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Automatic vehicle accident detection and alerting notification using internet of things

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ABSTRACT

Immigrants in developing countries have indirectly encouraged increased automobile use, leading to a strong association between automobile accidents and their victims. However, recent technological developments, especially artificial intelligence and electronics, seem promising in overcoming these risks. This research paper focuses on complex systems developed using internet of things (IoT) technology. The system integrates various components such as micro controller, radio frequency identification (RFID) card reader for license validation, liquid crystal display (LCD), Ultrasonic sensor for interference, measuring device and global positioning system (GPS) unit. Additionally, the system has a simple mail transfer protocol (SMTP) server that can send timely email alerts to emergency responds and log email addresses for real-time emergency detection. This facilitates rapid response and emergency rescue, thereby reduces the risk of accidents and increases overall safety.

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1. INTRODUCTION

The massive population growth in developing nations has indirectly fueled the rapid motorization and widespread expansion of automobiles. This has made traffic accidents inevitable, which is contributing to the high number of fatalities and serious injuries. The situation escalated with unprecedented speed. The seriousness of this problem stems from the constant reporting of events occurring every minute, every hour, and every day around the world. The conditions range in severity from mild to fatal and often occur without warning. In some cases, the consequences of not immediately contacting local healthcare facilities or providing emergency services and first aid can be serious and cause people to fall. As the number of incidents continues to increase, the urgency of solving this difficult problem becomes clear, demonstrating the need for emergency measures to reduce the impact of accidents and provide information. The severity of the conditions can range from minor to fatal and often occurs in unexpected situations. Under certain conditions, an accident may result in the sad loss of life if information is not promptly communicated to the local healthcare facilities or if emergency services or first aid are not accessible [1]-[3].

Considering these conditions, it is important to create a system that can quickly assess the situation and close the gap between the outcome of the situation and medical assistance. The main purpose of proposed system is to create a system that will prevent accidents using various methods using internet of things (IoT) technology [4]. In addition, emergency services and relevant institutions can be notified and the system can be interrupted quickly. To achieve this, smart sensors need to be integrated into the microcontroller installed in the vehicle. These sensors are designed to be activated when an event is detected. Global positioning system (GPS) modules help determine the location and provide instant information to nearby medical facilities and relatives. In this study, data transfer via e-mail has been simplified by opening the simple mail transfer protocol (SMTP) server program to the IoT application [5].

Figure 1 shows graphical data of road accident in India from 2018–2020 (data published by ministry of road transport and highways, government of India). It is necessary to create an assessment of the situation, taking into account all the circumstances and work well enough to close the gap between the outcome of the situation and the treatment. The main purpose of the project is to create a system that can be used to prevent accidents using IoT technology. It also aims to identify and notify the appropriate emergency centers and interested parties to address the problem quickly [6]. To make the system successful, here an attempt is done to study various research based on this topic and outcome can be implemented using various electronics components mentioned earlier.

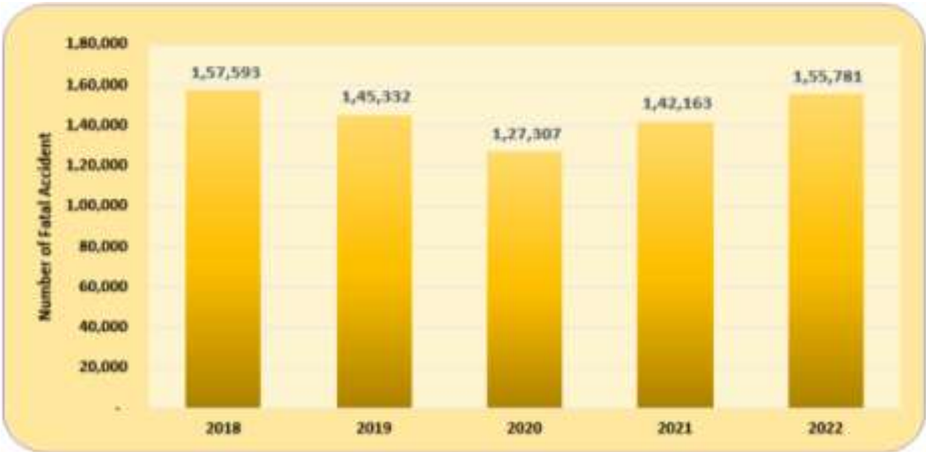

Figure 1. Trends in the number of fatal accidents in India: 2018-2022

2. LITERATURE REVIEW

Saida *et al.* [7] represents vehicle accident detection and alert system using IoT and artificial intelligence (AI). It offers a novel strategy for improving traffic safety by fusing AI and IoT technology. The technology uses an IoT-based gadget with sensors and machine learning algorithms to accurately identify accidents. The system guarantees prompt detection and warning of accidents by utilizing deep learning techniques such as convolutional neural networks (CNN) for picture processing and GPS for exact location monitoring [8]. When an event is detected, the system automatically notifies family members, neighboring hospitals and emergency services, which can save lives by speeding up response times. The research addresses important issues including real-time data processing and communication latency and demonstrates how well IoT and AI can be combined to produce a timely and trustworthy accident detection system [9]-[11].

In the article titled IoT-based Intelligent systems for vehicle presents an all-encompassing vehicle safety system that uses IoT technology to improve accident avoidance and monitoring. The system integrates multiple sensors, such as eye blink, vibration and alcohol detection using an ESP32 micro controller to monitor and react to possible hazards such driver weariness, drunk driving and accidents. GPS and GSM devices enable real-time car tracking and anti-theft alarms; the Twilio platform and Blynk app handle communication and control [12]. The system’s design prioritizes dependability, affordability and user-friendliness with the goal of delivering precise and fast safety alerts along with information. Evaluations conducted in the real-world show that the system is effective in improving vehicle safety and encouraging responsible driving, even in the face of obstacles like sensor calibration and data accuracy. This substantial advancement in intelligent car systems is represented by the integration of cutting-edge IoT components and machine learning algorithms which could enhance overall road safety and driver well-being [13]-[16].

In order to improve emergency response times [17], the study suggest an advanced car accident detection and localization system that makes use of GPS and GSM technology. The system efficiently recognizes and transmits accident occurrences by combining parts such the ATmega328 micro controller, SIM800 GPS module and SIM800 GSM modem. It also includes an ADXL 345 3-axis accelerometer [18]. When accelerometer readings indicate an accident, the system notifies pre-configured emergency contacts by SMS with exact geographic coordinates. By using GPS for precise location tracking and GSM for dependable message transmission, this strategy reduces emergency response times and attempts to lower death rates by enabling timely medical aid. The system's accuracy in monitoring the driver's condition is further enhanced by the addition of an eye blink sensor, which completes the package for improving road safety and emergency response [19]-[21].

An enhanced IoT based accident detection and warning system is presented with the goal of minimizing the effects of auto accidents by guaranteeing prompt emergency response [22]. The system uses a Raspberry Pi and a variety of sensors to monitor and identify accidents. It then uses machine learning methods, like decision trees to classify the accidents' severity in real time [23]. When it detects an accident, it uses cloud technology to notify emergency agencies of critical information like the accident's location and severity. The integration of machine learning algorithms improves the system's incident classification ac-curacy, which maximizes the distribution of rescue resources. This system's notable dependability and cost-effectiveness make it particularly advantageous for implementation in low- income areas where prompt medical attention is often missing but crucial. This study emphasizes how emergency response times and outcomes after traffic accidents can be enhanced by utilizing IoT, Raspberry Pi, and machine learning [24]-[26].

Priyadharshini *et al.* [17] offer the automated car accident alert system using IoT, which provides an Android-based application intended to promptly alert emergency contacts and services in the case of a car accident [27]. The technology immediately initiates warnings upon detecting accidents by utilizing built-in sensors for impact detection and GPS for precise location monitoring on Android devices. By drastically cutting down on reaction times, this feature will hopefully notify emergency services and designated contacts as soon as possible [28]. By enhancing emergency response co- ordination and guaranteeing prompt action, the integration with 911 has the potential to save lives. This system offers automated, effective, and integrated solutions for improving road safety and emergency response effectiveness, which is a significant improvement over conventional manual alert systems [29], [30].

Some existing systems incorporate machine learning techniques, which increases the system's cost. Some systems use the GPRS network for internet connectivity, which includes the cost of the GPRS service provider. The proposed solution communicates over the internet of one of the passengers in the vehicle, lowering the additional cost of communication.

3. SYSTEM COMPONENTS

This system integrates several key technologies to enhance vehicle safety and emergency response. radio frequency identification (RFID) is used to verify that only licensed drivers operate the vehicle by scanning driver's licenses [31]. The ESP32 microcontroller, programmed within an IoT framework, coordinates sensors and is capable of automatically alerting authorities in the event of a serious accident. The GPS provides precise location data, which is sent to the cloud to indicate the severity and exact location of the incident, ensuring swift ambulance response [32]. The GY-61 accelerometer measures acceleration across three axes to detect sudden movements, while ultrasonic sensors monitor the vehicle's surroundings to alert the driver of nearby obstacles [33]. Wi-Fi connectivity enables the ESP32 to access the internet, facilitating communication, including sending emails via SMTP when incidents occur. An liquid crystal display (LCD) screen [34] displays crucial messages like "Drive slow" or "Wi-Fi Connection," providing real-time feedback to the driver. Together, these components form a comprehensive system aimed at improving vehicle safety and emergency response efficiency.

4. METHODS (PROPOSED SYSTEM)

As a cost-effective solution, here car accident detection and alerting system make use of ESP32, a low-cost, high-speed micro-controller and the driver's mobile internet services as shown in Figure 2. It uses RFID tag reader to validate the driver's license. Additionally, it makes use of an ultrasonic sensor to calculate distance without the need for a machine learning technique, saving computational resources and lowering costs by enhancing detection latency. The suggested system would send an emergency email with the position of the car to a cloud server, which would then send an ambulance service emergency alert to the closest hospital. Figure 3 shows the flow of data of sensors with the microcontroller. Figure 4 shows the flowchart of the proposed system.

The prototype system that has been developed detects the accident instantly and informs the concerned people and authorities. In this prototype model, ESP32 micro controller is considered as the core of the overall system. It is considered as it is low power on-chip micro controller which has in built Wi-Fi and Bluetooth module. In addition to this it is battery friendly. The different sensors are interfaced to ESP32 which detects the various aspects of the vehicle functioning and drivers' condition while driving in order to ensure maximum safety. The different cases considered in this prototype system are:

- When the vehicle is hit from X or Y direction, there is a change in speed.
- The system, which detects whether there is a problem near the vehicle, is designed to send an advance warning or a warning for safe driving.

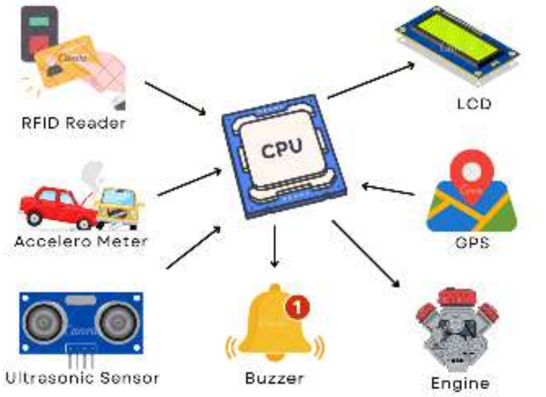

Figure 2. Block diagram of the proposed system

Figure 3. Data flow in the proposed system

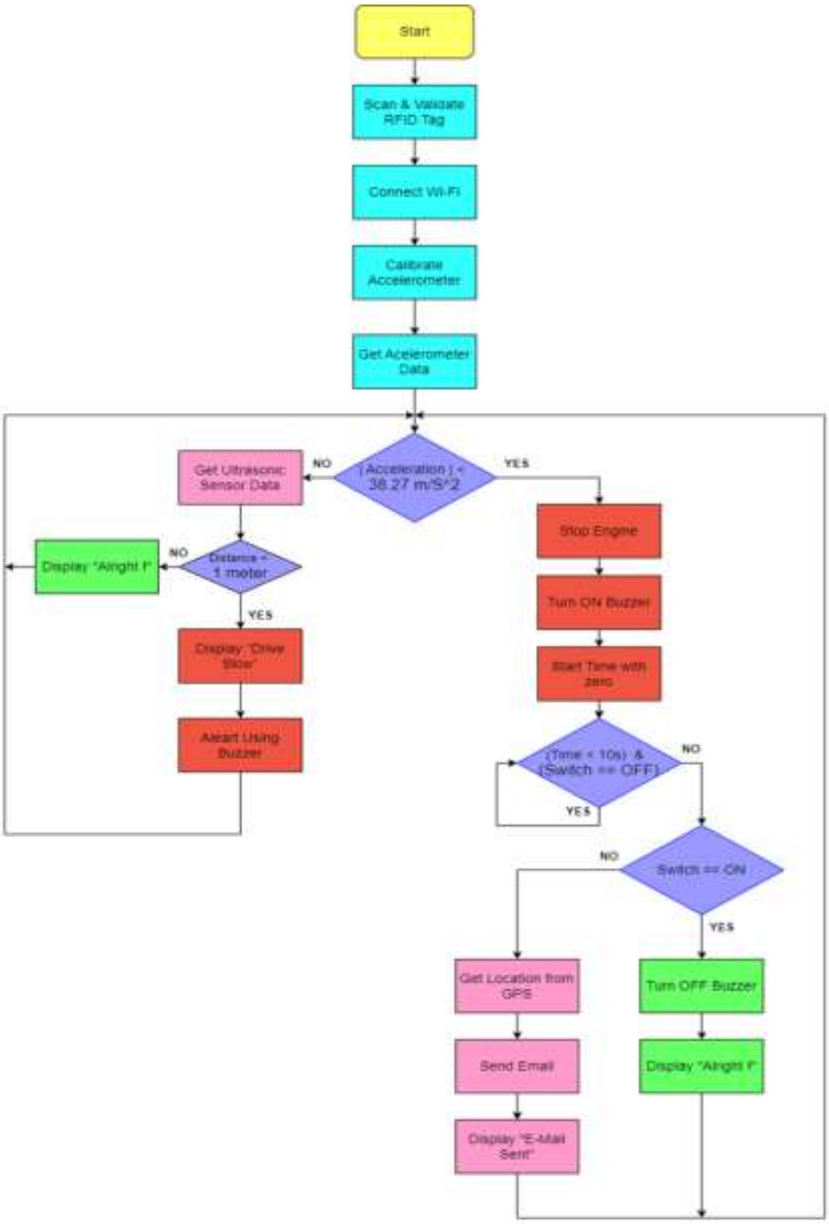

Figure 4. Flowchart of the proposed system

a) Step I: when the engine starts up, the system must first scan for licenses before allowing the engine to run. If this scan is not finished, the engine stays inert and cannot be started again until the license has been correctly checked. This safety measure improves system security and guarantees compliance with licensing requirements. Figure 5 shows the process to scan for the license. The system prioritizes safety and compliance by enforcing this requirement, hence reducing possible dangers and unauthorized access.
b) Step II: immediately after a license scan is completed, the system shows a confirmation message that reads “Successful”. Figure 6 shows the successful attempt is done. Once this validation is finished, the engine is quickly turned on and prepared to perform as intended. This smooth transition indicates that authorized access has been provided and all relevant licensing requirements have been satisfied, indicating that the system is ready to move forward with operational tasks. Users can interact with the engine with confidence as it starts up, knowing that their license status has been verified.
c) Step III: connecting to the embedded systems platform’s Wi-Fi network is the next step. Once the engine has been started and the licensing procedure has been finished, the device starts a scanning process to find Wi-Fi networks that are accessible in its immediate area. Through this scanning procedure, the system is able to pinpoint the precise network that is connected to the ESP, allowing for smooth device interaction and communication. The system’s functionality and possible uses are further expanded by connecting to the ESP and utilizing its resources and capabilities. The system is ready to take advantage of all the capabilities and services made possible by this connectivity now that the Wi-Fi connection has been made and the ESP network has been located as shown in Figure 7.

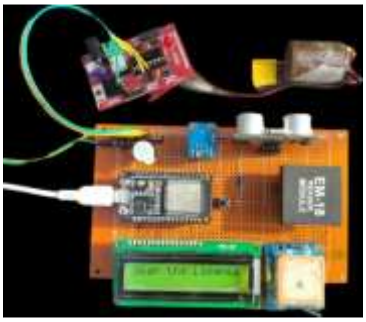

Figure 5. Scan the license

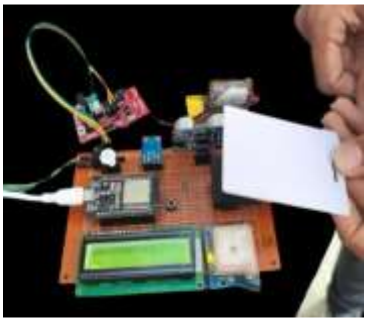

Figure 6. License scan successful

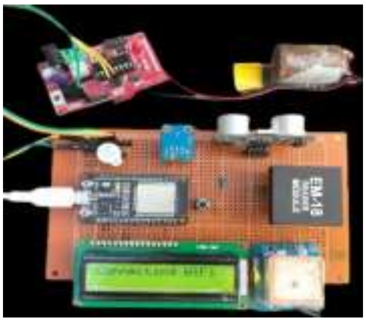

Figure 7. Connecting to Wi-Fi

d) Step IV: the system immediately shows a comforting message verifying the status after successfully connecting to the Wi-Fi network: “WiFi connected”. As shown in Figure 8, this message informs the user right away that their device is now connected to the specified network, allowing them to access data transfers, online services and other functions that rely on the internet. Users can confidently continue with their tasks as the message gives a clear and straightforward signal, removing any doubt regarding the connectivity status. This smooth integration improves user experience by enabling effective interaction and communication in the digital world.
e) Step V: now that the engine has started and all systems are primed, the traveler is prepared to set out. When license verification, WiFi connectivity and engine starting are all completed, the action is signaled. The engine’s readiness signals the start of any journey be it a drive, a chore or an adventure. Equipped with confidence on the functionality and compliance of the system, the user can go towards their desired destination with assurance. Figure 9 shows the starting confirmation of engine to the traveler.
f) Step VI: as an essential safety precaution, the ultrasonic sensor carefully searches the area for any potential impediments that could be dangerous if overlooked. When the system notices one of these dangers, it immediately sounds a buzzer alarm, alerting the driver to the impending risk. Concurrently, a warning sign that reads “Drive Slow” appears as shown in Figure 10, acting as a visual signal to be cautious and slow down appropriately. The driver can take proactive steps to reduce the likelihood of an accident by being instantly alerted of any upcoming risks by synchronized reaction mechanism. The technology improves road safety by integrating visual and audio inputs, creating a responsive and alert driving environment.
g) Step VII: the system reacts by showing a reassuring message, usually “Alright,” indicating that the immediate threat has been avoided once the object leaves the ultrasonic sensor’s danger range. Figure 11

confirms the message on LCD. Simultaneously, the buzzer that was previously activated is turned off, so stopping its warning sound. This coordinated response guarantees that the motorist gets unambiguous information about how the hazard has been resolved, enabling them to confidently resume regular driving circumstances. The” Alright” message provides reassurance that everything is safe once more, giving the driver and passengers a feeling of stability and confidence.

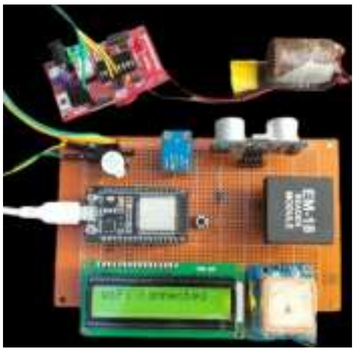

Figure 8. Wi-Fi connected successfully

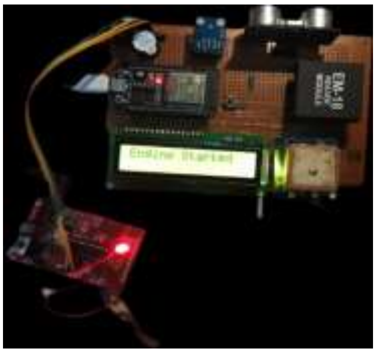

Figure 9. Engine (motor) started

Figure 10. Alert to drive slow

h) Step VIII: the accelerometer quickly identifies any abrupt acceleration that exceeds the pre-established threshold for typical conditions when there is a bump along the X or Y axis, regardless of direction. As soon as it detects something, the system prompts the driver to “Push the Button if Safe.” As shown in Figure 12 concurrently, the buzzer sounds a characteristic ringing sound, alerting people to the alert right away. The driver is prompted by this proactive response mechanism to evaluate the situation and if it is judged safe, to act by pressing the appropriate button. The technology enables quick decision making by giving audio cues and explicit directions, enabling the driver to prioritize road safety while successfully responding to unforeseen circumstances.

i) Step IX: the SOS GPS trackers are automatically activated by the system, if the designated button is not hit for ten seconds after the first alert. These trackers pinpoint the user’s exact location at any given time by using satellite positioning systems. They also constantly track the user’s location and status in real time, making it possible to provide help right away if necessary. This seamless GPS integration is a vital safety precaution that gives users and their families peace of mind by facilitating quick reaction and aid in an emergency as shown in Figure 13.

j) Step IX: as the user need assistance, an email alert is sent out right away via the SMTP server with all the important information, including the user’s location at the accident scene presented in Figure 14. Responders can easily get the precise coordinates by using the Google Maps link that conveniently contains this location information. At the same time, emergency services are immediately notified, allowing for quick action and the delivery of assistance to the user’s location. The user’s total safety and security is improved by the smooth integration of email notifications, GPS position sharing through Google Maps and real-time coordination with emergency services, which guarantees prompt aid and response in an emergency.

The email that was sent after the accident as shown in Figure 15 and includes important details about what happened. The email contains information on the accident, including the time and place, along with a link that allows the user to view their exact location on Google Maps. With the help of this thorough notification, responders will be fully prepared to provide a prompt and efficient reaction. Furthermore, the email is a vital line of contact for arranging emergency services and giving the person in need of aid the help they need.

When the message link is opened using Google Maps, the view in Figure 16 shows the latitude and longitude coordinates of the accident location. Responders are provided with an accurate and efficient way to navigate to the accident scene easily with graphic representation, which shows the actual location of the incident. The user’s coordinates are automatically converted into a map display by utilizing Google Maps, which offers contextual information to support emergency response activities. By integrating geographic data, rescue operations become more successful and help may be quickly provided to the user who needs it.

Hence in the proposed system, ultrasonic sensor is used for the detection of any sort of obstacles that might come in contact with the vehicle. Accelerometer GY-61 is incorporated for the accurate measurement of acceleration. The acceleration is measured in three axes which are X, Y, and Z directions. Positive and negative acceleration are measured by X and Y axes respectively. Along with these sensors the GPS module is incorporated to detect the vehicle location and for sending the notifications to the related people and authorities respectively. The SMTP Server allows to send emails to registered email address whenever accident is detected.

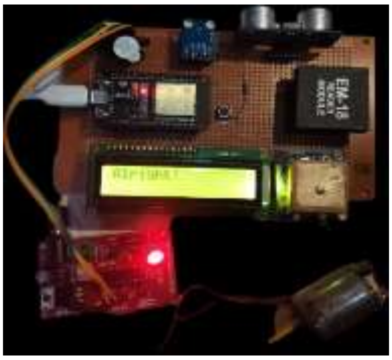

Figure 11. Safe to go

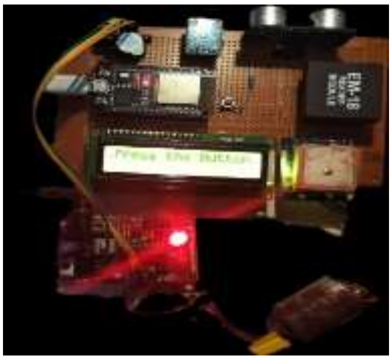

Figure 12. Press the button in good condition

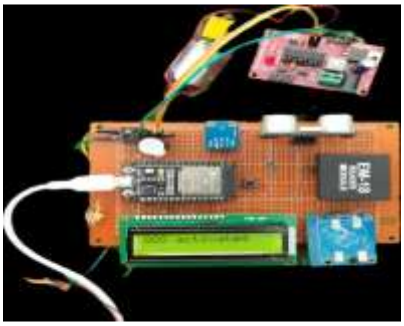

Figure 13. SOS activated

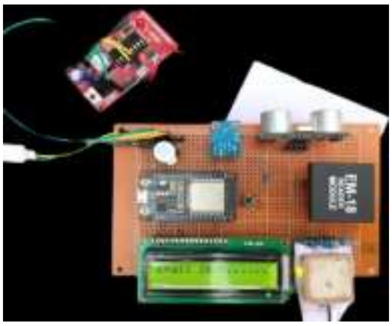

Figure 14. Email sent

5. RESULTS AND DISCUSSION

The system was carefully tested under various scenarios to assure its dependability and effectiveness. It accurately identified the distance between vehicles using ultrasonic sensors and successfully informed drivers when the distance was less than 1 meter, so preventing potential collisions. During simulated accident scenarios, the system consistently asked the driver for confirmation. If no answer was received within the 10-second time frame, the system immediately forwarded an email to the nearest hospital with the vehicle's GPS location via a cloud server. The system's efficiency in emergency response was demonstrated by the consistent end-to-end latency from accident detection to email notification, which was less than one minute. The GPS location accuracy was within a 100- meter range, allowing emergency services to find the vehicle quickly. Figure 15 shows the e-mail warning coupled with the location details received from the system and Figure 16 shows the system's location on the map. Overall, the system performed well in terms of accident prevention and emergency service alerts, demonstrating its potential to improve road safety and minimize emergency response times.

Figure 15. Notification email

Figure 16. Location on map

6. CONCLUSION

With this technological growing era, tremendous advancements take place all throughout the world. One of the newest and most promising technologies is IoT. A system built with IoT technology can produce results in a way that is more organized and logical. There is an enormous increase in the number of traffic accidents. When an accident happens, the person's life is the most important consideration. The terrifying threat of fatalities often exists due to both a lack of assistance and a delay in learning about the event. To combat these circumstances, IoT based technology assists in quickly identifying the accident scene and pinpointing the vehicle location. It then promptly notifies surrounding medical facilities and concerned family members of the emergency to prevent and monitor accidents in real life, a more effective system such to this one may be incorporated into automobiles during the production process. Using more precise GPS for location tracking and Lidar technology for distance measuring can improve the accuracy of the suggested system. A government can easily discover the data of automobile accidents in a specific location by utilizing this IoT technology.

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