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An IoT Enabled Real Time Communication and Location Tracking System for Vehicular Emergency

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Abstract: **The concept of remotely connecting and monitoring real-world devices or things over the internet is known as the Internet of Things or IoT. Various IoT solutions and services can make our life easier and even safer. With the continuous rise in the number of accidents and criminal activities occurring on the roads every year, developing an IoT enabled special system for vehicular emergencies can make a lifesaver system. In order to detect different predefined vehicular emergency situations, an IoT-enabled real-time communication and location tracking system for vehicular emergencies is developed in this paper. It then sends the location information and emergency type to the relevant parties, such as family members, the closest hospitals, and police stations through a SMS. Immediately after meeting with an accident or any other medical or criminal emergency, the system either detects the emergency and starts automatically or maybe triggered manually, depending upon the type of emergency the system initiates communication with the central control room/ hospital/ rescue team/ po- lice and shares critical information like emergency type, location information with easy to access link to the google location, name of the owner of vehicle and also the details of the vehicle like registration number, car make and model, colour, etc. The prototype of the proposed system is developed using an Arduino Uno board, GSM modem, GPS modem and uses a MEMS accelerometer for detecting the accident automatically.**

Index Terms: **Industry 4.0, IoT, Tracking and Safety, Cloud Application, Wireless Communication.**

I. Introduction

In the current era dominated by the Internet, there is a rapid transition toward smart cities and living, characterized by interconnected devices. The Internet of Things (IoT) plays a pivotal role in realizing this vision of a smarter world, fundamentally altering our lifestyles. Many developing nations are actively pursuing initiatives to convert their cities into Smart Cities through various projects. Modern automobiles exemplify this trend, boasting sophisticated sensors, software, and embedded hardware aimed at preemptively detecting and preventing collisions. While these advanced safety systems are invaluable for both drivers and passengers, they possess limitations. In the event of a system failure or a non-collision-related emergency such as driver illness or mechanical malfunctions, these systems prove ineffective. Shockingly, statistics indicate that in India alone, approximately 141,525 individuals lost their lives in road accidents in 2014, with delays in emergency response contributing significantly to fatalities. Thus, there exists a critical need for solutions that enable immediate transmission of accident information to relevant authorities, potentially saving lives.

This paper describes a position tracking and emergency communication system designed for certain vehicle emergencies.. Its primary objective is to mitigate damages following incidents such as accidents by promptly alerting hospitals and police stations. Additionally, it addresses medical emergencies and criminal incidents. Upon encountering an emergency, the system activates automatically or via manual triggering based on the situation, transmitting an emergency message to the control room. Subsequently, the control room forwards this message to the nearest appropriate authority (hospital, police station, government office) based on the emergency type. Notable features include a comprehensive range of potential emergencies and manual control room intervention for directing messages to the correct authorities promptly.

Our proposed system offers an effective, economical, and real-time approach to preventing vehicle accidents. Upon surpassing pre-established threshold levels, the system triggers an alert. If the driver fails to respond within a designated timeframe, the system intervenes by discontinuing fuel supply to the vehicle [1]. iHELM implemented a pragmatic model merging IoT and machine learning to address this concern. It identifies accident scenarios, distinguishes false positives, and promptly notifies the relevant authorities regarding the rider's condition [2]. A study on IoT and machine learning-based intelligent rescue team accident detection model was presented [3]. A Smart City's Emergency Rescue Services saw the development of an IoT-based Accident Detection and Management System, incorporating VANET architecture. This system leverages the Internet of Things and vehicular ad hoc networks to prioritize emergency vehicles. Its primary objective is to detect accidents promptly and deliver timely medical assistance [4].

A system based on the Internet of Things is suggested to guarantee the constant observation of a vehicle's operating parameters, such as number of applications of hard brake, the speed and driving quality. [5]. IoT assisted Automatic Smart Phone with detection of accident and alerting System. It can assist with accident detection and send out notifications to adjacent hospitals. [6].

Drowsiness detection for motorized vehicles employs computer vision technology and integrates Web Push Notifications to alert drivers before potential accidents happen [7]. A system designed to expedite the transmission of accident information to ambulance services utilizes a

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model that detects accidents and promptly notifies the ambulance service of their locations [8].

A smart accident detection model for rescue teams, integrating Internet of Things and machine learning, was put forward. It includes an IoT module capable of identifying accidents, collecting accident-related data such as location and pressure [9]. We propose a design for an accident detection system tailored for motorcycles, aimed at promptly informing the emergency contact of the injured motorcycle rider about their exact location, facilitating timely medical assistance [10]. A telegram-based notification system was proposed [11].

A system named CBITS was introduced, featuring a network of sensors capable of delivering real-time emission levels and promptly notifying authorities of accidents along with their locations [12]. This paper introduced the IoT-based Smart Accident Detection and Insurance Claiming System (ISADICS). It automatically notifies nearby hospitals, police departments, and insurance companies to expedite their response to the accident scene and fulfill their responsibilities [13]. A system for automotive accident detection and classification (ADC), based on IoT technology, utilizes both the built-in sensors of smartphones and connected sensors to not just detect but also identify the type of accident. [14]. In this paper, it was suggested to place a device/gadget in cars that can automatically identify accidents and notify the closest hospital. [15]. A thorough evaluation of the many approaches currently in use for foretelling and averting traffic accidents is provided, emphasizing their advantages and shortcomings [16]. Proposing an Online to Offline Interaction framework termed as Dilated Casual Convolutional Neural Network (O2O-DCNN) for predicting urban crowd flow [17].

A strategy involving intelligent transportation systems (ITS) utilizing connected vehicle technology infrastructure. Real-time computer vision, inspired by YOLO v4 (You Only Look Once), is employed for efficient detection of vehicles, pedestrians, and animals [18]. In this paper, there was discussion of a thorough assessment of the literature showcasing IoT devices for women's safety. [19]. An IoT system for smart homes was proposed [20,21]. A real-time flood monitoring system using IoT was proposed [22]. IoT based slope monitoring was proposed with can communicate using LoRA techniques [23]. A cloud based alert system was proposed and notification popup using OpenGTS and MongoDB [24]. Comparison of various communication protocols was discussed for better and swift communication and queue-telemetry transport protocol suited better form seismic activities monitoring and prediction [25].

The proposed IoT-enabled system for vehicular emergencies offers swift detection and communication of critical information to family, hospitals, and law enforcement. By swiftly detecting and notifying concerned parties about various predefined emergencies, including accidents or medical and criminal incidents, the system significantly reduces response time. This timely dissemination of critical information to family, hospitals, and law enforcement facilitates prompt intervention and coordination. With automated or manual triggering capabilities, coupled with comprehensive details shared, such as vehicle owner's name and registration details, the system ensures swift and effective assistance, potentially saving lives and minimizing the impact of emergencies on individuals and communities.

II. Design And Methodology

Figure 1 represents the block diagram of the system. The paper is combined a vehicular emergency detection mechanism with a Vehicular tracking system. Hardware used in this paper are listed below:

- Arduino Uno
- GSM Modem (Sim 900a)
- GPS Modem
- MEMS Accelerometer ADXl335
- LCD Interface.

Figure 1. Block Diagram of the system

The block diagram explains the working procedure of the system which is designed for this paper. An Arduino UNO is used here for automation and controlling of the other supporting devices like GPS, GSM, Accelerometer, LCD display, push buttons, etc. This paper gives a practical model of a vehicle emergency detection and rescue information system which can do routing, tracking of vehicles as well as detect accidents or other vehicular emergencies over a large geographical location. Figure 2 represents the schematic and Figure 3 the flow chart of the system. This system consists of two sections, the first one is tracking of location of the vehicle which is done by the GPS module simultaneously as the car moves from one location to the other, the GPS finds the location in terms of two coordinates that are the longitude and the latitude. These two coordinates communicate with GSM modem which is shown in the block diagram. The second one is detection of accidents through MEMS Accelerometer (ADXL335) sensor. To detect accident, a threshold is set to a minimum and maximum axis value of the sensor, If the change in axis value is greater than the threshold value, then it will consider that accident has occurred. There are two push buttons employed in the system, each one for medical and criminal emergencies, both the push buttons for criminal and medical emergencies are manual triggers which are pressed only during specified emergency situations.

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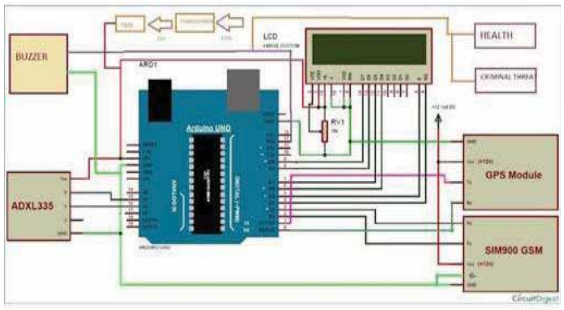

Figure 2. Schematic of the system

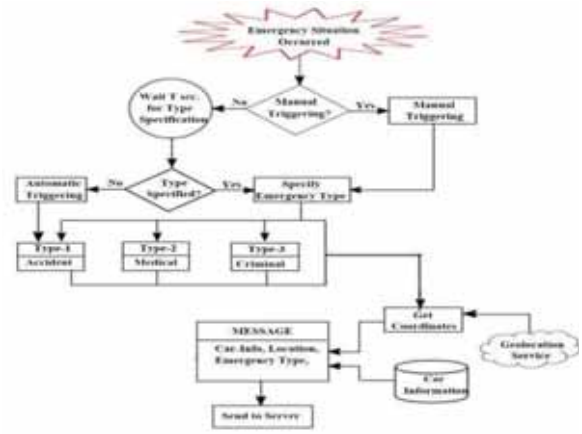

Figure 3. Flowchart of the system

After detection of an accident or it detects whether any of the medical or criminal emergency button is pressed, the system sends the vehicular emergency location in the form of a Mobile SMS to the registered phone numbers of the family, police station, rescue team, hospital, etc. Table 1. Shows the details of the Emergency Type and Respective Contact Authorities.

TABLE-I.
DETAILS OF EMERGENCY TYPE AND RESPECTIVE CONTACT AUTHORITIES

Emergency Type	Mode of Activation	Emergency Message	Contact Authorities	Emergency Priority
Type-1 Accident	Automatic/ Manual	Emergency type, car info, Location info	Police station and Hospital	High
Type-2 Medical Emergency	Manual	Emergency type, car info, Location info	Hospital	High
Type-3 Criminal Threat	Manual	Emergency type, car info, Location info	Police station and hospital	High

A. Circuit Diagram/ Hardware Connections

The hardware is designed to implement the system. The hardware will be installed in the vehicle and any user can track their vehicle during emergencies by using this system and also to any police station and hospital can get the notification of emergency through a Mobile SMS to push out any text that may try to fill in next to the graphic.

A vehicular emergency system plays a vital role in ensuring the safety, security, and reliability of smart cities. Its primary function is to activate automatically when a vehicle encounters an accident, tracking its location and promptly transmitting this information to the emergency control room. Subsequently, the communication is forwarded to the closest police station and hospital by the control room. Authorities at the hospital and police station evaluate the situation after getting the warning, then send rescue teams to the scene of the accident. Emergency situations are categorized into three distinct levels for effective management. Table 1 presents and type of emergencies and its associated authorities.

•Type-1(Accident): This is the most significant and common kind of emergency for a moving vehicle. The system notifies the control room or the registered mobile numbers of an emergency when a car collides or is involved in an accident.

•Type-2 (Medical): Occasionally It occurs that a driver or passenger in a car may suddenly get unwell and won't be able to find a nearby hospital, call for assistance, or travel to the hospital. If that's the case, they can manually activate the system by pressing a button, designating a medical emergency as the type of emergency. The closest hospital receives a notification from the control room designating this kind of incident as an emergency medical scenario, and the hospital responds appropriately.

•Type-3 (Criminal): In the event of a criminal incident, an automobile can also request assistance from the control room by employing this device

B. Real time implementation

GSM Module:

The GSM module is used to access the signals from carrier service and to establish communication between the victim at a location to the control room so that his emergency alert can be directed. The location and the type of emergency is sent through an emergency. The module generally consists of Vcc which is connected to 12v. Tx and Rx are connected to the Arduino Tx and Rx which is the Transmission and Receiving pair of communication lines enabling wired transfer between GSM module and Arduino. Ground is connected to the common ground point.

MEMS Accelerometer and Arduino:

The MEMS based accelerometer usually consists of FIVE Pins. Power Supply Pin Vcc works on 5v X Y Z which read the values of respective axes Ground Pin GND. Pin X Y Z are connected to the analog input pins A1, A2. The Vcc pin is connected to the 5 volts and ground is given to the common ground point.

GPS Module:

It keeps track of the current location, usually consists of four pins. The Power supply and Ground connections are given to +12v and common ground respectively. The Tx and Rx of the GPS Module are connected to the Tx and Rx of the Arduino to transfer the data to the, in essence the location details consisting of latitude and longitude details.

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LCD Display:

The LCD works on 5V power supply. IT's pins from D0 to D7 are connected to the Arduino board to 1 to 7 pins. It is also to adjust contrast.

Software Programming – Arduino IDE

The Java programming language powers the cross-platform Arduino integrated development environment (IDE), which is available for Windows, macOS, and Linux. It is used to engrave and upload programs on panels that are compatible with Arduino, as well as other vendor development boards with the use of third-party cores. The GNU General Public License, version 2, gives the IDE's source code unrestricted access. The Arduino IDE uses special rules for code composition to support the languages C and C++. A software library from the Wiring project is made available by the Arduino IDE and provides several input/output processes. Two fundamental functions are all that user-written code requires to start the sketch and the main program loop. These functions are combined with an executable cyclic executive package with the GNU toolchain and the IDE distribution, and are coupled via a program stub main (). The Arduino IDE utilizes a program to convert the executable code into a hexadecimal encoded text file, which is then uploaded into the Arduino board by a loader program embedded in the board's firmware. Figure 4 indicates the screenshot of mobile number registration.

Figure 4. Screenshot of mobile number registration

Arduino IDE stands out as a lightweight, cross-platform tool that introduces programming to beginners. Offering both an online editor and an on-premises application, it provides users the flexibility to save their sketches either on the cloud or locally on their computers. Renowned for its user-friendly interface, Arduino IDE can handle complex tasks efficiently without overburdening computing resources. Users benefit from easy access to contributed libraries and timely updates for the latest Arduino boards, ensuring compatibility with the latest IDE version. Figure 5. shows the GPS Coordinates displayed on the LCD Screen and Figure 6 shows the feed of the emergency contact number in LCD Screen.

Figure 5. GPS Coordinates displayed on the LCD Screen

Figure. 6. Feed of the emergency contact number on the LCD Screen.

III. Results and Discussions

Switch ON and start the system. The system displays "Getting the GPS coordinates", after few seconds it displays the Latitude and Longitude of the current location. Then the system displays "SEND MSG STORE MOBILE NUMBER", we need to send the mobile number to be registered through a SMS reading "*9xxxxxxxxx". The system displays the initial state of the MEMS Accelerometer, Health Emergency switch and Criminal Threat switch. Figure 7 shows the initial states of the switches.

Figure 7. Initial States of the switches

If the accelerometer detects any change in axis beyond threshold the state of the MEMS changes to "MOVED ACCIDENT" and the message with emergency type, location and other relevant information. Figure 8 depicts the change in MEMS Accelerometers Value and Fig. 9. Shows the screenshot of mobile SMS with Health emergency.

Figure 8. Change in MEMS Accelerometers Value

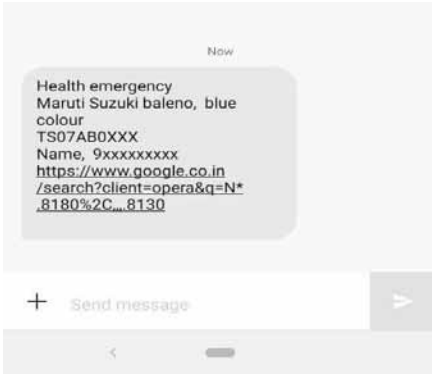

Figure 9. Screenshot of mobile SMS with Health emergency

If the Health emergency switch is pressed and the SW_H state changes to ON and the message with emergency type, location and other relevant information as shown in figure10 and figure 11 of criminal threat and accident respectively. The navigation to the location using link to google location is shown in Fig. 12.

Figure 10. Screenshot of mobile SMS with Criminal Threat

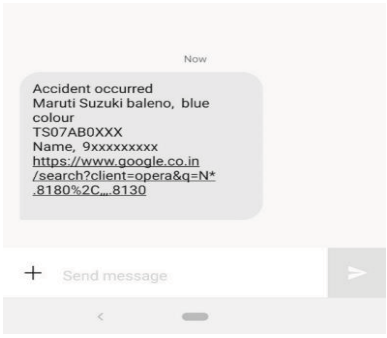

Figure 11. Screenshot of mobile SMS for accident alert

Figure 12. Navigation to the location using link to google location

IV. Conclusions

The system offers the following benefits.

Rapid Response: The system enables quick communication with relevant authorities, facilitating swift response to emergencies such as accidents or medical crises. This can significantly reduce response times and potentially save lives.

Customized Alerts: Tailored for specific vehicular emergencies, the system ensures that appropriate alerts are sent based on the type of incident encountered, whether it be a medical emergency, accident, or criminal activity. This customization enhances the efficiency of emergency responses.

Automatic Activation and Enhanced Safety: With automatic activation capabilities, the system can initiate emergency alerts without requiring manual intervention in critical situations. This feature ensures that help is summoned even if the vehicle occupants are incapacitated. By promptly alerting hospitals and police stations, the system contributes to improved safety outcomes following vehicular emergencies. It provides peace of mind to vehicle occupants and enhances overall road safety.

This paper concludes that Real Time Communication and Location Tracking System presented offers a vital solution for enhancing emergency response in vehicular incidents. With its automatic activation, customized alerts, and comprehensive coverage, the system provides a robust framework for mitigating damages and saving lives. Apart from automatic activation, it also indicated the type of emergency like Medical, Criminal Threat or Accident. By leveraging advanced hardware technology, it enables swift communication with relevant authorities, thereby ensuring timely assistance during critical situations. Implementing such a system not only improves safety for vehicle occupants but also enhances overall emergency management capabilities. As we continue to prioritize safety on the roads, the adoption of this system holds great promise for reducing the impact of vehicular emergencies and fostering safer communities.

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