Chain Accident Prevention Through Automatic Braking Using Vehicle-To-Vehicle Communication

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Abstract

This paper describes of how the v2v communication process is used in road safety focuses on developing a vehicle-to-vehicle (V2V) communication system using Arduino to enhance road safety and prevent accidents. The system utilizes various sensor and communication modules integrated with Arduino boards in vehicles. Vehicle 1 detects critical conditions like accidents, blind spots objects, high beam glare and driver negligence. These alerts are transmitted via Zigbee to Vehicle 2, which displays the warnings on an LCD. The system ensures Real-Time communication to prevent chain accidents, avoid high beam collisions and promote safer driving practices. Vehicle-to-Vehicle (V2V) chainless accident communication is an advanced system designed to mitigate road accidents by enabling direct, real-time communication between vehicles without relying on centralized communication infrastructure. Unlike traditional V2V systems that depend on a chain of communication nodes such as roadside units (RSUs) or cellular towers, a chainless approach utilizes a decentralized, peer-to-peer (P2P) network in which vehicles communicate directly with each other. This eliminates potential delays caused by reliance on external infrastructure, reducing the risks associated with communication breakdowns, congestion or coverage gaps.

Keywords: Arduino UNO, LCD display, Node MCU, US sensor, LDR sensor, Relay, LED, Motor Driver, Voltage regulator, Zigbee.

INTRODUCTION

Vehicle-to-Vehicle communication plays a pivotal role in modern traffic safety systems. Using Arduino, this project integrates sensors to monitor parameters such as driver behavior, collision risks, and environmental hazards. Communication between vehicles allows for real-time alerts, improving response times and mitigating potential accidents. The system is designed to function in scenarios involving chain collisions, high-beam glare, and blind spot detection, enhancing situational awareness for drivers.

For a long time, vehicles have received radio signals for audio entertainment for decades, more recently, have become ‘connected’ to enhance functionality such as navigation and provide some streaming services. However, advanced communication is becoming central to vehicle operation as automakers see this as a way of delivering enhanced road safety, increased efficiency / economy and an improved experience for driver and passengers which eventually leading to fully autonomous vehicles. As the sector is rapidly evolving, delivering these communication capabilities to vehicles presents a number of design challenges negotiating the regulatory environment and selecting the optimum component solutions.

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Objective of Research

V2V (Vehicle-to-Vehicle) communication using Arduino Uno is designed to improve road safety, optimize traffic flow, and support autonomous driving systems by enabling vehicles to exchange real-time data. The main goal of V2V communication is to facilitate the sharing of critical information, such as speed, location, and direction, helping to prevent accidents by alerting drivers to potential risks like sudden stops, road blockages, or vehicles in blind spots. By utilizing Arduino Uno, this system can be built with cost- effective sensors and modules, showcasing communication between vehicles. through wireless technologies like Wi-Fi, Bluetooth, or Zigbee. Furthermore, V2V communication can help optimize traffic management by sharing information between vehicles, allowing for better coordination and smoother driving experiences. It can also serve as a foundation for more advanced autonomous driving systems, where vehicles make intelligent decisions based on data from surrounding vehicles.

Literature Survey

Shah and Bhatt et al., (2017) [1] built an automated headlight dimming system using LDR sensors to detect high beam lights. Their study confirmed the effectiveness of LDR sensors in regulating headlight intensity based on external light sources. Our project's inclusion of an LDR sensor to detect high beams and automatically switch to low beams matches this technology, ensuring a safer and more comfortable driving experience during night-time conditions.

Kopelias et al., (2019) [2] reviewed advanced emergency braking systems and found that integrating V2V communication in braking systems enhances response time, reducing the chances of multiple-vehicle accidents.

Kalpana Seelam & Ch. Jaya Lakshmi et al., [3] explained about the Road accidents are one of the world's major public health and injury prevention problems. According to the World Health Organization (WHO), road accidents claim the lives of over a million children worldwide each year. This project aims to develop an Arduino-based embedded system designed to enhance passenger safety and security.

Min Li, Daowen Zhang & Qi Liu et al., [4] it focuses on driver injury from vehicle side impacts. When automatic emergency braking and active seat belts are used, as an advanced driver assistance system, automatic emergency braking (AEB) can effectively reduce accidents by using high- precision and high-coverage sensors. In particular, it has a significant advantage in reducing front-end collisions and rear- end accidents.

Shekharesh Barik, Surajit Mohanty, Rajeev Agarwal et al., [5] A Proposed Wireless Technique in Vehicle-to-Vehicle Communication to Reduce a Chain of Accidents Over Road It mainly explains about the Vehicle-to-vehicle (V2V) communication is used to transmit data between vehicles to prevent chain of accidents. Chain of accident refers to serial collision of vehicles one behind another, which happens in a busy traffic.

Lee et al., (2013) [1] explored V2V communication for accident prevention by using Dedicated shortrange

Communications (DSRC), which enables vehicles to share real-time information. The study demonstrated that V2V systems could effectively reduce the reaction time for drivers, thus avoiding accidents by triggering preventive actions such as braking.

WORKING PRINCIPLE

The working principle of chain accident prevention through automatic braking using Vehicle-to-Vehicle (V2V) communication centers on the ability of vehicles to exchange real-time information to enhance safety. Each vehicle is equipped with communication systems that transmit data about speed, position, direction, and braking status to nearby vehicles. This allows vehicles to be aware of potential hazards, even if they are not directly visible or detectable. When a sudden change in a vehicle's speed or braking behavior occurs—such as a vehicle in front abruptly slowing down— the V2V system detects the potential risk of a collision and shares this information with the following vehicles. In response, these vehicles can automatically activate their braking systems, reducing speed and preventing or mitigating a chain reaction of accidents. The system operates using technologies like Dedicated Short-Range Communications (DSRC) or Cellular Vehicle-to-Everything (C-V2X), which enable fast and reliable communication between vehicles.

By coordinating braking actions across multiple vehicles, the system prevents rear-end collisions and ensures smoother traffic flow, even in situations where human reaction time would be too slow.

The automatic braking system can thus reduce the risk of chain accidents in heavy traffic, offering a significant safety advantage by reacting faster than a human driver could.

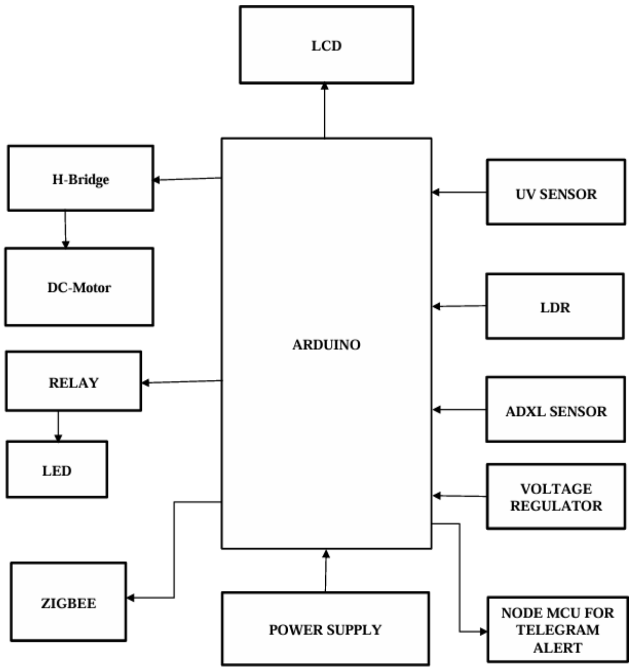


Fig.1: Block Diagram of vehicle 1

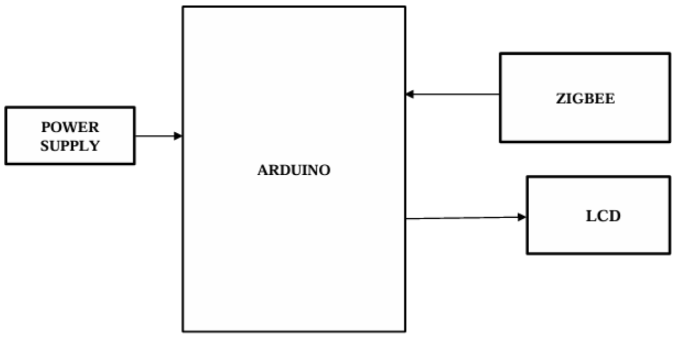


Fig.2: Block Diagram of vehicle 2

HARDWARE DISCRIPTION

Requirement:

This system utilizes Vehicle-to-Vehicle (V2V) communication, implemented with an Arduino Uno, and requires several key components, which are illustrated below"Fig.1 and Fig.2".

1. Ultrasonic sensors are used for front object detection and blind spot monitoring.
2. ADXL accelerometer sensor detects sudden changes in vehicle movement, identifying accidents.
3. LDR sensor detects high beams from oncoming vehicles for automatic headlight adjustment.
4. Zigbee communication is employed to transmit alerts to nearby vehicles, notifying them of potential hazards. Zigbee is a standardized technology designed for network control and sensing applications.
5. Voltage regulator regulates voltages to all the components
6. Arduino: The central controller for managing sensors and communication modules
7. Node MCU: Sends notifications to the driver or emergency contacts via Telegram in case of an accident or critical warnings.

Using above mentioned components, we connect the components by using jumping wires as shown in

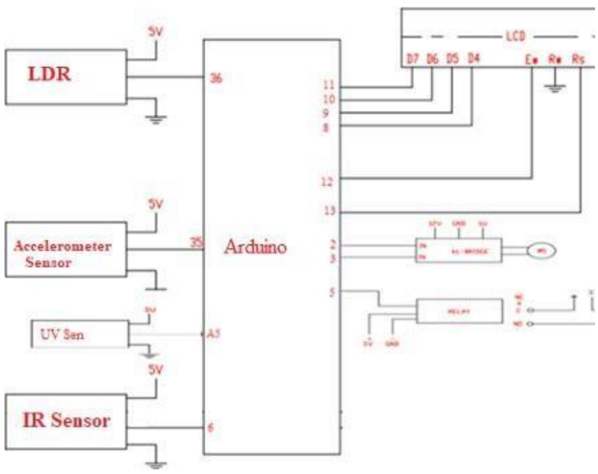


Fig.3: Circuit connections

Arduino

Arduino is a popular open-source hardware platform, freely available under a Creative Commons license. It supports add-on shields that can be stacked and controlled through an I²C bus. Standard Arduino boards run on a 5V regulator with a 16 MHz oscillator, though specialized versions like the LilyPad operate at 8 MHz without a regulator. These boards are powered by Atmel 8-bit AVR microcontrollers with varying flash memory capacities. pins, and features are shown in Fig.4.

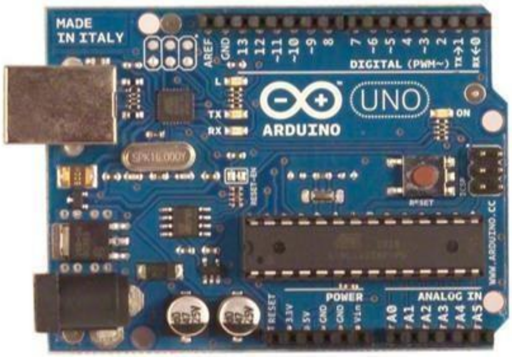
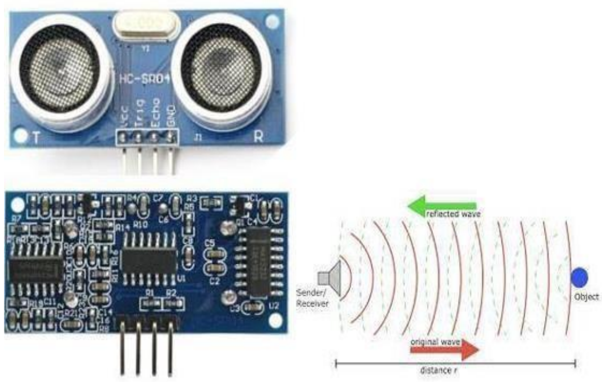


Fig.4: Circuit connections

Ultrasonic Sensor

In Fig. 5, an Ultrasonic Sensor is employed to detect objects. The HC-SR04 ultrasonic sensor utilizes SONAR technology to measure the distance to an object, similar to how bats navigate. It provides precise and stable non-contact distance measurements ranging from 2 cm to 400 cm (or 1” to 13 feet) in a compact, easy-to-use design.

The operation is not affected by sunlight or black material, although acoustically, soft materials like cloth can be difficult to detect. It comes complete with ultrasonic transmitter and receiver module.



In Fig. 6, a Light Dependent Resistor (LDR), or photoresistor, is displayed. This component adjusts its resistance depending on the intensity of incoming electromagnetic radiation, which makes it responsive to light. LDRs are also known as photoconductors, photocells, or photo conductive cells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate LDR, one of the most commonly used is shown in the figure below. The arrow indicates light falling on it.

Light-dependent resistors are constructed using photosensitive semiconductor materials such as lead sulfide, lead selenide, indium antimonide, or cadmium selenide. These materials are arranged in a zigzag pattern for optimal performance.

The LDR operates based on the principle of photoconductivity. When light strikes its photosensitive material, the material absorbs the light's energy, causing electrons in the valence band to become excited and move to the conduction band. This movement increases the material's conductivity, which is directly related to the intensity of the light. For this process to occur, the energy of the incident light must be higher than the bandgap energy, allowing electrons to transition from the valence band to the conduction band.

Fig.6: Ultrasonic Sensor

ADXL sensor

In Fig. 7, an accelerometer is shown, which is a device used to measure vibration, motion, or acceleration within a structure. Modern cameras and smartphones often incorporate an accelerometer with an axis-based motion sensor. This electromechanical device can measure both static and dynamic acceleration. Acceleration, as we know, is the measure of change in velocity upon a given time. In Fig 4.19, ADXL345 accelerometer is used to detect if accident occurred or not. Accelerometer are used in the compass app you use on your phone. The motion sensors in accelerometers can detect earthquakes too. Another example is when the accelerometers measure the gravitational pull to determine at which angle is the device being titled.

Fig.7: ADXL Sensor

Node MCU

In Fig. 8, the Node MCU is an open-source firmware based on LUA, specifically developed for the ESP8266 Wi-Fi chip. By leveraging the capabilities of the ESP8266 chip, the Node MCU firmware is provided with the ESP8266 Development Board/Kit, commonly known as the Node MCU Development Board..

The Node MCU Dev Kit/Board features the ESP8266 Wi- Fi chip. Developed by Espressif Systems, the ESP8266 is a cost-effective Wi-Fi chip that supports the TCP/IP protocol. For further details about the ESP8266, you can refer to the ESP8266 Wi-Fi Module

Zigbee

ZigBee is an open, global, packet-based protocol designed to offer a simple, secure, and reliable framework for low- power wireless networks. It allows flow or process control equipment to be placed anywhere within the system, maintaining communication regardless of location. Additionally, components such as sensors, pumps, or valves can be easily relocated since the network is not dependent on their physical positions.

ADVANTAGES AND DISADVANTAGES

Advantages:

1. Accident Prevention: Real-time communication prevents chain accidents and minimizes damage in high- risk situations.
2. Enhanced Safety: Alerts for blind spots, high beams, and improper driving posture ensure safer driving.
3. Emergency Response: Automatic accident notifications reduce response time for emergency assistance.
4. Driver Assistance: Warnings and alerts improve driver awareness and decision-making.
5. Efficient Communication: Zigbee-based V2V communication is reliable and energy efficient.

B. Disadvantages:

1. False Alerts and Unnecessary Braking: The system could sometimes trigger false alarms or unnecessary braking if it misinterprets the situation.
2. Dependence on Technology: The system relies heavily on the effectiveness of V2V communication and the hardware within each vehicle.
3. Incompatibility Among Vehicles: Not all vehicles on the road may be equipped with V2V technology. Older vehicles or those without this advanced communication system cannot participate in the network, reducing the overall effectiveness of the system.
4. Over-reliance on Automation: Drivers might become overly reliant on the automatic braking system, potentially leading to reduced awareness and attention while driving.
5. High Costs and Infrastructure Requirements: Implementing V2V communication technology in all vehicles requires significant investment in both vehicle hardware and the necessary infrastructure.

RESULT AND CONCLUSION

The implementation of chain accident prevention through automatic braking using Vehicle-to-Vehicle (V2V) communication has shown significant promise in enhancing road safety. Studies and simulations have demonstrated that when vehicles are equipped with V2V communication systems, they can effectively share real-time data such as speed, location, and braking status. This allows vehicles to anticipate potential collisions and take preemptive action by automatically applying brakes in response to sudden deceleration or braking by a lead vehicle.

The system's rapid response time, faster than a human driver's reflex, was particularly crucial in preventing accidents in high- traffic conditions. Additionally, coordination among multiple vehicles helped prevent the escalation of minor incidents into full-

The use of automatic braking systems integrated with V2V communication technology offers a substantial improvement in road safety, especially in preventing chain accidents.

The system's ability to prevent accidents and enhance traffic flow makes it a promising step toward safer roadways. With continued research, development, and widespread implementation, V2V communication systems can play a crucial role in reducing traffic-related injuries and fatalities.

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