

Vehicle to vehicle communication system using lora for intelligent road safety

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Abstract

Vehicle-to-Vehicle (V2V) communication is an emerging technology that significantly improves road safety by enabling vehicles to exchange important information in real time. This project proposes a low-cost and efficient V2V communication system using LoRa Technology integrated with Internet of Things for accident prevention and hazard detection. The system is designed to detect dangerous conditions such as fire, gas leakage, sudden impact, and vehicle tilt using multiple sensors mounted on the transmitting vehicle. The transmitter section continuously monitors the environmental and vehicle conditions through fire sensors, gas sensors, accelerometers, and vibration sensors. In addition, a GPS Module is used to collect the exact location of the vehicle during hazardous situations. The collected sensor data along with the GPS coordinates is processed by a microcontroller and transmitted to nearby vehicles using a LoRa Transmitter Module. LoRa technology is selected because of its long communication range, low power consumption, and reliable data transmission capabilities. On the receiver side, a NodeMCU module receives the transmitted information from the nearby vehicle. The received data is displayed on an I2C LCD Display to inform the driver about the type of hazard detected. Simultaneously, a buzzer alert is activated to provide immediate warning and attract the driver's attention. The system also uploads the sensor data to the ThingSpeak cloud platform for real-time. The proposed system offers a practical and affordable solution for improving road safety in both urban and rural areas. By enabling early warning communication between vehicles, the system can help reduce accidents, minimize damage, and save lives. Furthermore, the use of LoRa and IoT technologies makes the system energy-efficient, scalable, and suitable for future intelligent transportation systems.

Keywords-arduino,Gps,sensors,Lora,thingspeak,Node MCU.

Introduction

The rapid increase in the number of vehicles on roads has led to a significant rise in road accidents, traffic congestion, and hazardous situations. Many accidents occur because drivers do not receive warning information in time about nearby dangers such as fire, gas leakage, sudden collisions, or vehicle overturning. In most existing systems, communication depends mainly on cellular networks and internet

connectivity. However, these systems may not function properly in remote areas, highways, rural regions, or locations with poor network coverage. Therefore, there is a need for a reliable, long-range, and low-power communication system that can provide immediate alerts between vehicles. Vehicle-to-Vehicle (V2V) communication is an advanced technology that allows vehicles to exchange critical information directly without depending entirely on mobile networks. Through V2V communication, vehicles can send and receive warning messages related to accidents, fire, gas leakage, vehicle tilt, sudden impact, and GPS location. This early warning mechanism helps drivers take preventive actions before reaching dangerous areas, thereby reducing the possibility of accidents and improving overall road safety. V2V systems are becoming an important part of modern intelligent transportation systems because they support real-time communication and faster decision-making. In this project, Arduino Uno is used as the transmitter-side controller to collect information from various sensors. The system includes fire sensors to detect flames, gas sensors to identify harmful gas leakage, accelerometer sensors to detect vehicle tilt, and vibration sensors to detect sudden impacts or accidents. A GPS Module is also integrated to provide the exact location of the vehicle during an emergency situation. All the collected data is processed by the Arduino controller and transmitted to nearby vehicles using a LoRa Module. LoRa, which stands for Long Range communication, is a low-power wireless technology specially designed for IoT applications. It can transmit data over several kilometres while consuming very little energy. Compared to Wi-Fi, Bluetooth, or ZigBee, LoRa provides better communication range and is more suitable for highways, rural roads, and remote locations. Its ability to maintain stable communication over long distances makes it an ideal choice for V2V communication systems. On the receiver side, a NodeMCU receives the transmitted data from the LoRa module. The received information is displayed on an I2C LCD Display so that the driver can easily understand the warning message. In addition, a buzzer is activated whenever a hazardous condition is detected, ensuring that the driver gets immediate attention even if they are not looking at the display. The received sensor data is also uploaded to the ThingSpeak cloud platform for remote monitoring and data analysis. The proposed system is cost-effective, easy to implement, and highly useful for improving road safety. It helps drivers receive early warnings about dangerous situations and provides enough time to take corrective actions. Because of its low power consumption, long communication range, and cloud connectivity, this system can play a major role in future smart transportation and accident prevention systems.

Literature Survey

Vehicle-to-Vehicle (V2V) communication has become an important research area in intelligent transportation systems, aiming to enhance road safety, reduce accidents, and improve traffic efficiency. Early research in this field mainly focused on technologies such as Dedicated Short Range Communication (DSRC), Wi-Fi, and cellular networks. DSRC-based systems enable direct communication between vehicles with low latency and high reliability, but they are limited by short communication range and high implementation cost. Similarly, Wi-Fi and Bluetooth technologies have been explored for vehicular communication; however, their short range and high power consumption make them unsuitable for large-scale deployment in dynamic traffic environments.

With the advancement of cellular technologies, LTE and 5G-based V2V communication systems have been proposed to provide wider coverage and higher data rates. These systems rely on network infrastructure and offer improved connectivity in urban areas. However, their performance is highly dependent on network availability, and they may not function effectively in remote or rural regions. Additionally, the operational costs and energy requirements of cellular communication systems are relatively high, which limits their practicality for continuous vehicle monitoring and communication.

The emergence of the Internet of Things (IoT) has significantly influenced the development of smart transportation systems. IoT-based V2V communication integrates sensors, microcontrollers, and wireless communication modules to enable real-time data exchange between vehicles. Various studies have utilized technologies such as Zigbee and RF modules for short-range communication. While these approaches are cost-effective and easy to implement, they are constrained by limited communication range and reduced reliability in high-mobility scenarios.

In recent years, Low Power Wide Area Network (LPWAN) technologies have gained attention as a promising solution for long-range communication with low power consumption. Among these, LoRa (Long Range) technology has emerged as a suitable candidate for V2V communication systems. LoRa enables communication over several kilometers while consuming minimal energy, making it ideal for vehicular applications where only small packets of critical data, such as speed, location, and warning signals, need to be transmitted. Research studies have demonstrated that LoRa-based systems can effectively support applications such as collision avoidance, accident alerting, and traffic monitoring.

Several implementations of LoRa in vehicular communication have shown that it can operate efficiently even in areas with limited infrastructure. It provides advantages such as long communication range, low cost, and scalability. Unlike traditional communication systems, LoRa does not require continuous internet connectivity, which makes it highly reliable in rural and semi-urban environments. Researchers have also explored integrating LoRa with GPS modules to enable location-based alert systems, allowing vehicles to share their position and movement information in real time.

Despite its advantages, LoRa-based V2V communication systems also face certain challenges. The low data rate of LoRa restricts the transmission of large data such as images or videos. There may also be issues related to signal interference and packet loss in dense urban environments. Security and privacy concerns are another important aspect, as unauthorized access to vehicular data can lead to potential risks. Furthermore, high-speed vehicle movement can introduce latency and synchronization challenges in communication.

To address these limitations, recent research trends focus on hybrid communication models that combine LoRa with other technologies such as cellular networks, edge computing, and artificial intelligence. These approaches aim to enhance system reliability, reduce latency, and improve decision-making capabilities. For example, edge computing can process data locally to provide faster responses, while AI-based algorithms can predict potential accidents and generate timely alerts.

Existing System

In existing vehicle safety systems, most communication methods are based on GSM or GPRS networks. These systems use SIM cards and mobile internet to send emergency alerts, accident notifications, and vehicle location details. Although such systems are widely used, they depend completely on the availability of cellular network coverage. In areas where the network signal is weak or unavailable, the communication process becomes unreliable and ineffective. Another major limitation of current systems is their high operational cost. Since GSM-based communication requires SIM cards, data packs, and network subscriptions, the maintenance cost becomes higher for users. In addition, continuous internet connectivity is necessary for sending and receiving information, which increases dependency on external service providers. This makes the system less suitable for low-cost vehicles and rural transportation applications. Existing vehicle safety systems also suffer from delayed response times during emergency conditions. When an accident occurs, the information must first be sent to a server or cloud platform before reaching other users or emergency services. This indirect communication process increases the delay in alert generation and may reduce the chances of preventing further

accidents. Immediate warnings are very important during fire accidents, gas leakage, vehicle tilt, or sudden collisions. Most low-cost vehicle models do not include a direct Vehicle-to-Vehicle communication feature. As a result, nearby vehicles do not receive real-time warning messages about dangerous situations. This lack of direct communication reduces driver awareness and increases the risk of secondary accidents. Therefore, the limitations of existing systems make them less efficient in emergency situations where fast, reliable, and low-cost communication is required.

Proposed System

The proposed system is a LoRa-based Vehicle-to-Vehicle (V2V) communication model integrated with Internet of Things technology for improving road safety and accident prevention. The main objective of the system is to detect hazardous situations in one vehicle and immediately send warning information to nearby vehicles. This helps drivers become aware of dangerous conditions before reaching the affected area. The complete system is divided into two main sections: the transmitter side and the receiver side.

On the transmitter side, Arduino Uno is used as the main controller. It is connected to multiple sensors that continuously monitor the condition of the vehicle and its surroundings. A fire sensor is used to detect flames or unusual heat inside or near the vehicle. This helps identify fire accidents at an early stage. A gas sensor is included to detect the leakage of harmful gases or smoke that may occur due to fuel leakage or engine-related issues. The system also uses a MEMS sensor to detect sudden vibration, vehicle tilt, or collision. If the vehicle overturns or experiences a strong impact, the MEMS sensor immediately sends the information to the Arduino. In addition, a GPS Module is connected to capture the exact latitude and longitude of the vehicle during emergency situations. All the sensor readings and location data are collected and processed by the Arduino controller. After processing the sensor information, the Arduino sends the complete data to a LoRa Transmitter Module. LoRa technology is used because it supports long-distance communication with low power consumption. It can transmit warning messages over several kilometres, which makes it highly suitable for highways, rural roads, and remote locations where cellular networks may not be available.

On the receiver side, a NodeMCU is used as the main processing unit. It is connected to a LoRa receiver module that receives the transmitted data from the nearby vehicle. Once the data is received, the NodeMCU processes the information and identifies the type of hazard detected, such as fire, gas leakage, collision, or vehicle tilt. The received sensor information and GPS location are displayed on an I2C LCD Display so that the driver can easily understand the warning message. For example, the display may show messages such as "Fire Detected," "Gas Leakage Alert," or "Accident Ahead," along with the vehicle location details. This provides real-time awareness to nearby drivers and helps them take necessary precautions. To provide immediate attention during emergency situations, a buzzer is also connected to the receiver side. Whenever an abnormal condition is detected, the buzzer is activated automatically to alert the driver. This ensures that the warning is noticed even if the driver is not looking at the display screen. The receiver system is further integrated with the ThingSpeak cloud platform. The NodeMCU uploads all received sensor data and location details to the cloud in real time. This allows remote monitoring, data storage, and analysis of vehicle conditions from any location. The cloud platform can also be used to maintain historical records of accidents and hazardous events for future reference. Overall, the proposed system is simple, low-cost, energy-efficient, and highly effective for improving road safety. By using LoRa communication and IoT technology, the system provides direct and reliable communication between vehicles without depending completely on cellular networks.

Block Daigram

1.Transmitter side :

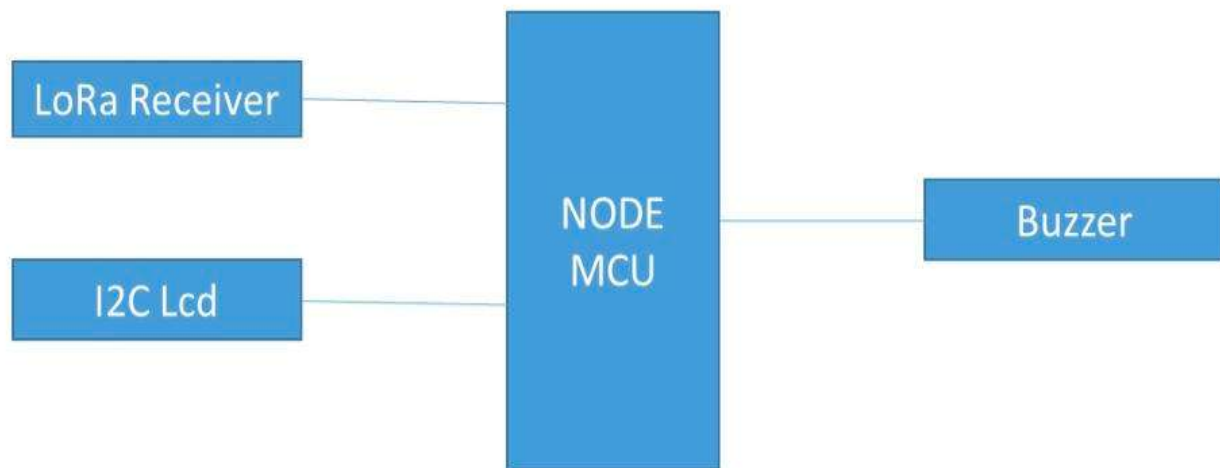


1. Transmitter Side (Source Vehicle)

This unit collects environmental and positional data and broadcasts it

- Data Collection: The Arduino UNO acts as the central brain, constantly reading data from several sensors:
- Fire & Gas Sensors: Detect fire or hazardous gas leaks within or around the vehicle
- MEMS Sensor: Typically used to detect sudden impacts, tilts, or accidents (accelerometer|gyroscope).
- GPS Module: Provides the exact real-time geographical coordinates (latitude and longitude) of the vehicle.
- Transmission: The Arduino processes this sensor data and sends it to the LoRa Transmitter Module. LoRa is used because it can transmit small packets of data over long d
- distances with very low power consumption, which is ideal for moving vehicle.

Receiver side :



2.Receiver Side (Target/Emergency Vehicle)

This unit receives the broadcasted data and alerts the user or logs it to the cloud.

- Signal Reception: The LoRa Receiver picks up the data packets sent by the transmitter vehicle.
- Data Processing & Connectivity: The NodeMCU (ESP8266) receives this data from the LoRa module.
- IoT Integration: Because the NodeMCU has built-in Wi-Fi it can upload the received emergency data (like GPS location and sensor alerts) to an IoT platform (like Blynk or Thing Speak) for remote monitoring • Alerting:
 - I2C LCD: Displays the specific alert message (e.g., "GAS LEAK DETECTED") and the location coordinates.
 - Buzzer: Provides an immediate audible alarm to notify the driver of the receiver vehicle of a nearby emergency or hazard.

Result

The proposed Vehicle-to-Vehicle communication system using LoRa Technology and IoT successfully detects hazardous conditions such as fire, gas leakage, vehicle tilt, and sudden impact. The sensor data is transmitted effectively from the transmitter vehicle to the receiver vehicle over a long distance with low power consumption.

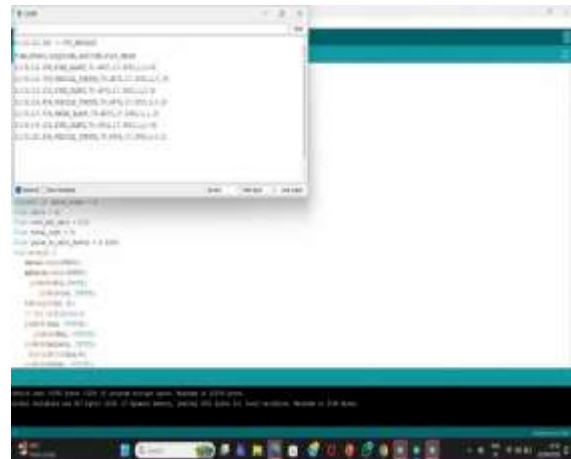
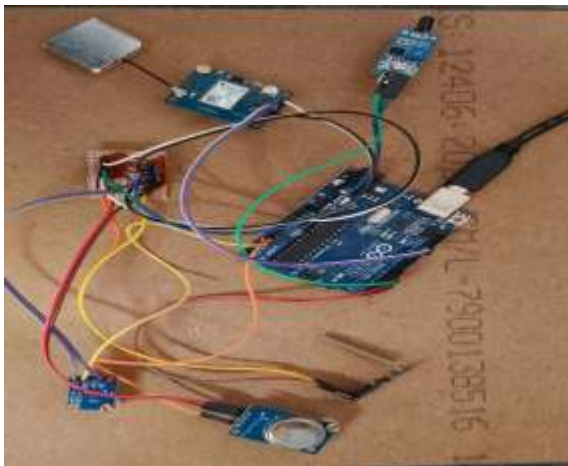


Fig: Serial Monitor Output

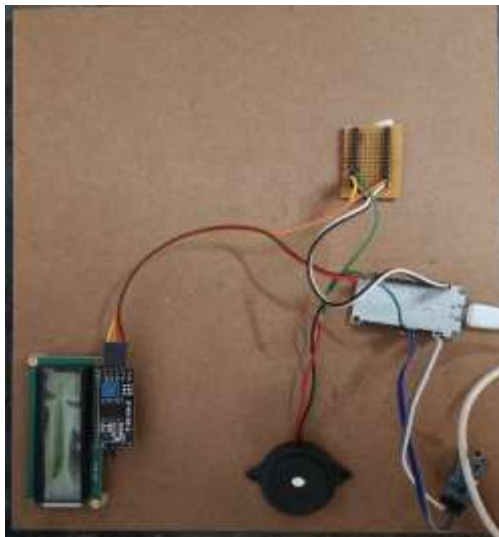


Fig: LCD Output

The receiver unit built with NodeMCU receives the warning messages and displays them on the LCD screen. The buzzer alert is activated immediately whenever an abnormal condition is detected. The system also uploads the received data to the ThingSpeak cloud platform for real-time monitoring and storage. The results show that the system is reliable, cost-effective, and suitable for both urban and rural areas. It provides faster communication between vehicles and helps drivers take early precautions, thereby reducing accident risks and improving road safety.

Advantages

Long-Range Communication

Enables data transmission over several kilometers (up to 10–15 km in rural areas), allowing vehicles to receive early warnings and improve reaction time.

Low Power Consumption

LoRa technology consumes very less power, making the system energy-efficient and suitable for continuous vehicular operation.

Cost-Effective Solution

Operates on unlicensed frequency bands and does not require expensive cellular infrastructure, reducing overall implementation and maintenance costs.

Infrastructure Independence

Does not rely on internet connectivity or cellular networks, ensuring reliable communication even in remote and rural areas.

Real-Time Data Exchange

Supports instant transmission of critical parameters such as speed, location, and direction, enabling quick decision-making.

Applications

Long-Range Communication

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Real-Time Data Exchange

Supports instant transmission of critical parameters such as speed, location, and direction, enabling quick decision-making.

Can be integrated with advanced technologies such as AI, machine learning, and edge computing for smarter decision-making.

Conclusion

The Vehicle-to-Vehicle communication system using LoRa Technology with IoT provides an efficient and reliable solution for improving road safety. The system continuously monitors vehicle conditions using sensors for fire, gas leakage, vibration, and tilt detection. By integrating a GPS Module, the system can also provide the exact location of the vehicle during emergency situations. The collected information is transmitted to nearby vehicles through LoRa communication for quick warning delivery. On the receiver side, the warning information is displayed to the driver and an alert buzzer is activated immediately. This helps drivers take preventive actions before reaching the hazardous area. The system is also connected to the ThingSpeak cloud platform for real-time monitoring and data storage. Because of its low power consumption, low cost, and long-range communication capability, the proposed system is highly suitable for modern transportation. Overall, this project can help reduce accident risks, improve emergency response time, and contribute to the development of smarter and safer transportation systems.

Future Scope

In the future, the proposed system can be enhanced by adding more advanced sensors such as alcohol detection sensors, heart rate sensors, and fatigue monitoring sensors for driver safety. These additional features can help prevent accidents caused by driver health issues or careless driving. The system can also be integrated with traffic management systems and emergency services. For example, if an accident occurs, the system can automatically send alerts to nearby hospitals, police stations, or ambulance services along with the vehicle location. Future versions may also use Artificial Intelligence to analyze sensor data and predict possible accidents before they happen. Image processing cameras can be added to detect obstacles, lane changes, and traffic signals. The communication range and efficiency of the system can be further improved by integrating LoRa with 5G or other advanced wireless technologies. This project can become an important part of future smart city and intelligent transportation systems.

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