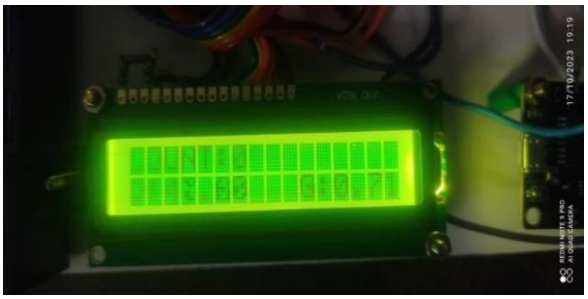

Fig. 4. Detection of Obstacles and Alcohol Sensor

Fig. 4 Illustrates that the integrated MQ3 sensor monitors the bus driver's breath, triggering alarms and alerting authorities if alcohol consumption exceeds set thresholds, ensuring driver sobriety and passenger safety. Additionally, the strategically placed ultrasonic sensor acts as an obstacle detection system, reducing the risk of mishaps.

Fig. 5. LCD displaying Bus Overcrowded

Illustrating a pivotal role, the LCD display and automatic door-closing system in Figure 5 significantly contribute to the safety and efficiency of the project. The LCD display acts as a real-time indicator, illuminating "Bus Full" when the Infrared (IR) sensor detects passenger counts surpassing the limit. This immediate alert informs passengers and triggers safety measures. The strategically placed IR sensor also actively participates in the automatic door-closing system, streamlining boarding processes, reducing dwell times, and emphasizing the project's commitment to passenger safety and transportation optimization.

V. CONCLUSION

The implemented IoT-based system for monitoring and reporting passenger overload presents a comprehensive solution to enhance public transit safety. The integration of infrared sensors, automated doors, and real-time communication effectively addresses overcrowding issues and ensures prompt response during emergencies. Enhanced safety measures include ultrasonic sensors for obstacle detection and the MQ3 sensor for continuous monitoring of the bus driver's sobriety. ThingSpeak's cloud-based data storage facilitates real-time monitoring and provides valuable insights for future enhancements. Automated door-closing technology improves operational efficiency by streamlining passenger boarding. Overall, this system signifies a robust and innovative advancement in public transport, offering commuters a more secure and reliable travel experience.

Future enhancements include leveraging predictive analysis and collected data to forecast passenger overloading, enabling proactive route adjustments and improved planning. Additionally, the system will be enhanced to directly communicate with emergency services, facilitating swift responses from medical services and the fire department in severe emergencies or accidents.

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