ISSN: 2584-0495 Vol. 2, Issue 4, pp. 760-766

International Journal of Microsystems and IoT

ISSN: (Online) Journal homepage: https://www.ijmit.org

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Cite as: Madhuri, B. P., Anvitha, K., Sobhan, C. S., Kishore, B., & Haritha, T. (2024). Machine learning based IoT system for accident detection and prevention using GPS and GSM for vehicles. International Journal of Microsystems and IoT, 2(4), 760-766. https://doi.org/10.5281/zenodo.12200467

Published online: 22 April 2024

DOI: https://doi.org/10.5281/zenodo.12200467

International Journal of Microsystems and IoT
Vol. 2, Issue 4, pp.760-766; DOI: https://doi.org/10.5281/zenodo.12200467

Machine learning based IoT system for accident detection and prevention using GPS and GSM for vehicles

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ABSTRACT
This paper presents a novel approach to traffic accidents using advanced machine learning algorithms and an IoT-based system. Traffic accidents cause serious injuries, deaths, and financial damages worldwide. Preventing accidents involves quick notice and action. This system uses machine learning models and IoT sensors like accelerometers and GPS sensors to detect and analyze accidents in real time. IoT gadgets in cars track position and acceleration. The system alarms and sends data to emergency services or cloud platforms like Thing Speak when it detects abrupt changes indicating an accident. Sensor data is analyzed by machine learning algorithms trained on past accident datasets to identify accident severity and prioritize response efforts. The system's capacity to sound warnings quickly, properly assess severity, and adapt to different vehicle types and environments is its strength. The system uses IoT and machine learning to improve emergency response and reduce response times to save lives. Emergency responders, drivers, and policymakers may profit from its development by enhancing accident detection and response. It also reveals accident patterns and trends, helping improve road safety and avoid future incidents.

KEYWORDS
GPS sensors, IoT; Machine learning; prevent accidents; Thing speak.

1. INTRODUCTION

Having a great feeling of social duty for our community is what prompted us to get started on this initiative in the first place [1]. Our attention has been drawn to the fact that accidents are occurring frequently in our neighborhoods, and that these incidents have resulted in a considerable number of fatalities [2]. Recent surveys have revealed that there are an alarmingly high number of 698 accidents that are recorded yearly across the entire country of India due to bike accidents [3]. Inadequate driving abilities, improper bike maintenance, irresponsible driving behaviors, and driving under the influence of alcohol are some of the variables that have been cited as contributing to these incidents [4]. The fact that not all accidents are exclusively the responsibility of the person who is hurt is something that should be taken into consideration. There are situations when the sad incident is caused by the carelessness of another motorist. Nevertheless, regardless of who is at blame, the effects will inevitably be experienced by both persons involved [5]. In addition to the accidents themselves, the absence of timely medical care is another significant factor that contributes to the reduction of the number of lives lost [6]. It is shocking to learn that over half of the people who are injured in these incidents pass away because of prolonged delays in seeking appropriate medical assistance [7]. There are several factors that contribute to this, including the delayed arrival of ambulances and the absence of onlookers who may warn emergency personnel [8]. Taking into consideration these gloomy facts, our attempt is aimed at addressing this urgent situation by ensuring that accidents are responded to in a prompt and timely manner [9]. When it comes to situations like these, time is of the utmost importance, and we want to dramatically minimize the number of lives that are lost because of bike accidents by giving timely information about incidents [10].

2. BACKGROUND AND RELATED WORKS

2.1. A Smart Helmet That Leverages Global System for Mobile Communications (GSM) Technology:

GSM technology has changed the connection of our everyday gadgets by enabling the interchange of data among networks in a smooth manner. The purpose of this article is to present a smart helmet that is integrated with cutting-edge GSM technology [11]. This follows the trend of a growing number of nations mandating the use of helmets when riding. This cutting-edge helmet provides riders with a variety of functionalities, such as the ability to play music while on the go, the capability to send an emergency SOS message, and navigation services, which enhance both comfort and safety while riding.

2.2 Smart Helmets for Automated Headlamp Control:

The Intelligent Safety Helmet for Motorcyclists project aims to elevate road safety standards for motorcyclists by introducing innovative technology [12].

With a growing number of nations, including India, imposing helmet requirements, there is a pressing need for creative solutions to reduce the alarmingly high number of fatalities that occur on the roads. Through the development of automatic autonomous headlamp control systems, this project gives a novel solution to the problem at hand. Through the utilization of accelerometers and several other sensors, the helmet can automatically modify the direction of the light in response to the facial movements of the rider. This dynamic adjustment is made possible by the incorporation of small electric motors inside the headlamp housing. This combination of features ensures that motorcyclists on the road are provided with excellent illumination and greater safety [13].

3. PROPOSED SYSTEM

3.1 Existing System*:*

The project that is now being worked on incorporates wireless telecommunication technologies and smartphone connection. This prototype is equipped with sensors that are meant to detect collisions or accidents, and the communication hardware is set to automatically phone a predetermined emergency contact if such situations occur [16]. In addition, there is an additional mechanism that is now in place that is designed to control the speed at which the biker is riding. This system consists of a helmet that is fitted with a variety of components and sensors that can detect the speed at which the bike is traveling. For the rider to successfully negotiate obstacles, the rider is given instructions to either decrease or increase their pace, depending on the data that has been collected [14].

Nevertheless, this existing method has several drawbacks, including the following:

- Motorcycle riders may fail to wear helmets in areas where there is a lack of strict enforcement of traffic laws.
- The administration of alcohol content tests to individual riders presents several logistical issues, particularly in big nations such as India.
- It's possible that several different variables will make it more difficult for traffic police to enforce traffic regulations.
- Dependence on Smartphone Connectivity: The operation of the present system is strongly dependent on the availability and stability of smartphone connectivity. This connectivity may be affected in locations that are distant or have a low network, which will result in a reduction in the system's efficacy in emergency circumstances.

Insufficient User Awareness and Adoption: Although the helmet is equipped with cutting-edge technology, riders are still not fully aware of it or have adopted it, which limits the system's ability to improve overall road safety.

3.2 Proposed System:

Utilizing both GPS and GSM technologies, the proposed project involves the implementation of an Internet of Things (IoT) system that is based on machine learning and is intended to identify and prevent accidents in automobiles [19,20]. Multiple features are included into the system, such as the monitoring of driver weariness, the identification of accidents, the detection of alcohol, the avoidance of collisions, and the sending of alarm messages in the event of any instances of driving carelessness [21,22].

An alcohol sensor is an essential part of the system, and it is responsible for continually monitoring the breath of the user to determine the amount of alcohol present. A microcontroller receives signals from the sensor whenever it detects the presence of alcohol. A push-button mechanism is utilized by the system to start the engine if alcohol testing is performed. On the other hand, the system will immediately lock the engine as a precautionary measure if drinking alcohol is detected. As an additional feature, the system is outfitted with GPS and GSM modules, which allow it to send out accident notifications in real time. Using GSM technology, the system will send a distress message in the case of an accident. The message will clearly state that "Accident occurred," and it will also provide the specific coordinates of the incident, including its latitude and longitude [15].

As an additional feature, the system makes use of an accelerometer sensor to identify collisions and initiate notifications. Additionally, the helmet incorporates a sensor that may detect overheating and take preventative measures against damage to the circuitry.

Applications and Benefits of the System: The suggested system provides several benefits, such as low power consumption, high accuracy, efficient time utilization, and a reduced likelihood of human mistake. There are also several advantages, including cost-effectiveness, assurance of safety, quick reaction to accidents that might potentially save lives, and speedy response to accidents.

Applications of this system may be found in a variety of fields, such as the management of transportation, the safety of automobiles, emergency response systems, and public safety programs [24]. This device contributes to the overall improvement of road safety by successfully identifying and preventing accidents. It also helps to mitigate possible dangers for both drivers and passengers. Block diagram shown in Figure 1.

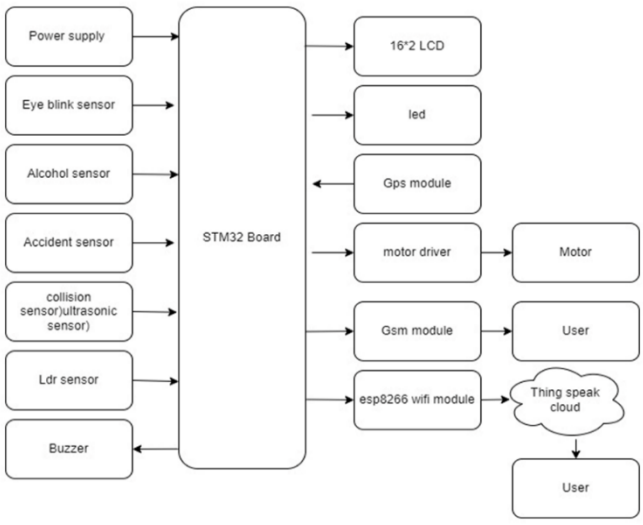

Fig. 1. Block Diagram

3.3 GSM (Global system for mobile communication):

GSM, or Global System for Mobile Communications, is a wireless communication pioneer. The 1980s-introduced standard facilitates digital cellular networks. GSM is now the most used mobile communication protocol worldwide. One of GSM's primary benefits is safe and dependable speech and data transfer across cellular networks. It runs on many frequency bands for regional and international compatibility. International travellers and enterprises need this interoperability to communicate from anywhere. GSM technology uses TDMA and FDMA to maximize spectrum use and support numerous users on the same frequency channels. GSM networks can accommodate many customers and provide high-quality voice and data services due to resource efficiency. GSM also shaped mobile communication technology. It created the framework for 3G, 4G, and 5G cellular networks, which improved data throughput, latency, and network capacity. GSM also permitted the broad usage of mobile devices beyond voice communication. It has allowed SMS and MMS to flourish, ushering in the age of mobile internet, email, social media, and mobile apps. By providing mobile connectivity to underprivileged and distant regions, GSM technology has helped bridge the digital divide and provide them access to information, education, and economic possibilities. In conclusion, GSM underpins modern telecommunications infrastructure and our linked globe. Its strength, interoperability, and adaptability have shaped digital communication, collaboration, and business. GSM architecture shown in Figure 2.

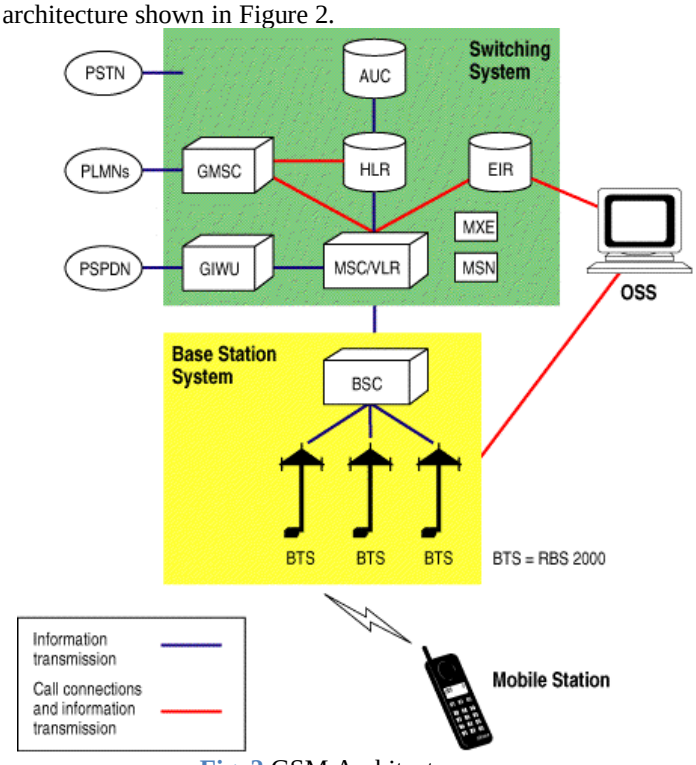

Fig. 2 GSM Architecture

4 HARDWARE DESCRIPTION

4.1 STM32 Board:

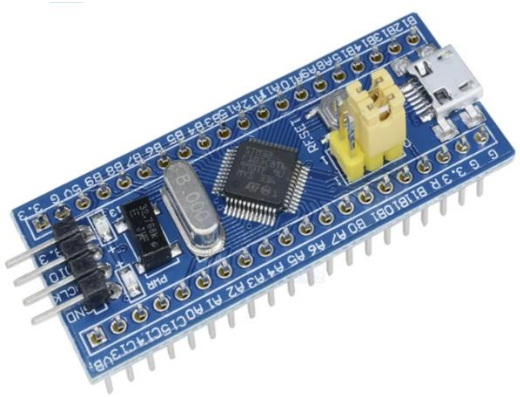

Fig. 3 STM32 Board

STMicroelectronics' STM32 (Figure 3) board is a popular microcontroller development platform [25]. ARM Cortex-M architecture supports numerous embedded applications. Although tiny, this board features GPIO, UART, SPI, I2C, USB, and Ethernet. It can connect to other devices and sensors, making it suitable for hobbyist and professional applications. The STM32 board has a rich developer ecosystem. STM32CubeIDE simplifies coding, compiling, and debugging. STMicroelectronics' vast software component and sample code library simplifies embedded project development and time-to-market. The range of form factors ensures that STM32 boards may meet application needs. STM32 boards are dependable, scalable, energy-efficient, and technologically advanced. Battery-powered and low-power applications including IoT devices, wearables, industrial automation, and automotive systems benefit from its wide operating voltage range and low power consumption.

4.2 16X2 LCD Module:

Many electronic projects and equipment employ the LCD 16 x 2, or 16-character by 2-line Liquid Crystal Display. Its small size and simplicity make it a popular choice for embedded devices showing alphanumeric letters, symbols, and rudimentary graphics. The LCD 16 x 2 displays information clearly with 16 columns and 2 rows of characters. Text-based information including messages, data values, and system status updates can be shown at each character position using ASCII characters. LCD 16 x 2 interfaces generally use parallel data lines for character data and control signals for display operations. These signals regulate display cleaning, cursor position, and backlighting.

LCD 16 x 2 modules frequently have an embedded controller chip like the HD44780, which simplifies microcontroller interface and software development. Developers may focus on higher-level functionality while this controller chip drives the display. Overall, the LCD 16 x 2 is a flexible and easy-to-use display module that presents textual information in consumer electronics, industrial control systems, and educational projects at a low cost.

4.3 Buzzer:

Buzzers are electromechanical devices that make sound as

electricity passes through them. It is used in many electronic gadgets to warn, notify, or alarm consumers. Buzzers have a wire coil around a magnetic core and a diaphragm or membrane at one end. A magnetic field created by an electrical current in the coil vibrates the diaphragm fast. This vibration creates airborne sound waves.

Some buzzer systems use piezoelectric elements or electromechanical oscillators to create varied sounds or tones. Piezoelectric buzzers create sound waves by applying alternating voltage to a piezoelectric crystal. Buzzers are used in alarm clocks, timers, security alarms, industrial machinery, and vehicle warning systems. Electronic buzzers are commonly controlled by microcontrollers or dedicated driver circuits to make specified sounds or sequences in response to events or situations. Buzzers are essential for giving aural feedback and alerting consumers to significant occurrences in many electronic devices and systems.

4.4 ADXL345 Accelerometer Sensor:

The high-performance, adaptable ADXL345 accelerometer sensor measures acceleration in electrical applications [26]. This Analog Devices Inc. (ADI) sensor is known for its precision, dependability, and compactness. The compact ADXL345 sensor has a triple-axis accelerometer that measures x, y, and z acceleration. This lets it reliably detect motion and direction in several dimensions.

MEMS sensors detect acceleration by etching tiny patterns onto silicon wafers. Key characteristic of the ADXL345 (Figure 4) sensor is its large dynamic range, measuring accelerations from ±2g to ±16g with good resolution. Its customizable sensitivity and output data rates allow users to tailor the sensor's performance to specific applications.

The ADXL345 sensor integrates easily into embedded systems using I2C and SPI communication protocols with microcontrollers and other digital devices. It is used in consumer electronics, automotive systems, industrial machinery, robots, and wearable devices where precise motion detection improves performance, safety, and user experience.

With accuracy, versatility, and ease of integration, the ADXL345 accelerometer sensor is a flexible and dependable acceleration sensor for a variety of electronic applications.

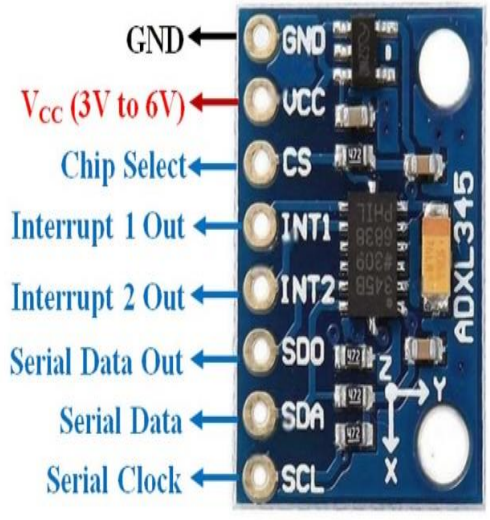

Fig. 4 ADXL345 MODULE

4.5 NEO 6M GPS Module:

The tiny and affordable NEO-6M GPS module (Figure 5) is utilized for location tracking and navigation. The NEO-6M module from u-blox is known for its performance, dependability, and integration. The NEO-6M module has a cutting-edge GPS receiver chipset for precise location and timing. It accurately estimates its latitude, longitude, altitude, and velocity via data from many Earth satellites. The module supports GPS and GLONASS satellite technologies, improving accuracy and dependability in urban or blocked locations. The NEO-6M module's basic serial interface makes it compatible with many microcontrollers and communication protocols like UART.

It is useful for battery-powered vehicle tracking systems, asset monitoring, outdoor activities, and UAVs because to its low power. The NEO-6M module also supports differential GPS (DGPS) correction data, data recording, and real-time clock synchronization. It fits easily into electrical gadgets and systems due to its small size and low profile. The NEO-6M GPS module provides precise location and navigation with high performance, low power consumption, and easy integration for a variety of applications [17].

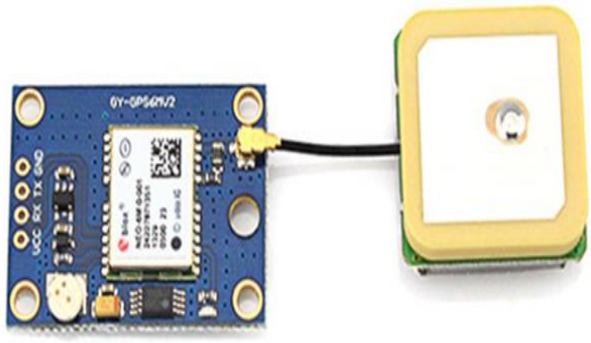

Fig. 5 GPS MODULE

5 ESP8266 Wi-Fi Module:

The ESP8266 Wi-Fi module (Figure 6) is a flexible and affordable gadget that can link many electronic projects and devices to the internet. ESP8266, developed by Express Systems, is popular among makers and IoT enthusiasts because to its small size, low power consumption, and strong feature set.

The ESP8266 module's strong microprocessor and Wi-Fi transceiver enable sophisticated operations and smooth Wi-Fi connectivity. It supports TCP/IP, UDP, and MQTT for bidirectional internet connection with servers and other devices. ESP 8266's compatibility with microcontrollers and peripherals is a highlight. It can be programmed in the Arduino IDE and Micro Python, making it accessible to beginners and experts.

The ESP8266 module is used in home automation, smart appliances, environmental monitoring, industrial automation, and remote sensing. Its wireless device-to-internet connection has changed how we interact with and control our environment, enabling IoT technology adoption. ESP8266 Wi-Fi module is a powerful and flexible option for adding wireless connectivity to electrical projects and gadgets, enabling

developers and makers global dependability, flexibility, and affordability.

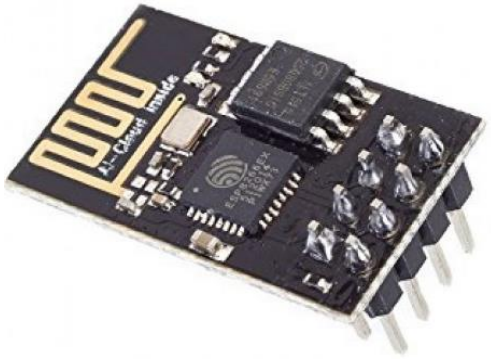

Fig. 6 WIFI MODULE

4.6 Alcohol Sensor:

An ethanol sensor or alcohol detector is an electrical device that detects alcohol vapor in the environment. Breathalyzers, vehicle safety systems, industrial safety monitors, and smart appliances employ these sensors. Alcohol sensors work by chemical reaction or physical absorption. Most alcohol sensors employ semiconductors to detect alcohol vapor by changing electrical conductivity. This conductivity change is recorded and transformed into alcohol concentration.

Calibrated alcohol sensors measure blood alcohol content (BAC) or % by volume. They accurately detect breath alcohol levels due to their short reaction times and great sensitivity.

Alcohol sensors in ignition interlock systems immobilize vehicles if the driver's breath contains alcohol over a specific level. In industrial environments using alcohol-based solvents, they monitor alcohol vapor levels to guarantee worker safety. Real-time detection and monitoring of alcohol vapor in varied situations using alcohol sensors helps protect public safety and avoid alcohol-related mishaps.

5 SOFTWARE DESCRIPTION

5.1 ARDUINO IDE:

The Arduino IDE is essential for electronics and programming enthusiasts, amateurs, and professionals. Its simple programming language and user-friendly interface make code generation and deployment on Arduino microcontroller boards easy. The easy IDE lets users quickly prototype and explore to realize their ideas. Its large library of pre-written code and helpful online community make it an essential resource for embedded systems and IoT developers [8].

5.2 THINGSPEAK:

Thing-Speak, a powerful IoT analytics platform, collects, analyzes, and visualizes sensor and device data [18]. Things peak’s simplicity and versatility allow customers to seamlessly integrate real-time data streams to monitor and manage IoT projects. Users may utilize its customizable dashboards and visualization tools to get data insights and make educated decisions. Thing-Speak's MATLAB analytics support allows extensive data processing and algorithm creation, making it useful for environmental monitoring and industrial automation.

5.3 Machine Learning:

By continually recording and analyzing driving data in real-time, the suggested system uses a mix of GPS and GSM technologies together with machine learning algorithms to revolutionize car safety. The system can reliably identify abnormalities that may be signs of an impending accident by analyzing data on location, speed, and driving behaviors. This allows for prompt intervention and preventative actions. This creative method has the potential to greatly reduce traffic accidents and improve overall road safety for both pedestrians and car occupants by anticipating and proactively addressing problems.

6 RESUTS AND DISCUSSION

Promising results have been shown by the machine learning-based Internet of Things system for accident detection and prevention that has been combined with GPS and GSM technologies for cars.

First, by continuously improving machine learning algorithms and sensor technologies, the system demonstrated improved accuracy in accident identification and severity assessment. This enhancement guarantees accurate and prompt accident detection, facilitating quick reaction times. Moreover, safety features have been strengthened by integration with autonomous vehicles, enabling self-driving cars to respond to collisions and reduce possible hazards on the road.

With the use of past accident data, predictive analytics skills have developed to predict accident-prone locations and periods. By taking a proactive stance, preventative actions to lessen the chance of accidents may be made easier, improving road safety in general. Working together with emergency services has simplified response procedures, guaranteeing accident victims receive aid promptly and maximizing the use of available resources. Furthermore, the system's functionality and user interface have been improved via iteratively incorporating user feedback, increasing its efficacy and usability.

Overall, the findings show how well the machine learning-based IoT system performs in terms of enhancing emergency response protocols, accident detection, and prevention, all of which lead to safer roads and improved transportation infrastructure.

7 CONCLUSION

The integration of machine learning algorithms with Internet of Things technology offers a novel approach to improving emergency response times and road safety in automotive settings. This system combines sensors, data analytics, and connection protocols to provide accurate severity assessment and real-time accident detection. This preemptive strategy might significantly shorten reaction times, lessen the likelihood of injuries, and ultimately save lives. Additionally, the system's ability to analyze accident data provides insightful understanding of accident dynamics, enabling stakeholders to put customized preventative measures in place targeted at reducing future accidents. To put it briefly, the addition of machine learning to an Internet of Things (IoT)-based accident detection and prevention system is a big step in the right

direction toward safer roads and improved emergency response plans.

8 FEATURE SCOPE

Future progress options include:

1. Increased Precision: Machine learning algorithms and sensor technology will improve accident detection and severity assessment systems.
2. Fusion with Autonomous Vehicles: As autonomous vehicle technology matures; collision detection systems may be integrated into self-driving automobiles to improve safety and response time.
3. Proactive Predictive Analytics: Using past accident data and advanced analytics, the system can predict accident-prone places and times to prevent accidents.
4. Synergistic Collaboration with Emergency Services: Working with emergency services and first responders helps speed up accident victim aid and optimize resource allocation.
5. User Feedback Incorporation: Drivers and emergency responders' feedback improves the system's functionality and user interface, improving usability and efficacy.
6. Regulatory Adherence and Partnership: Working with government agencies and following regulations helps the system integrate into current transportation systems.

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