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Vehicle-to-Vehicle Communication using CAN Bus Protocol

Prof. M. T. Kanwade, Rohini Rahane, Rohan Rodge, Pratiksha Bhor
Department of Electronic Engineering
Amrutvahini College of engineering, Sangnmar, India

Abstract: *This abstract introduces a groundbreaking Crash Avoidance System aimed at bolstering road safety in response to escalating vehicular congestion. Through the utilization of Vehicle-to-Vehicle (V2V) communication facilitated by the Controller Area Network (CAN) bus, the system seamlessly integrates cutting-edge hardware components to enable real-time data exchange and collision detection among vehicles. Strategic functional partitioning optimizes communication protocols and collision detection mechanisms, employing a suite of sensors and microcontrollers to orchestrate the system's functionality. Rigorous testing procedures have been conducted to validate the efficacy of collision detection and avoidance maneuvers. Future iterations of the system are envisioned to incorporate advanced driver assistance systems, machine learning algorithms, and expanded connectivity via Vehicle-to-Everything (V2X) communication, while prioritizing cybersecurity measures and regulatory adherence. This innovative system not only addresses immediate road safety imperatives but also lays the foundation for intelligent transportation networks, effectively mitigating collision risks and enhancing overall traffic safety*

Keywords: vehicle to vehicle communication(v2v),Control area network(CAN), Hardware components, Sensor, Smart transportation system

I. INTRODUCTION

In response to a notable surge in vehicular traffic and associated accidents, there is a pressing need to implement intelligent and adaptable traffic management systems alongside vehicle collision prediction systems. This study aims to explore existing technologies utilized for predicting and preventing motor vehicle collisions. While luxury cars commonly feature airbags and air brakes to enhance passenger safety during accidents, the integration of sensors and data processing modules remains prohibitively expensive for approximately 90% of vehicles in India. Consequently, researchers are directing their efforts toward developing cost-effective vehicle systems.

The collision prediction system module functions to anticipate the likelihood of accidents by considering factors such as vehicle speed and relative positioning. Notably, the vision-based traffic alert system aims to provide early warnings to drivers regarding potential hazardous traffic scenarios, primarily focusing on object tracking and recognition.

Past implementations have utilized stereo analysis and classification for traffic recognition based on visual inputs. Furthermore, advancements have been proposed in combining stereo and motion analysis for improved object recognition. Noteworthy enhancements in crash prediction systems have been achieved through the utilization of radar and laser sensor modules, enhancing reliability and functionality.

Research and development efforts are actively exploring communication and sensor technologies to enhance road safety and intelligence. Intelligent Vehicle Communication networks enable vehicles and road units to exchange safety alerts and traffic information, promising improved safety and ride comfort. The integration of wireless communication technologies holds potential to reduce signal propagation delays, crucial for timely distress signal transmission.

Active safety measures encompass perception and communication activities, with communication pertaining to security involving periodic and event-driven messages. These messages convey crucial vehicle information to detect hazardous situations promptly.

Interest in ITS has drastically surged due to the emergence of wireless communication applications, with cooperative systems in vehicles showing great promise in reducing accident rates. These advancements underscore the ever-growing importance of wireless communication in modern traffic safety systems!

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Overall, the integration of V2V communication is vital in enhancing safety on the roadways, the key to achieving safer transportation systems in the future.

A. Objective

The objective is to develop a crash avoidance system utilizing vehicle-to-vehicle (V2V) communication based on the Controller Area Network (CAN) bus. The primary aim is to design, implement, and test a system capable of detecting potential collisions between vehicles and executing preventive measures to avert accidents.

B. Problem statement:

In today's congested roadways, accident risks persist as a significant concern. While traditional safety measures like seatbelts and airbags have reduced accident severity, there remains a need for proactive accident prevention. Vehicle-to-vehicle (V2V) communication systems offer promise in enhancing road safety by enabling real-time exchange of critical information among vehicles.

C. Methodology:

The methodology for developing a V2V communication system for pre-crash system typically involves several key steps:

1. Requirement Analysis: Define functional requirements, including message types, transmission frequency, and message priority. Identify safety-critical scenarios and necessary information for crash avoidance, such as vehicle speed, position, acceleration, and heading.
2. System Design: Design the system architecture, encompassing hardware components (CAN bus modules, antennas, etc.) and software components.
3. Hardware Implementation: Select appropriate CAN bus modules and other hardware components based on the system design. Integrate these components into the vehicle's electrical system, ensuring compatibility and reliability. Conduct thorough testing to validate functionality and performance metrics like data transmission rates, latency, and power consumption.

II. LITERATURE SURVEY

Design and Implementation of CAN bus Protocol for Monitoring Vehicle Parameters

Authors: A. A. Salunkhe, Pravin P. Kamble, Rohit Jadhav

Findings/Technology Used: CAN Bus

This study addresses the application of the Controller Area Network (CAN) bus protocol in tracking vehicle parameters. The CAN bus, a well-established automotive network standard, facilitates communication among microcontrollers and devices within vehicles without requiring a central computer.

Vehicle-to-Vehicle Communication Fair Transmit Power Control for Safety-Critical Information

Authors: Marc Torrent-Moreno, Jens Mittag

Findings/Technology Used: Direct Radio Based V2V Communication

This paper investigates how managing the transmission power in vehicle-to-vehicle (V2V) communications can impact the distribution of vital safety information.

Vehicle to Vehicle Communication Dedicated Short range Communication and Safety Awareness

Authors: Yu. A. Vershinin, Yao Zhan

Findings/Technology Used: LIN, CAN, MOST

The paper likely evaluates how these technologies can be integrated to bolster safety awareness among vehicles.

III. ARCHITECTURE

CAN Bus Infrastructure:

Physical Layer: The architecture begins with the physical layer, including the CAN bus itself and the transceivers responsible for transmitting and receiving signals.

Data Link Layer: This layer manages the transmission of data packets over the CAN bus, including error detection and arbitration.

Microcontroller Integration:
Each vehicle involved in V2V communication is equipped with a microcontroller responsible for managing the CAN bus communication.
The microcontroller interfaces with various vehicle systems, sensors, and actuators to gather and disseminate relevant information.

Message Structure and Protocol:
Define a standardized message structure and protocol for V2V communication. This includes defining message types, data fields, and message priorities.
Messages may include vehicle speed, position, acceleration, heading, and status information.

Message Broadcasting and Reception:
Vehicles periodically broadcast V2V messages containing their current state and status information.
Upon receiving V2V messages from neighboring vehicles, each vehicle's microcontroller processes the information to assess potential collision risks and determine appropriate actions.

Collision Avoidance Algorithms:
Implement collision avoidance algorithms that analyze incoming V2V messages, predict potential collisions, and trigger warning signals or corrective actions.
These algorithms consider factors such as relative velocities, distances, and trajectories of nearby vehicles.

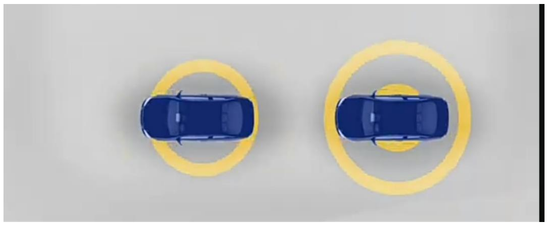
Safety and Reliability Measures:
Introduce safety and reliability measures to ensure the robustness of the V2V communication system.
This may include error detection and correction mechanisms, redundancy in critical components, and fail-safe mechanisms to handle communication failures.

Integration with Vehicle Systems:
Integrate the V2V communication system with existing vehicle systems to enable coordinated responses to V2V messages.
For example, the system may interface with the vehicle's braking and steering systems to implement collision avoidance maneuvers.

Regulatory Compliance and Standards:
Ensure compliance with relevant regulatory standards governing V2V communication systems, such as IEEE 802.11p for wireless communication and ISO 11898 for CAN bus communication.
Adherence to standards facilitates interoperability and compatibility with other V2V-equipped vehicles.

IV. THEORY

The theory behind the V2V communication using the Controller Area Network (CAN) bus for crash avoidance projects revolves around utilizing the CAN bus, a standard communication protocol in automobiles, to facilitate real-time data exchange between vehicles. This communication facilitates vehicles in exchanging vital data like speed, direction, and proximity, empowering the detection of possible collisions and enabling timely preventive measures. The theory integrates concepts from signal processing, wireless communication protocols, sensor fusion, and decision-making algorithms to ensure accurate detection and effective avoidance strategies. Leveraging this technology empowers vehicles to enhance safety on the road by proactively avoiding accidents through cooperative awareness and intelligent decision-making



V2V Communication

History of V2V Communication:

1. Research Initiatives (1990s-2000s): During the 1990s and early 2000s, numerous research projects explored The capability of V2V communication to improve road safety by facilitating the exchange of data like vehicle position and speed to prevent accidents.

The IEEE 802.11p standard was established in the 2000s and has been instrumental in enabling seamless communication among vehicles and infrastructure. The standard serves as a foundation for future advancements in smart transportation systems and autonomous vehicles!

2. Proof of Concept (2000s): Several proof-of-concept trials and demonstrations were conducted during this period to showcase the feasibility and benefits of V2V communication. These trials involved equipped vehicles communicating with each other in real-time to exchange safety-critical information.

3. Regulatory Developments (2010s During the 2010s, multiple nations's regulatory agencies had been acknowledging potential of V2V communication for enhancing road safety, which was a great thing! For instance, the United States; it advocated strongly for the adoption of Dedicated Short-Range Communications (DSRC) technology, promoting V2V communication.

It is essential for all stakeholders involved in V2V communication to stay updated on the latest developments and updates from these standardization organizations. By following the established protocols and structures, they can contribute to creating a more secure and reliable network for communication between vehicles.

Vehicle-to-Vehicle (V2V) communication systems:

Vehicular communication systems, also known as Vehicle-to-Vehicle (V2V), have experienced notable development since their inception in 2003 through the Vehicle Infrastructure Integration (VII) initiative, which evolved from the Automated Highway Systems of the 1990s. These systems leverage concepts that are derived from the Internet of Things (IoT) and computational technologies to enable smooth communication between vehicles on the road.

V2V communication empowers vehicles to exchange crucial data concerning traffic conditions through an Ad hoc mesh network, thereby playing a pivotal role in accident prevention. Depending on the vehicle's technology, drivers receive timely warning messages regarding road traffic or potential hazards ahead, or the vehicle autonomously adjusts its route or halts safely! Research indicates that timely warning messages could potentially prevent 60% of road accidents worldwide.

The V2V communication protocol employs broadcasts to relay warning messages, with messages transmitted and received at a frequency of 10 times per second. Equipped with suitable software applications, vehicles can receive messages from nearby vehicles to proactively avoid accidents and navigate congested routes. These messages encompass a range of 300 meters and consider variables such as weather conditions, traffic, and terrain to identify potential hazards.

In conjunction with broadcast messages, V2V communication systems might incorporate radars and cameras for collision detection and mitigation. This innovation not only aids drivers and autonomous vehicles in anticipating dangers but also plays a crucial role in accident prevention. It can be effortlessly integrated into different vehicle categories such as automobiles, coaches, and freight carriers, to improve visibility and bolster overall road safety. Moreover, the V2V communication protocol emphasizes safeguarding driver data confidentiality during warning message transmission, thereby enhancing the security system's efficacy and potentially averting numerous road accident fatalities annually.

V. COMPONENTS OF VEHICLE-TO-VEHICLE COMMUNICATION PROTOCOL

CAN Module MCP2551:

The CAN Module MCP2551 plays a crucial role in enabling Controller Area Network (CAN) communication, which is necessary for supporting vehicle-to-vehicle communication within the system.

Ultrasonic Sensor:

The Ultrasonic Sensor serves as a vital element in identifying the proximity between the vehicle and obstacles, playing a pivotal role in collision detection systems. The Ultrasonic ranging module HC-SR04 provides a contactless measuring function, capable of gauging distances from 2cm to 400cm with remarkable precision, reaching up to 3mm

AtMega328P Microcontroller:

The AtMega328P is a popular microcontroller commonly used in various embedded systems due to its versatility and performance.

In a V2V communication system, the AtMega328P may serve as the central processing unit responsible for coordinating communication between vehicles, processing incoming data from sensors and other vehicles, and executing collision avoidance algorithms.

It interfaces with other components such as the ultrasonic sensor, CAN module, and wireless communication modules to exchange data and make decisions based on the received information

16MHz Crystal Oscillator:

The 16MHz crystal oscillator provides a stable clock signal for the AtMega328P microcontroller, ensuring precise timing for its operations.

22 Picofarad (pF) Capacitor:

The 22pF capacitor is typically used in conjunction with the crystal oscillator to form an oscillator circuit that determines the frequency of oscillation

VI. WORKING

Certainly! Vehicle-to-vehicle (V2V) communication using the Controller Area Network (CAN) bus operates through a collaborative exchange of data between vehicles to enhance safety, efficiency, and situational awareness on the road. Here's how it works:

Message Generation: Each vehicle equipped with V2V communication capabilities continuously generates and updates status messages containing information such as speed, position, acceleration, heading, and vehicle status.

Message Broadcasting: These status messages are broadcasted periodically over the CAN bus to nearby vehicles within communication range.

Message Reception: Upon receiving these messages, the receiving vehicle's CAN bus controller processes the data, extracting relevant information about nearby vehicles' positions, speeds, and behaviors.

Collision Detection and Avoidance: Utilizing the received data, the vehicle's onboard systems analyze potential collision risks based on factors like relative velocities, distances, and trajectories of nearby vehicles.

Warning Generation: If a collision risk is detected, the vehicle's safety systems generate warnings to alert the driver or take autonomous actions to avoid the collision. These warnings may include visual alerts, auditory alarms, or haptic feedback.

Redundancy and Reliability: The CAN bus architecture ensures reliability through redundant communication paths, error detection, and fault tolerance mechanisms. Redundant CAN buses, transceivers, and microcontrollers minimize the risk of communication failures.

Integration with Existing Systems: V2V communication systems are integrated with the vehicle's existing systems, including braking, steering, and propulsion, to enable coordinated responses to V2V messages.

Regulatory Compliance: V2V communication systems adhere to regulatory standards and protocols to ensure interoperability and compatibility across different vehicle manufacturers and models. Standards such as IEEE 802.11p and ISO 11898 govern V2V communication protocols and hardware specifications.

Testing and Validation: Before deployment, V2V communication systems undergo rigorous testing and validation in simulated and real-world environments to verify their performance, reliability, and safety under various conditions.

Benefits of Vehicle-to-Vehicle Communication Protocol:

- Accident Prevention: V2V communication protocols help prevent accidents by providing timely warning messages to drivers regarding traffic conditions and potential hazards, thereby reducing the risk of collisions and fatalities on the road.
- Traffic Management: Implementation of V2V communication improves traffic management by facilitating real-time data streams that enable law enforcement officers to monitor traffic conditions and enforce regulations more effectively, ultimately reducing congestion and improving overall traffic flow.

Limitations of Vehicle-to-Vehicle Communication Protocol:

- Frequency Band Constraints: The frequency band allocated for V2V communication may not support a large number of vehicles simultaneously, posing limitations on scalability and performance.
- Security Concerns: Implementation of V2V communication systems raises security issues such as cyber-attacks, which can compromise the integrity and safety of the system, leading to potential risks and threats to vehicle and driver safety.
- Privacy Risks: Stored data about vehicle and driver details in V2V communication systems may be vulnerable to misuse, posing risks such as identity theft and unauthorized access to sensitive information.
- Lack of Regulations: The absence of government regulations and rules governing V2V communication systems may lead to uncertainties and challenges in ensuring system reliability and compliance with safety standards.

Safety Functions of Vehicle-to-Vehicle Communication Systems:

Safety functions of V2V communication systems are classified into scenarios involving following vehicles closely, vehicles approaching from the opposite direction, crossing intersections, and changing lanes. These functions encompass features like warning of impending collisions from the front, signaling electronic braking in emergencies, cautioning against overtaking, aiding left turns, assisting at intersections, alerting of blind spots, and indicating lane changes, all designed to prevent accidents and enhance road safety. These functions employ diverse performance criteria to assess system efficiency and guide the formulation of national motor vehicle safety regulations, ultimately playing a role in mitigating fatalities and injuries on roads.

VII. CONCLUSION

The crash avoidance system, leveraging vehicle-to-vehicle communication through the Controller Area Network (CAN) bus, has yielded significant advancements in improving road safety by effectively detecting and preventing collisions. Key findings and conclusions from this endeavor are as follows:

1. Efficient Communication Strategy: Functional partitioning optimizes communication channels, ensuring accurate collision detection.
2. Dependable Sensor Integration: Sensors play a crucial role in acquiring real-time data for collision detection algorithms, contributing to system reliability.
3. Enhanced Road Safety: The implementation of this system significantly reduces collision risks, contributing to overall road safety.

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Finally, we acknowledge the ongoing commitment of automotive manufacturers, technology providers, and researchers to further innovate and improve V2V communication capabilities, paving the way for a safer and more connected future on the roads.

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