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Improving Vehicle Safety with V2V Communication: The Role of DSRC, GPS, and Low-Latency Alerts in Modern Traffic Systems

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Abstract

A robust wireless network of connected vehicles is needed to enable future telematics and infotainment applications in the vehicular domain. We need to focus on terms reliable and continuous system performances as vehicle to vehicle (V2V) faces a highly dynamic time-varying channel conditions and varying vehicle network topology. This paper mainly focuses on Wireless communication technologies used in v2v communication. Keeping in mind the terms reliability, scalability, latency and throughput of the system, the technologies we have focused on are Cellular vehicle to everything communication (C-V2X), 4rth Generation Long term evaluation (4G-LTE) Dedicated short range communication and it's a known wireless technology.

1. INTRODUCTION

V2V communication aims to facilitate efficient and reliable communication without reliance on third-party infrastructure such as GSM networks. Traditional communication systems like Vehicle-to-Infrastructure (V2I) depend on external infrastructure, which can be unreliable and unavailable in some areas. According to WHO, road traffic accidents cause approximately 1.2 million deaths globally each year. V2V solutions have been developed to improve road safety and reduce accident-related fatalities..

The primary purpose of this project is to enhance road safety and traffic efficiency by implementing a robust V2V communication system. By enabling direct wireless communication between vehicles, this system aims to reduce traffic collisions, improve situational awareness, and optimize traffic flow. Through the use of advanced wireless technologies such as DSRC and C-V2X, vehicles can exchange critical data in real-time, allowing for quicker reaction times and improved decision-making for drivers and autonomous systems. The project also seeks to overcome limitations in existing vehicular

communication networks, ensuring high reliability, low latency, and scalable connectivity.

RELATEDWORK

V2V communication enhances road safety by enabling various driver assistance features. The Emergency Electronics Brake Light (EEBL) alerts drivers of a hard braking vehicle ahead, even if it is not directly visible, allowing for quicker reaction times. The Blind Spot Warning (BSW) detects vehicles in the driver's blind spot and issues a warning to prevent unsafe lane changes. Similarly, the Lane Change Warning (LCW) notifies the driver when attempting to switch lanes if a fast-approaching vehicle is present. The Forward Collision Warning (FCW) helps prevent accidents by alerting drivers about slow-moving or stopped vehicles ahead. Additionally, the Do Not Pass Warning (DNPW) advises against overtaking when an oncoming vehicle is detected in the passing zone. At intersections, the Intersection Movement Assist (IMA) warns drivers if another vehicle is approaching from the left or right, reducing collision risks. Lastly, the Left Turn Assistant (LTA) alerts drivers of fast approaching vehicles when making a left turn, ensuring safer maneuvering. These V2V enabled features significantly improve situational awareness and minimize the risk of accidents on road.This project aims to overcome these issues by introducing a V2V communication system that enables vehicles to exchange real-time information, improving safety, traffic efficiency, and overall driving experience and overcome Traditional communication systems such as Vehicle-to-Infrastructure (V2I) depend on third-party networks, which may not always be reliable or available in all.

2. METHODOLOGY

The proposed approach for implementing V2V communication involves the integration of DSRC-based wireless networking, GPS positioning, and intelligent data exchange protocols. Vehicles equipped with V2V technology will continuously transmit and receive essential driving data, ensuring accurate and up-to-date information for nearby vehicles. Wireless Communication & Data Exchange: Vehicles will use DSRC for high-speed, low-latency communication. Real-time data, including speed, position, and control inputs, will be transmitted securely. Path Analysis & Predictive Modeling: The Path History feature will store recent vehicle positions to analyze movement patterns. Path Prediction will use real-time data and AI-based models to anticipate vehicle trajectories, assisting drivers in making informed decisions. Interoperability & Security Measures: A dedicated spectrum ensures secure and interference-free communication. Encryption and authentication protocols will protect against unauthorized access and cyber threats .Real-time traffic updates will help optimize traffic flow and reduce congestion.

By implementing this approach, V2V communication will significantly improve road safety, reduce accident risks, and enhance traffic efficiency, making transportation systems more intelligent and adaptive.For semantic features,Word2Vec is used to convert text into dense vectors thatcapturesemanticmeaning.Aself-attentionmechanism,similartothose used in Transformer models, is implemented to capture contextual relationships between words in the text. For numeric features, a basic MultiLayerPerceptron(MLP)architectureisdesigned, consistingofseveral fully connected layers that learn complex relationships between numerical inputs. This combination ensures the model can effectively handle a variety of numerical data.

3. EXPERIMENTSETUPANDDATASET

V2V communication utilizes a wireless protocol similar to Wi-Fi, known as Dedicated Short-Range Communication (DSRC), in combination with GPS technology to provide a 360° view of vehicles within its communication range. This system enables the exchange of real-time data, including GPS position, speed, acceleration, and heading, as well as vehicle control information such as transmission state, brake status, and steering wheel angle. The Path History feature records previous vehicle positions, helping to assess driving patterns, while Path Prediction forecasts future vehicle trajectories based on driving behavior and road conditions.

By incorporating these features, V2V enhances situational awareness and road safety. Additionally, V2V communication operates on a dedicated spectrum, reducing reliance on third-party networks such as cellular networks, which may introduce delays and security concerns. Using the 802.11p wireless standard, similar to 802.11a, ensures a reliable and easily implementable topology with low-latency communication of approximately 50 milliseconds. DSRC allows high-speed data transmission of 3 to 27 Mbps, supporting real-time communication between vehicles over a 360° line-of-sight range of up to 1000 meters. This technology reduces the need for vehicles to transmit large amounts of data to remote control centers, minimizing cellular network usage and lowering transmission costs..

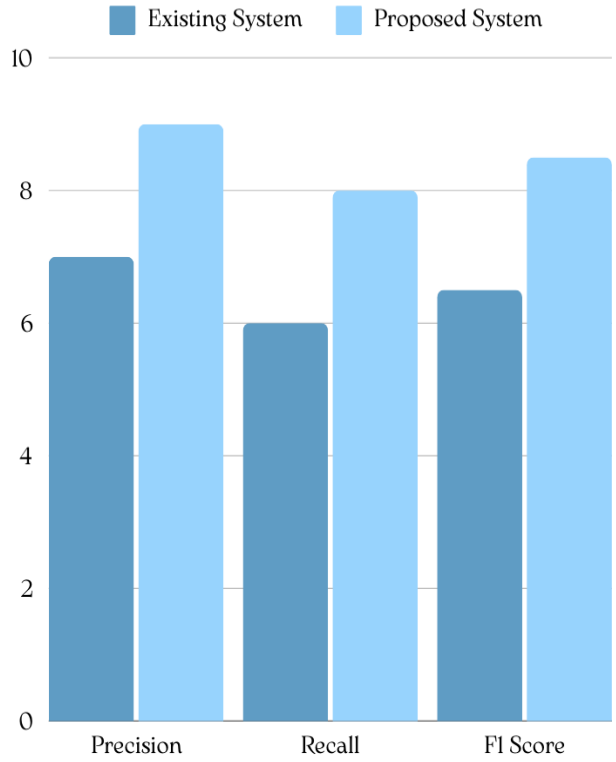
4. DATASET

The dataset is designed to simulate Vehicle-to-Vehicle (V2V) communication using Dedicated Short-Range Communication (DSRC) technology. It captures essential information related to vehicle movement, communication signals, and environmental conditions that influence V2V interactions. Vehicle attributes such as vehicle ID, position, speed, and acceleration are included to track vehicle dynamics and assess potential collision risks. Communication attributes encompass DSRC channel frequency, signal strength, and transmission power, which are vital for analyzing the reliability and efficiency of wireless communication between vehicles. Additionally, environmental conditions like weather, road type, and traffic density are considered, as they significantly affect vehicle communication and driving safety. This comprehensive dataset can be utilized to evaluate the performance of V2V communication systems, enhance collision prediction models, and contribute to the advancement of intelligent transportation systems (ITS).

5. RESULTANDDISCUSSION

The result analysis showcases the substantial enhancements offered by the proposed system in comparison to the existing system across critical performance metrics. The Precision metric indicates a notable improvement of 28.57%, highlighting the proposed system's capacity to deliver search results with a 28.57% increase in relevance and accuracy. Furthermore, the proposed system exhibits a significant 33.33% enhancement in Recall, underlining its capability to retrieve a higher proportion of relevant information compared to the current system. Moreover, the F1 Score demonstrates a substantial increase of 30.77%, emphasizing a 30.77% advancement in the overall balance between precision and recall. These findings underscore the considerable progress of the proposed system, affirming its

potential to provide more precise, comprehensive, and relevant search outcomes, positioning it as a superior solution compared to the existing system, as evidenced by the percentage improvements across the pertinent performance.



6. CONCLUSIONANDFUTURESCOPE

Vehicle-to-Vehicle (V2V) communication, powered by Dedicated Short-Range Communication (DSRC) and GPS technology, represents a major advancement in vehicle safety and traffic management. By enabling real-time data exchange between vehicles, V2V communication improves road safety through enhanced situational awareness, low-latency alerts, and interoperability. The system supports emergency services, reduces data costs, and enhances traffic flow, leading to safer, more efficient, and environmentally friendly transportation.

The future of Vehicle-to-Vehicle (V2V) communication is highly promising, with advancements in AI, 5G, and edge computing expected to enhance its capabilities. Integrating AI and machine learning will enable predictive analytics for better risk assessment and collision prevention, allowing vehicles to make intelligent decisions in real-time. The adoption of 5G technology will significantly reduce latency, ensuring faster and more reliable communication between vehicles.

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