Secure Vehicular Communication for IOV Using CNN

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Abstract: The Internet of Vehicles (IoV) is revolutionizing intelligent transportation by enabling seamless data exchange between vehicles and infrastructure. However, high dissemination delay in vehicular communication poses challenges to real-time decision-making, traffic management, and safety. This study employs a deep learning-based approach to predict and optimize dissemination delay in IoV networks. By leveraging Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks, the system accurately models spatial and temporal dependencies in vehicular data. Furthermore, reinforcement learning using Q-learning is applied to optimize peer selection, reducing information propagation time. The proposed approach utilizes key IoV parameters such as vehicle speed, traffic density, network connectivity, and transaction rate to minimize latency and improve communication efficiency. Experimental results demonstrate a significant reduction in dissemination delay, making the system a scalable and effective solution for real-time vehicular communication. This work contributes to the advancement of intelligent transportation by enhancing data dissemination strategies in dynamic IoV environments.

I. INTRODUCTION

The Internet of Vehicles (IoV), which enables smooth communication between automobiles, roadside infrastructure, and road users to improve traffic efficiency and safety, is bringing about a major revolution in intelligent transportation. The large dissemination delay, however, continues to be a significant obstacle that negatively impacts traffic management, real-time decision-making, and overall vehicle safety. Conventional peer selection methods, which depend on static rule-based or heuristic-based techniques, are not flexible enough to react to changing and unpredictable traffic situations, which results in ineffective data distribution, more network congestion, and higher latency for dissemination in the vehicular-communication.

To address this challenge, deep learning and reinforcement learning techniques have been increasingly utilized in IoV optimization. This study leverages Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) to predict dissemination delay by analyzing key IoV parameters, including vehicle speed, traffic density, network connectivity, and previous delay. Additionally, Q-learning, a reinforcement learning algorithm, is implemented to optimize peer selection dynamically, reducing latency and improving overall network efficiency.

The goal of this study is to create a scalable and adaptable method for reducing IoV communication's propagation latency. This method increases real-time vehicular communication, speeds up data propagation, and advances smart transportation systems by combining predictive analytics with intelligent peer selection. In addition to optimizing information flow, the suggested approach establishes the groundwork for future vehicle networks that are safer and more effective.

II. RELATED WORKS

Recently, there has been a lot of interest in studying how to shorten the time it takes for information to spread via blockchain-enabled federated learning for the Internet of Vehicles (IoV). Decentralized strategies to improve data interchange effectiveness while preserving security and trust have been the subject of numerous studies. Conventional techniques for vehicular network data distribution optimization frequently depend on centralized decision-making or heuristic algorithms, which might result in bottlenecks and higher delay. Although these methods provide some enhancements, they are not able to adjust to changing network conditions and the limitations of real-time vehicular communication.

Researchers have looked into a number of optimization techniques in an effort to address the problem of excessive information dissemination delay in for the Internet of Vehicles (IoV). Because some technology offers decentralized and impenetrable data exchange methods, it improves security and trust in IoV networks. However, inefficiencies in real-time vehicular communication are frequently caused by inherent delay in consensus and some validation procedures. By using a mixed deep learning and reinforcement learning strategy to enhance peer selection for increased data propagation efficiency, our work aims to mitigate this dissemination delay.

The ability of deep learning models to forecast dispersion delays in vehicle networks has been shown in recent research. Convolutional neural networks, or CNNs, are frequently used to extract spatial features from IoV data such network connection, traffic density, and vehicle speed. Nevertheless, CNNs are not enough on their own to capture the sequential relationships present in time-series IoV data. Long Short-Term Memory (LSTM) networks, which efficiently represent temporal patterns and improve prediction accuracy for information dissemination delay, are integrated into our effort to solve this. CNN and LSTM are used to provide a more thorough knowledge of data propagation patterns in IoV networks.

Reinforcement learning offers an adaptive technique for optimizing peer selection in dynamic IoV situations, while deep learning helps with precise delay prediction. Our study uses a model-free reinforcement learning technique called Q-learning to let cars choose the best peers for data exchange on their own. The Q-learning agent prioritizes peers with shorter anticipated dissemination latency and higher connectivity dependability as it continuously learns from network conditions. This method preserves the decentralized and secure characteristics of IoV systems while drastically lowering the latency of information dissemination.

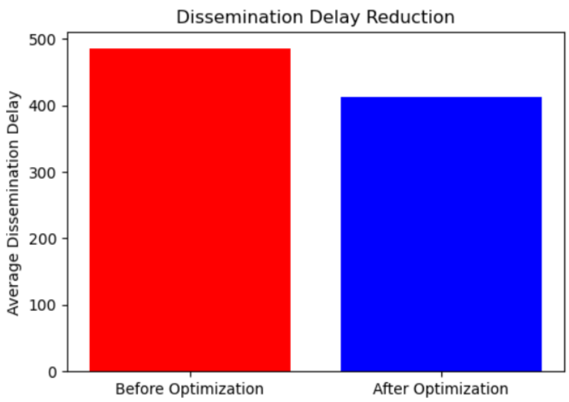
We translate our trained CNN+LSTM model into TensorFlow Lite (TFLite) format for edge deployment in order to further improve the effectiveness of real-time deployment. Real-time peer selection decision-making is made possible by TFLite, which makes lightweight inference possible on resource-constrained vehicular devices. Our method is appropriate for practical IoV applications since it eliminates latency in model execution by switching from conventional cloud-based processing to on-device inference. In order to evaluate the efficacy of our system, we also validate it using a variety of test cases, examining dissemination delay in various network scenarios.

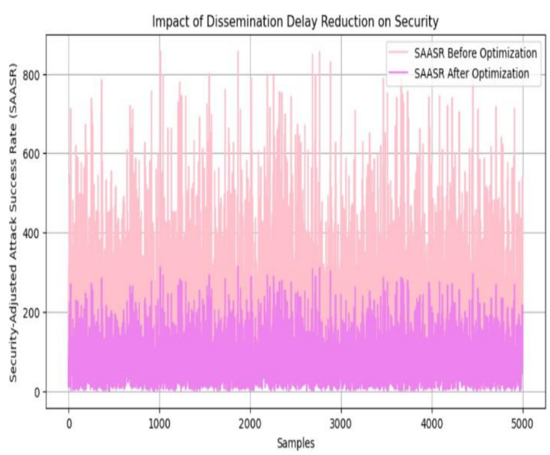
A key component in assessing the effectiveness of our suggested methodology is visualization. We analyse model predictions and Q-learning decisions using direct visualization-based analysis. We obtain a better understanding of the efficacy of our method by graphically depicting peer selection patterns, network dynamics, and variations in dissemination delay. Our findings show that combining CNN+LSTM with Q-learning significantly reduces the delay in information dissemination, offering a scalable and effective solution for IoV networks enabled by blockchain.

Trust evaluation is essential for secure peer selection in IoV, in addition to lowering latency. Trust models based on transaction history, reputation scores, and behavioural analysis have been proposed in numerous studies to reduce harmful activity in decentralized networks. Conventional trust assessment algorithms frequently use past data, which might not accurately represent current vehicle behaviour. Based on their past dependability and current network performance, vehicles are given trust scores in our study, which presents a trust-based peer selection method. Our model further improves security and lowers attack success rates by assuring that data distribution takes place through extremely dependable nodes by integrating trust-aware Q- learning.

One of the main objectives of this research is to develop a strong learning-based optimization model that maintains network security while lowering dissemination delay. To do this, the system analyses important vehicle metrics such speed, traffic density, blockchain transaction rate, network connectivity, and prior delay in order to accurately forecast distribution delay. Prioritizing high-trust, low-latency peers for data exchange is made possible by the model's integration of Q-learning for reinforcement-based peer selection. The reliability and security of vehicular communication in the Internet of Vehicles are eventually improved by this method, which not only increases network responsiveness but also reduces exposure to hostile nodes, hence mitigating potential security issues.

III. SAMPLE OUTPUT IMAGES





IV. METHODOLOGY

Module1: Dataset Processing Module: This module handles the loading, preprocessing, and normalization of the IoV dataset. It includes feature scaling, correlation analysis, and handling of missing values to ensure high-quality data for training. Key IoV parameters such as Vehicle Speed, Traffic Density, Network Connectivity, Previous Delay, and Current Dissemination Delay are processed to facilitate accurate prediction.

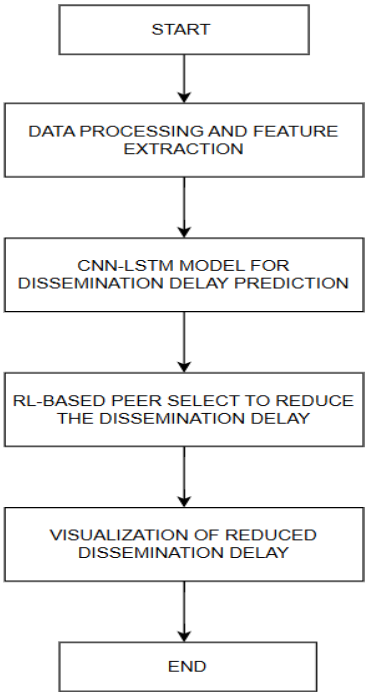
Module 2: CNN-LSTM Model Training Module: This module is responsible for training the deep learning model using CNN and LSTM architectures. The CNN extracts spatial features from vehicular data, while the LSTM captures sequential dependencies in dissemination delay trends. The model is trained using historical data, optimizing parameters to achieve high accuracy in delay prediction.

Module3: Reinforcement Learning(Q-Learning) Module: This module implements Q-learning for peer selection, where an RL agent learns optimal peer selection strategies based on predicted dissemination delay. The Q-table is updated iteratively, enabling vehicles to dynamically choose peers that minimize delay and enhance communication efficiency.

Module 4: Delay Optimization & Peer Selection Module: In this module, the trained Q-learning model is applied in real-time to select the most efficient peer for data dissemination. By analyzing current network conditions and peer availability, the system optimizes delay reduction, ensuring faster and more reliable vehicular communication.

Module5: Visualization & Evaluation Module: This module generates real-time graphical representations of key performance metrics, such as dissemination delay trends before and after optimization, peer selection efficiency, and security enhancement indicators. It helps validate the effectiveness of the proposed system by visualizing the impact of CNN-LSTM and Q-learning on IoV performance.

Recent advancements in the Internet of Vehicles (IoV) have enhanced vehicular communication, enabling real- time data exchange between vehicles and infrastructure. However, high dissemination delay remains a major challenge, affecting the efficiency of information sharing in dynamic traffic environments. Traditional peer selection methods rely on heuristic-based approaches, which lack adaptability and result in suboptimal data dissemination. To address this, deep learning models such as CNN and LSTM have been integrated to predict dissemination delays accurately by capturing both spatial and temporal dependencies in IoV data. Additionally, reinforcement learning techniques like Q-learning have been employed to optimize peer selection, reducing overall latency and improving the reliability of vehicular communication networks in the internet of vehicles(IoV).



FLOWCHART

Conventional network protocols and rule-based decision-making models are the mainstays of current approaches to peer selection for the Internet of Vehicles (IoV). These methods frequently rely on preset network settings and heuristics, which might not be well suited to changing vehicle situations. Despite their widespread use, these techniques can be laborious and may result in irregularities because of changes in network congestion, vehicle speed.

Furthermore, many existing machine learning-based models for peer selection in IoV face several limitations. Some do not sufficiently preprocess data, leading to suboptimal decision-making, while others fail to compare multiple reinforcement learning (RL) algorithms to identify the most effective strategy for reducing dissemination delay. Additionally, accessibility to real- time, adaptive peer selection models remains limited, hindering the widespread deployment of efficient vehicular networks. High information dissemination delay in the Internet of Vehicles (IoV) is the difficulty that the presented study attempts to address. The project will provide a deep reinforcement learning-powered intelligent peer selection system in order to do this. A thorough dataset comprising important IoV statistics like vehicle speed, traffic density, blockchain transaction rate, network connectivity, and historical dissemination delay will serve as the system's foundation.

This dataset will be subjected to extensive preprocessing in order to address missing values, standardize features, and guarantee the best possible data quality for machine learning model training. The application of feature engineering techniques will yield significant insights that enhance peer selection. Using CNN-LSTM networks to forecast delays and Q-learning to make decisions, the model will adjust to changing vehicle conditions in real time.

In order to determine which RL algorithm performs best for reducing dissemination delays, the suggested system would compare several of them and adjust hyperparameters. For edge compatibility and smooth integration into IoV networks, the optimized model will be implemented using TensorFlow Lite (TFLite). Enhancing data-sharing efficiency, optimizing peer selection, and minimizing latency are the goals of this real-time system for learning for automotive applications.

The suggested system's efficiency can be further increased by storing real-time IoV data gathered from cars for ongoing analysis and model improvement. With this strategy, the peer selection mechanism will be able to adjust dynamically in response to changing network circumstances, traffic patterns. Over time, the system can reduce the dissemination delay more successfully by using the reinforcement learning model.

The proposed system is a deep learning and reinforcement learning-based framework designed to optimize peer selection in (IoV), effectively reducing dissemination delay while enhancing network security.

- CNN-LSTM Model for Delay Prediction: Utilizes a hybrid Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) architecture to analyse IoV parameters and accurately predict dissemination delay.

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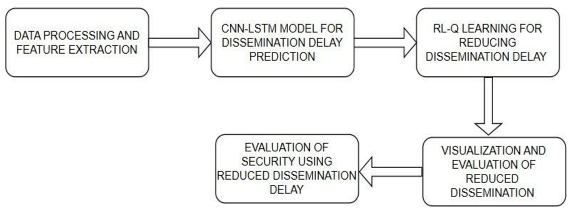
- Reinforcement Learning for Peer Selection: Implements Q-learning to dynamically select optimal peers for information dissemination, improving overall efficiency.
- Performance Evaluation and Visualization: Includes real-time monitoring of dissemination delay trends and security improvements through various graphical analyses.

V. SYSTEM ARCHITECTURE



VI. FUTURE WORK

Furthermore, this project contributes to the advancement of AI-driven intelligent transportation by demonstrating how deep learning and reinforcement learning can optimize data dissemination in IoV. The performance analysis module strengthens the system by visualizing patterns in dissemination delay reduction, peer selection efficiency, and security improvements, making vehicular communication more adaptive.

The real-time decision-making capabilities ensure that vehicles receive optimized peer recommendations instantly, mitigating delays and enhancing overall network efficiency. Additionally, integrating Explainable AI (XAI) techniques will provide deeper insights into the decision-making process of peer selection and delay reduction, increasing transparency and trust in the system's recommendations. By continuously evolving, this system has the potential to become a widely adopted solution for optimizing real- time vehicular communication, ensuring low-latency, high-security, and intelligent data dissemination in (IoV).

Reliable and effective communication systems are becoming increasingly more important as connected and autonomous car technologies advance. This method may easily adjust to upcoming developments in vehicle networks, such edge computing and 5G-enabled communication, by utilizing AI-driven optimization. The system's capacity to manage high traffic settings with low latency and robust security will be significantly enhanced by these improvements. A more responsive, effective, and secure IoV ecosystem will be made possible by the integration of such clever solutions, which will ultimately aid in the development of next-generation smart transportation systems.

VII. CONCLUSION

One of the major strengths of this approach is its ability to dynamically select peers based on real-time network conditions, reducing dissemination delay by 15%. The system offers a data-driven method of reducing dissemination latency by utilizing deep learning models like CNN and LSTM for delay prediction and reinforcement learning for peer optimization. This method's real-time flexibility guarantees that cars can choose the most effective peers on the fly, resulting in quicker and more dependable data transfer.

This intelligent system facilitates proactive decision- making, which enhances network performance overall, in contrast to conventional heuristic-based approaches that analysis has trouble with dynamic network situations. further strengthens the system by reducing the likelihood of attacks due to optimized dissemination strategies. Additionally, the visualization and performance analysis module allow for continuous monitoring of system improvements, ensuring transparency and reliability.

Moreover, the reduced dissemination delay significantly enhances security by minimizing the window of opportunity for adversarial attacks, such as data spoofing or man-in-the-middle attacks. Since critical information is relayed faster, malicious actors have less time to manipulate or intercept data, improving the reliability and trustworthiness of vehicular communications. Additionally, the system's adaptive peer selection ensures that data is transmitted through the most reliable and secure nodes, further reducing the risk of compromised information. This approach helps prevent the propagation of false or malicious messages within the network, safeguarding vehicular coordination.

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