ISSN: 2414-1895
DOI: 10.6919/ICJE.202506_11(6).0040

Research on the Application and Optimization of V2X Communication Technology for Intelligent Transportation

Hailiang Ma[1], Yufei Wu[2], Yufan Tong[3]

[1] School of Economics and Management, North China University of Science and Technology, Tangshan, China

[2] School of Economics and Basic Medicine, North China University of Science and Technology, Tangshan, China

[3] School of Economics and Science, North China University of Science and Technology, Tangshan, China

Abstract

Under the background of "big data and artificial intelligence", the traffic management system, as an indispensable part of human life, urgently needs to be optimized. To keep up with the trend of The Times, this project proposes an intelligent transportation system based on V2X communication technology. Firstly, each vehicle is regarded as an independent agent. The data of the vehicle state is obtained by using the vehicle kinematic model, the dynamic model of the lateral vehicle motion and the spatial model of the motion mechanics state. Then, the global real-time position and state sharing of the data is achieved through V2X communication technology to obtain real-time road condition decisions, and finally an intelligent transportation system is established. This system can reduce energy consumption, optimize traffic flow, improve road safety and enable efficient operation of traffic management.

Keywords

V2X; Agent; Intelligent Transportation System.

1. Introduction

1.1 Research on V2X Communication Technology

V2X communication technology has been the focus of research and development in recent years, and various studies have emphasized its importance and potential applications.

Abroad: Rakouth et al. (2013) utilized the Dedicated Short Range Communication (DSRC) technology based on the IEEE 802.11p/Vehicle Environment Wireless Access (WAVE) standard. The implementation of V2X technology in projects such as SMARTWAY in Japan, Drive C2X in Europe and the connected vehicle security pilot in the United States was discussed. This study also mentioned the use of complementary technologies such as DSRC in the lower UHF frequency band and the realization of V2X through 4G LTE cellular technology[1]. Zhu et al. (2016) proposed the Information-Centric Network (ICN) as a potential alternative to the traditional TCP/IP solution in connected vehicles, highlighting its compatibility with V2X communication technology[2]. Alnasser et al. (2019) focused on the security challenges and solutions of V2X communication networks, emphasizing that the expanding vehicle network requires strong security measures[3]. Duan et al.(2020) and Hakeem et al.(2020) discussed the role of V2X communication technology in the evolution of intelligent connected vehicles and the development of 5G-V2X communication networks, and emphasized that ultra-low latency, high reliability and large bandwidth are crucial for supporting wireless communication services of V2X applications[4][5]. Jung et al. (2020) proposed a V2X

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

communication-assisted autonomous driving system, demonstrating the growing interest in autonomous driving research to enhance road safety and traffic efficiency[6]. Hegde et al. (2020) introduced the Artery-C simulation framework to evaluate the cellular V2X protocol and its application performance[7]; Furthermore, Hakeem et al. (2020) also discussed the significance of lightweight message authentication and privacy protection protocols for ensuring the security of V2X communications[8]. Miao et al. (2021) focused on the evolution and deployment of pc5 cellular v2x and emphasized the use of RF side links to directly connect low-latency vehicle sensors to achieve the goal[9]. Faragetal.(2023)ThendisplayC-VI(Vehicle-to-Infrastructure,vehicle-to-infrastructure)andV-I(Vehicle-to-Infrastructure). Between vehicles and Infrastructure, C-VIX(Cellular Vehicle-to-Everything, cellular Internet of Everything Vehicle) and V-I(Vehicle-to-Infrastructure, the digital communication process from vehicles to infrastructure) are used. Good results have been achieved in the application of energy-saving dynamic routing and the characteristics of the communication process affecting the application of intelligent transportation systems have been revealed[10].

Domestically: Wei Wei (2017) pointed out that V2X communication has received increasingly widespread attention, mainly used for researching the D2D resource allocation algorithm based on auction theory and the sparse vehicle networking resource allocation scheme based on LTE. Zheng Canjian (2018) proposed using V2X communication to improve the energy efficiency of the uplink in cellular networks. Li Xiaoshuai (2020) pointed out that in the case of imperfect Channel State Information (CSI), the interference in the D2D-based V2X communication network is suppressed through a novel joint optimization mode selection and resource allocation algorithm, and their road safety is improved respectively. Performance in three aspects: system capacity and user fairness. Feng Yijia (2022) proposed to enhance road capacity, alleviate traffic congestion, reduce Vehicle energy consumption and decrease exhaust emissions through trajectory planning and V2X(Vehicle-to-Everything) transmission technology. Hu Yanru (2023) pointed out that V2X technology based on 5G networks still has great potential for development in the future. Based on the current application status of 5G V2X communication, the update process of side link identifiers adopted in V2X communication, and the precise management of this process can improve the transmission success rate of V2X service frames and further ensure the reliability of Internet of Vehicles communication. Luo Chunli (2023) proposed: With V2X communication technology as the technical support, based on the classic traffic flow model, a brand-new traffic flow model was established by considering the collaborative transmission effect of traffic information. Through theoretical analysis and numerical simulation, relevant research conclusions were drawn to effectively solve the problem of traffic congestion.

1.2 Research on Intelligent Transportation Systems

The development of intelligent transportation systems has always been a research hotspot in recent years.

Ren et al. (2019) proposed an intelligent transportation system based on Internet of Things (IoT) and blockchain technologies, aiming to record changes in the transportation system and establish a credit token mechanism for public transportation services[11]. Zichichi et al. (2019) proposed an intelligent transportation system infrastructure based on a distributed ledger to promote social benefits in user mobility[12]. Alfarraj(2020) introduced an Internet of Things system that uses bio-inspired deep learning methods for precise road crack detection[13]. In addition, Zhang et al. (2021) discussed the architecture of intelligent traffic safety systems supporting the Internet of Things using geospatial methods[14], while Kumar et al. (2021) developed a traffic light scheduling framework based on deep reinforcement learning for intelligent transportation systems supporting SDN (Software Defined Network)[15]. Suryadithia et al. (2021) are dedicated to exploring the technological development of intelligent transportation systems and deepening research in this field[16]. Mohanta et al. (2021) achieved results in supporting the Internet of Things (iot) safe transportation system by implementing an accident severity prediction and classification model[17]. Esapour et al. (2022) proposed an integrated smart city model that combines intelligent transportation systems, microgrids, and smart energy hubs for energy conversion[18]. Karim (2022) focuses on developing security solutions for the Internet of Vehicles Technology (IoVT) of intelligent vehicles[19]. Finally, Hasanujjaman et al. (2023) proposed the use of surveillance cameras for sensor fusion to achieve the goals of detection, positioning, and AI network applications for on-road supervision in autonomous vehicles. These studies are jointly promoting the rapid development of intelligent and wireless electronic information processing and transmission by integrating Internet of Things, blockchain, deep learning and geospatial technologies.

In China: Lu Yuting (2020) adopted the improved Le NET5 license plate character recognition algorithm and the improved Tiny-YOLOv3 structured network algorithm to study the machine vision and deep learning technologies in intelligent transportation systems[20]. Wang Mingsheng (2022) proposed the concept and service areas of intelligent home systems to enhance the intelligent level of management and thereby alleviate traffic pressure. Xing Honghong, Xu Ying, et al. (2023) studied the application of 5G communication technology in intelligent transportation systems, explored and analyzed the application of 5G communication technology in roads, and provided a demonstration model for the construction of intelligent transportation systems on roads in China.

2. Research Content

2.1 V2X Communication Technology

V2X (Vehicle-to-Everything) communication technology is a key component of intelligent transportation systems (ITS), enabling vehicles to communicate with everything aroundthem, includingothervehicles(V2V,Vehicle-to-Vehicle)andpedestrians(V2P).Vehicle-to-Pedestrian, infrastructur (V2I,Vehicle-to-Infrastructure)andnetwork(V2N,Vehicle-to-Network). Through this communication, V2X technology aims to enhance road safety, optimize traffic flow, reduce congestion, lower energy consumption, and support the implementation of autonomous driving technology.

The traditional traffic management system mainly relies on the scheduling of fixed traffic signals to manage traffic flow. Although this method may be effective in handling simple traffic flows, its limitations begin to emerge when facing the increasing transportation demands and the complex urban traffic environment. These limitations mainly include the inflexibility of fixed timing sequences, limited ability to deal with emergencies, as well as issues such as maintenance costs and energy consumption. Currently, vehicle-to-everything (V2X) technology is shaping a real-time and reliable connected vehicle environment, opening up a feasible path for more safely and efficiently coordinating the passage of autonomous vehicles (CAVs) at intersections. This technology not only enhances the communication capabilities among vehicles but also improves the interaction with transportation infrastructure, thereby achieving efficient collaboration in complex traffic environments and bringing revolutionary improvements to urban traffic management.

V2X (Vehicle-to-Everything) technology is mainly used to achieve comprehensive management of all passing vehicles at intersections. Through communication between vehicles and between vehicles and infrastructure, intelligent dispatching and path planning at intersections are realized. During this process, V2X technology transmits and shares information such as the position, speed and driving direction of vehicles in real time, enabling the computing center at the intersection to have a comprehensive understanding of the status of vehicles near the intersection, thereby achieving unified dispatching and optimized path planning. In the case of intersections without traffic signals, V2X technology becomes the key to achieving intelligent path planning and traffic management. Through the application of V2X technology, the traffic efficiency at intersections can be maximized, congestion can be reduced, traffic safety can be enhanced, and the operational efficiency of the overall traffic system can be improved.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

2.2 Multi-agent

A multi-agent system refers to a system composed of multiple agents (that is, individuals with independent thinking and action capabilities), and these agents can communicate with each other, collaborate and jointly solve problems. Each agent can independently perceive the environment, make decisions and carry out actions. Meanwhile, through interaction with other agents, the overall intelligent behavior of the system can be achieved.

In this traffic management system, each vehicle is regarded as an independent agent, and real-time location and status sharing throughout the bureau is achieved through the utilization of V2X technology. This collaborative mechanism enables all vehicles to communicate with each other, collaborate, and jointly participate in the overall intersection dispatching. Real-time road condition decision-making is carried out through the LLama3 large model. The system can make the optimal dispatching decisions based on traffic conditions and the status of each vehicle to improve traffic efficiency and safety.

In terms of role allocation and task division, each vehicle has its own tasks and roles, and needs to take corresponding actions based on the system's instructions and road condition information. By clarifying the role of each vehicle as an agent, it can be ensured that every participant in the system can effectively perform tasks, work collaboratively, and jointly achieve the overall traffic dispatching goals. This division of labor and collaboration mechanism helps to improve the operational efficiency and adaptability of the system, enabling the traffic management system to operate more intelligently and efficiently.

2.3 Vehicle Kinematics

When conducting vehicle path simulation, it is crucial to consider the specific circumstances of the vehicle. The planning of vehicle paths must conform to the kinematic laws of vehicles, so as to ensure that vehicles can travel normally at actual intersections. We need to know the specific parameters of the vehicle, such as its size, turning radius, maximum acceleration and maximum speed. These parameters will directly affect the driving conditions of vehicles at intersections. By considering these factors, we can simulate the driving paths of vehicles under different road conditions more accurately. The kinematic law of the vehicle also needs to be considered. If these rules are ignored, the simulated path may cause vehicles to be unable to pass through intersections normally and even lead to accidents. In actual road traffic planning and design, vehicle path simulation is an important tool. By reasonably considering the specific conditions and kinematic laws of vehicles, we can better optimize road design, improve traffic efficiency and ensure the safe driving of vehicles. Therefore, when conducting vehicle path simulation, it is essential to fully consider the specific conditions and kinematic laws of the vehicle. Only in this way can the accuracy and practicality of the simulation results be guaranteed. Only in this way can we better optimize road design and improve the overall operational efficiency of the transportation system.

Vehicle kinematic models are used to describe and predict the movement of vehicles on a two-dimensional plane. This model regards the vehicle as a rigid body and mainly focuses on the relationship among the vehicle's pose (including position coordinates and heading Angle), speed and front wheel Angle. In the premise assumptions of this model, the motion in the Z-axis direction is ignored, that is, it is assumed that the vehicle only moves on a two-dimensional plane. Assume that the steering speeds and angles of the left and right tires of the vehicle are the same; It is believed that the vehicle moves so slowly that the transfer of load between the front and rear axles can be ignored. And assume that the vehicle moves and turns with front-wheel drive. The kinematic square model of the vehicle is described as follows:

$$\begin{cases} \dot{x} = v_x = v\cos\varphi \\ \dot{y} = v_y = v\sin\varphi \\ \dot{\varphi} = \dfrac{v\tan\delta}{l} \end{cases} \Rightarrow \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\varphi} \end{bmatrix} = \begin{bmatrix} v\cos\varphi \\ v\sin\varphi \\ \dfrac{v\tan\delta}{l} \end{bmatrix} = \begin{bmatrix} f_1 \\ f_2 \\ f_3 \end{bmatrix} \tag{1}$$

Based on this kinematic model, after the control input (a, δ) at a certain moment is given, the state information (coordinates, yaw Angle and speed) of the vehicle at the next moment can be estimated.

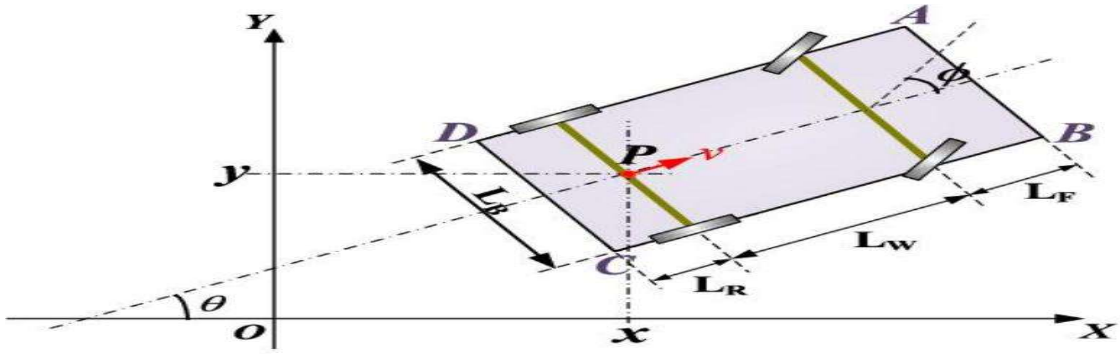

Figure 1. Analysis diagram of vehicle motion state

At higher vehicle speeds, the speed on each wheel no longer follows the direction of the wheels. At this point, we need to establish a dynamic model of the lateral vehicle movement rather than a kinematic model. This paper aims to study how to control the lateral and longitudinal movements of vehicles at traffic intersections without signals. According to the direction of force application, we divide it into lateral dynamics and longitudinal dynamics, which are usually studied separately after decoupling. The longitudinal dynamic model can be obtained in the following form through Newton's second law:

$$ma_x = F_{xf} + F_{xr} \tag{2}$$

The following model is obtained from Newton's second law in lateral dynamics:

$$ma_y = F_{yf} + F_{yr} \tag{3}$$

The lateral force exerted by the tires on the front and rear four-wheel systems is expressed as:

$$\begin{bmatrix} F_{yf} \\ F_{yr} \end{bmatrix} = 2\begin{bmatrix} C_{\alpha f} & C_{\alpha r} \end{bmatrix} \begin{bmatrix} \delta - \theta_{Vf} \\ -\theta_{Vr} \end{bmatrix} \tag{4}$$

Among them, the constants Cαf and Cαr are respectively represented as the steering stiffness of the front and rear wheels, θVf is the Angle between the velocity vector of the front wheel and the longitudinal axis of the vehicle, and δ is the Angle between the front wheel and the longitudinal axis Substituting the above equation yields the dynamic state space model:

$$\frac{d}{dt}\begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & -\frac{2C_{\alpha_f}+2C_{\alpha_r}}{mV_x} & 0 & -V_x-\frac{2C_{\alpha_f}l_f-2C_{\alpha_r}l_r}{mV_x} \\ 0 & 0 & 0 & 1 \\ 0 & -\frac{2C_{\alpha_f}l_f-2C_{\alpha_r}l_r}{I_zV_x} & 0 & -\frac{2l_f^2C_{\alpha f}+2l_r^2C_{\alpha_r}}{mV_x} \end{bmatrix}\begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{2C_{\alpha f}}{m} \\ 0 \\ \frac{2l_fC_{\alpha f}}{I_z} \end{bmatrix}\delta \tag{5}$$

Based on the system equation of state, it is possible to analyze the lateral displacement, lateral velocity, yaw Angle and the response of yaw Angle velocity of the vehicle under the given input of front wheel Angle.

2.4 Specific Implementation Steps

This study, by systematically reviewing the existing literature, innovatively combines V2X communication technology with multi-agent systems to construct a new generation of intelligent transportation decision-making framework. This framework realizes the full-dimensional interconnection among vehicles (V2V), pedestrians (V2P), infrastructure (V2I), and networks (V2N). Through a low-latency and highly reliable data transmission mechanism, it shares the dynamic state information of vehicles in real time, significantly enhancing the perception ability of the traffic environment.

The system adopts a distributed intelligent decision-making architecture. While each agent makes autonomous decisions based on local information, it realizes global information sharing through the V2X network and finally forms a collaborative and optimized traffic dispatching scheme. To ensure the physical feasibility of vehicle driving trajectories, this study established an accurate vehicle kinematic model, which fully considers:

Vehicle dynamics constraints

Road geometric characteristics

Dynamic characteristics of traffic flow

Verified through numerical simulation, this model can accurately predict the vehicle movement trajectories in different traffic scenarios, providing a reliable theoretical basis for intelligent dispatching decisions.

Table 1. shows the partial data results

x	y	yaw	delta	trajectory_x	trajectory_y
0.1	0.1	0	0.5235987755982988	0.1	0.1
0.20279252680319093	0.17736084332503327	0.012533374730193447	0.5235987755982988	0.20279252680319093	0.17736084332503327
0.3081963063570514	0.2387142001172592	0.03249155659885572	0.5235987755982988	0.3081963063570514	0.2387142001172592

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

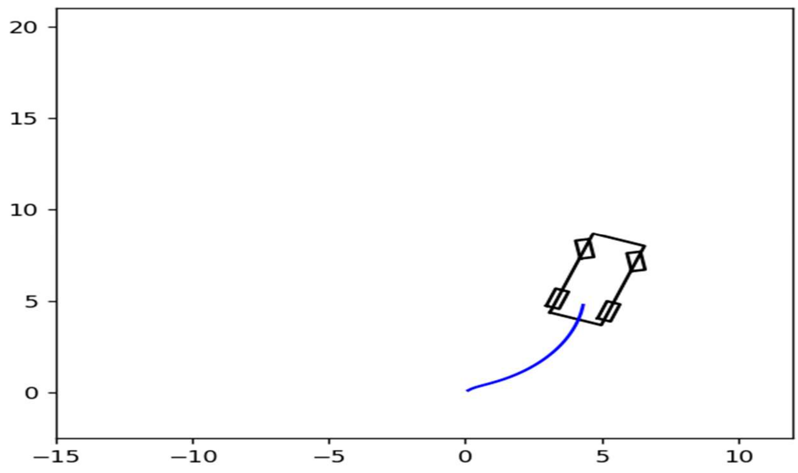

Figure 2. Dynamic picture of the car simulation effect -1

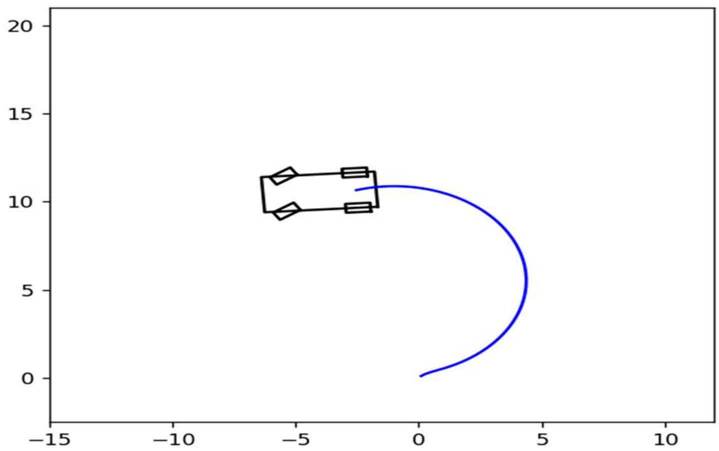

Figure 3. Dynamic picture of the car simulation effect -2

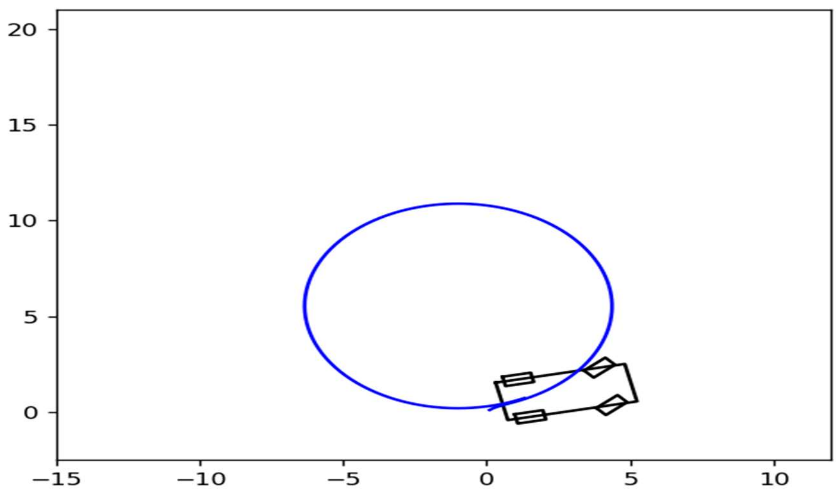

Figure 4. Dynamic picture of the car simulation effect -3

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

3. System Structure Design

The intelligent transportation system designed and implemented in this study adopts a modular architecture, mainly including three core functional modules: V2X data access, vehicle kinematics simulation and historical planning query.

V2X Data Access Module: This module is responsible for the real-time collection and analysis of multi-source heterogeneous traffic data, supports the efficient import of traffic flow data and road network maps, and realizes dynamic map visualization based on Geographic Information System (GIS) technology, providing data support for traffic situation awareness.

Vehicle kinematics simulation module: By establishing a parametric vehicle kinematics model, it supports users to customize vehicle dynamics parameters (such as acceleration, steering Angle, etc.), and realizes multi-vehicle collaborative motion simulation based on numerical calculation methods, providing a theoretical verification platform for traffic flow optimization.

Historical planning query module: It adopts a structured data storage solution to build a historical traffic planning case library, supporting multi-dimensional search and visual display, providing data references for traffic management decisions.

The modular design of this system not only realizes the full-process management of traffic data, but also provides technical support for the theoretical research and engineering application of intelligent transportation systems.

3.1 Login Module

This study designed and implemented a set of login modules for intelligent transportation systems based on database verification. In terms of interface design, a modern and simple style is adopted, with a pure white background as the main body. The system logo and login form controls are arranged on the left side, and two dynamic traffic scene diagrams (visualization of vehicle passage at intersections) are provided on the right side. This ensures the aesthetic appeal of the interface while enhancing the expression of the system's theme. At the functional implementation level, interact with the SQL Server database through Structured Query Language (SQL), establish a user identity authentication mechanism, and adopt the account-password matching algorithm to achieve secure login verification. The design of this module takes into account both human-computer interaction friendliness and system security, providing a reliable access control basis for the subsequent realization of intelligent traffic management functions. Realization effect Diagram 5:

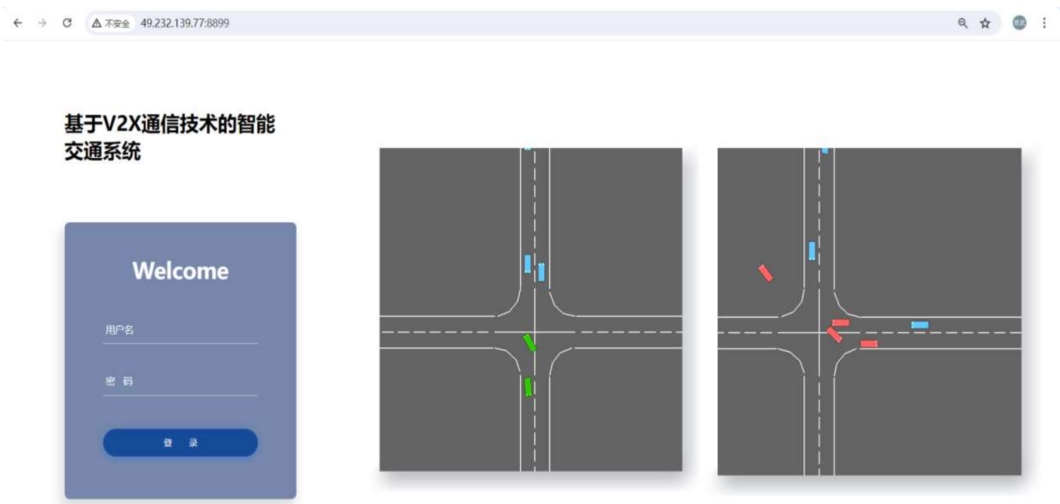

Figure 5. Effect drawing of the login interface

This system adopts the credential authentication mechanism to implement user access control. After the system is initialized, the user first enters the authentication interface and needs to complete the identity verification by entering a legal operator credential (username-password pair). In terms of input validation, the system implements a strict format validation policy: The username is limited to the alphabetic character set ([A-Za-z]), and the password adopts an open character policy to enhance user-friendliness. During the authentication process, the system compares the input credentials with the benchmark data stored in the database through the security verification algorithm. If the match is successful, access rights are granted and redirected to the main operation interface. If the verification fails, the system will return a standardized error prompt message "Username or password error", while maintaining the security status of the authentication interface. The design of this authentication process takes into account both user experience and operational efficiency while ensuring system security.

3.2 V2X Data Access Module

This system adopts a responsive column layout design. The left navigation bar integrates the entrances of five core functional modules: V2X data access, vehicle kinematics simulation, and historical planning query. The main display area on the right dynamically presents the visual content corresponding to the selected module.

As shown in Figures 6 and 7, the V2X data access module realizes the complete visualization of the traffic data processing flow. This module completes the three-dimensional reconstruction of the traffic scene and real-time data mapping by sequentially executing the three functional units of "CAD drawing import ", "road network data generation" and "V2X vehicle access ". Among them:

The CAD drawing import unit realizes the standardized input of road infrastructure data.

The road network data generation unit completes the automatic construction of the topological structure.

The V2X vehicle access unit realizes the data fusion of dynamic traffic participants.

This modular interface design not only optimizes the user experience process, but also realizes the intuitive presentation of complex traffic data through visualization technology, providing effective support for decision analysis.

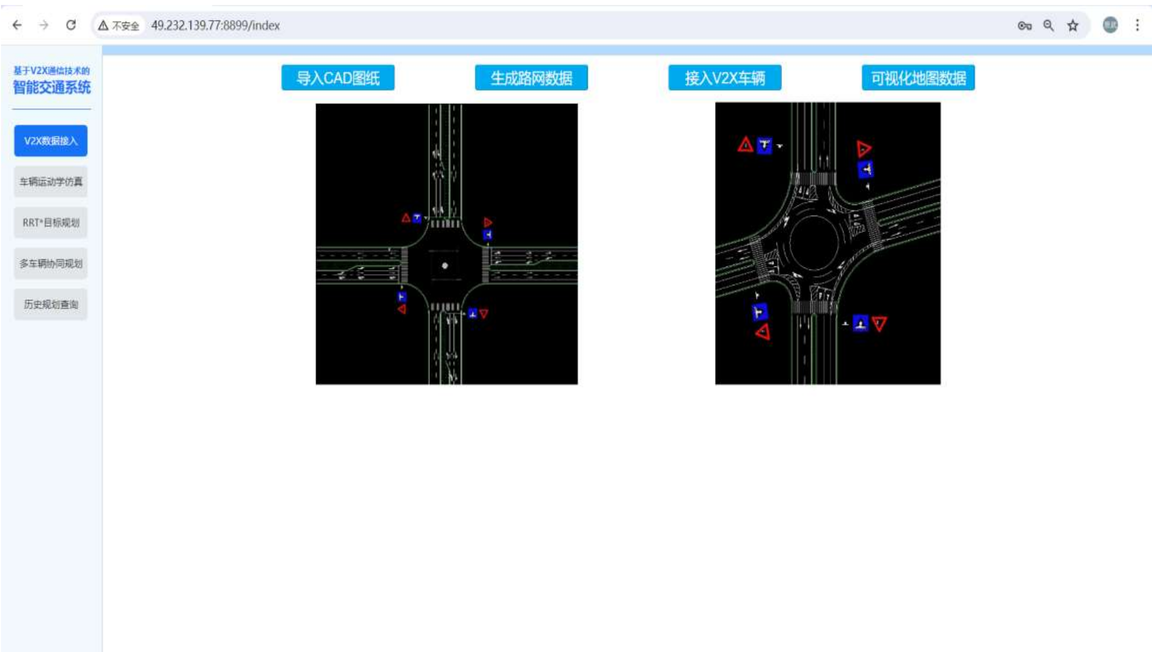

Figure 6. Visual effect diagram of traffic V2X data importn Figure 6, by clicking the "Visualize Map Data" button, the driving OD pair data of the vehicle can be presented in the form of a table:

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

Figure 7. shows the effect of the traffic visualization map data

3.3 Vehicle Kinematics Simulation Module

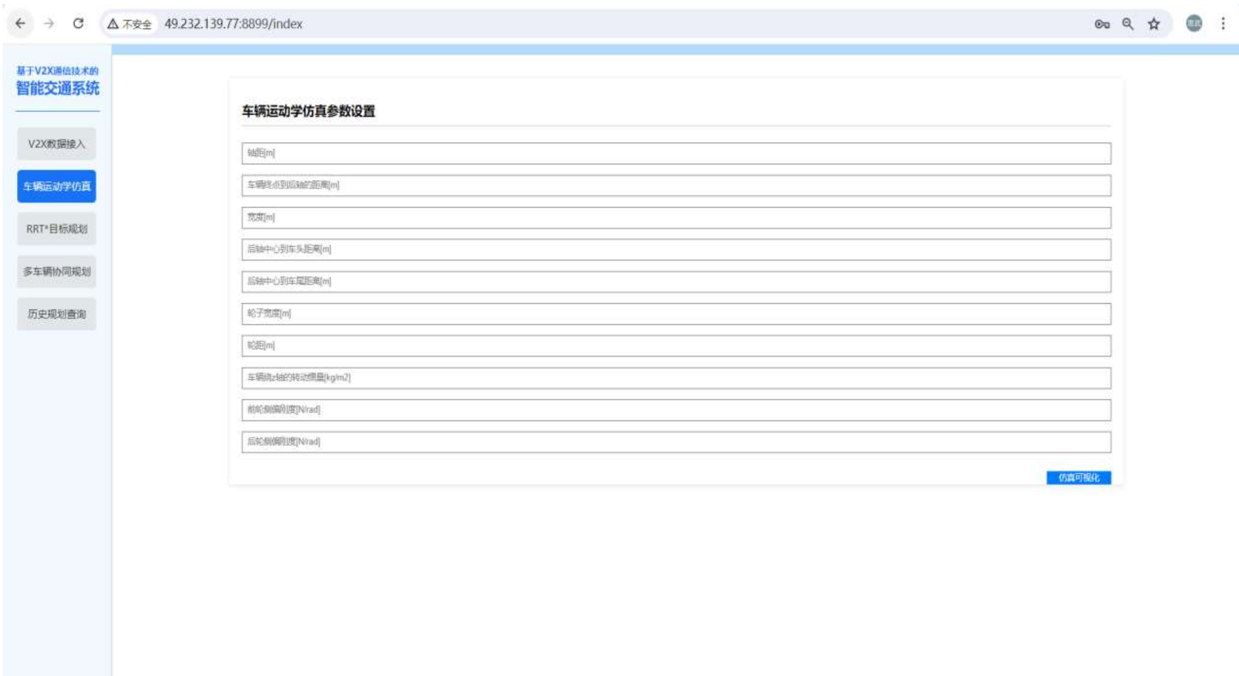

Figure 8. Effect diagram of vehicle kinematics simulation parameter Settings

The vehicle kinematics simulation module designed in this study (as shown in Figure 8) adopts the parametric modeling method and supports users to configure the vehicle dynamics characteristics in multiple dimensions. This module contains the input interfaces of the following key parameters:

Geometric parameters: wheelbase, vehicle width, Rear-Axle to front/rear distance

Steering characteristic parameter: front/rear tire cornering stiffness

Dynamic parameters: moment of inertia around the Z-axis

Gear train parameters: track width, wheel width

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

After the parameter configuration is completed, the system triggers the calculation engine by clicking the "Simulation Visualization" button, conducts numerical simulation based on the established vehicle dynamics model, and presents the results in real time through the 3D visualization interface (as shown in Figure 9). This implementation method not only verifies the accuracy of the vehicle kinematic model, but also provides an effective test platform for the development of intelligent vehicle control algorithms. The simulation results can visually display the dynamic response characteristics of the vehicle under different parameter configurations, providing data support for the optimization of vehicle control strategies.

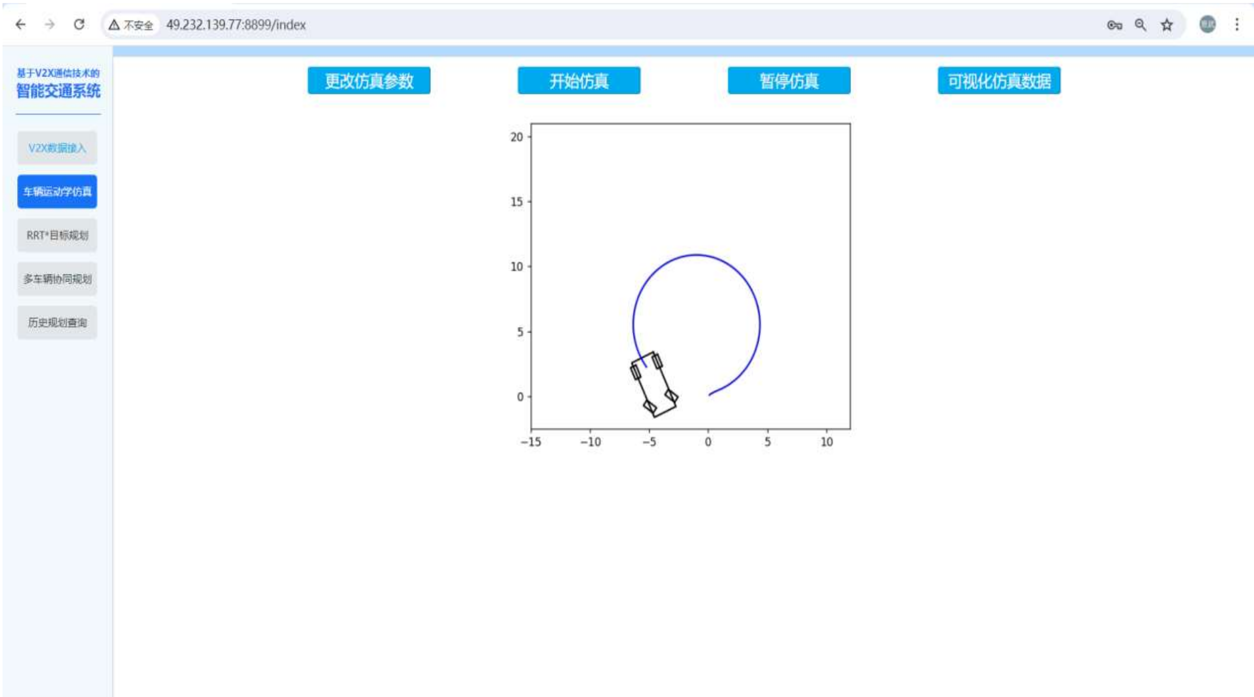

Figure 9. kinematic simulation effect diagram of the simulated car

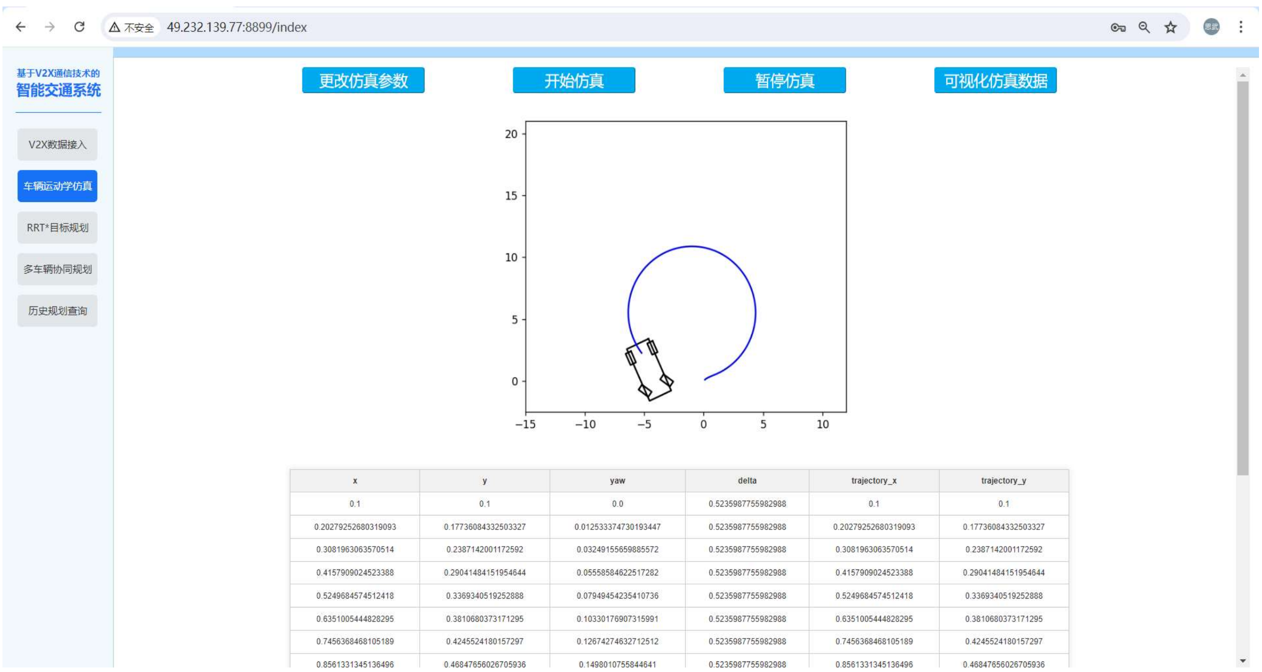

Figure 10. shows the effect diagram of the simulation data display of the simulated car

ISSN: 2414-1895
DOI: 10.6919/ICJE.202506_11(6).0040

It can be seen from Figure 9 that the page contains a button for changing simulation parameters. After clicking it, it can jump back to Figure 8 to modify the simulation parameters. The Start Simulation and pause simulation buttons begin to simulate the movement stop situation of the car. After clicking the visual simulation data button, the data collected during the movement of the simulated car will be saved, uploaded to the database, and also displayed on the page. The effect is shown in Figure 10:

3.4 Historical Planning Query Module

The main functions of the historical planning query module are shown in Figure 11:

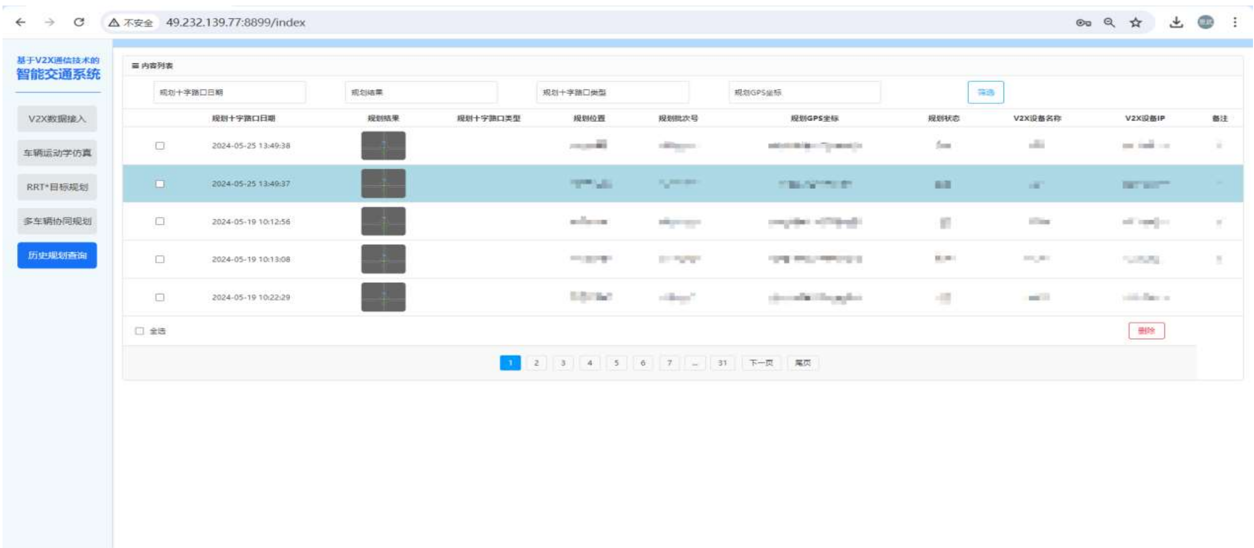

Figure 11. Effect drawing of the historical planning query module

As shown in Figure 11, the historical planning query module designed in this study realizes a complete user operation audit and data traceability mechanism. This module adopts front-end embedding technology to capture users' planning behaviors in real time. The key data dimensions recorded include:

Spatio-temporal information: planning date, GPS coordinates, location information

Planning features: Intersection type, planning result status, batch number

Device information: V2X device identification, IP address

Supplementary explanation: User remarks information

The system persistently stores the structured log data to the SQL Server database through the asynchronous transmission mechanism and adopts the relational data model to achieve efficient management. At the front-end display layer, the system provides multi-dimensional compound query functions and supports the following four retrieval methods:

Precise query: Retrieval based on the time dimension of the planned date range

Category query: Filter by the attributes of the intersection type

Spatial query: Geographical location filtering based on GPS coordinates

Status query: Match according to the status of the planning result

After the user sets the query conditions, the system realizes the non-refreshing data loading through AJAX technology and dynamically renders the historical records that meet the conditions. This design not only ensures the integrity of data traceability, but also improves the retrieval efficiency of large-scale historical data, providing reliable data support for transportation planning decisions.

4. Conclusion

This study constructed a new type of intelligent transportation system based on V2X communication technology and innovatively improved the traditional traffic management system under the background of "big data and artificial intelligence" technology. The research adopts a multi-agent system architecture, modeling each vehicle as an agent with autonomous decision-making ability. The precise characterization of the vehicle state is achieved through the vehicle kinematic model, the lateral dynamics model, and the state space model based on motion mechanics. The system builds a distributed computing framework based on the V2X communication network, achieving real-time sharing of status information and collaborative decision-making among traffic participants. The experimental results show that this intelligent transportation system demonstrates significant advantages in energy consumption optimization, traffic flow balance and improvement of road safety, providing a feasible technical solution for the intelligent transformation of modern urban traffic management. This research achievement not only verifies the application value of V2X technology in the field of intelligent transportation, but also provides a theoretical basis and practical reference for the optimal design of future transportation systems.

gree of people's love, taking into account the diversity of fashion design changes. When designing, we must conform to the concept of human development, and innovate the decoration mode because of the change of human aesthetic taste. Therefore, the traditional form of expression of scientific facilities, the location of its decoration and the mode of transformation, so that it has a modern design atmosphere. Therefore, in the process of modern clothing development, designers need to put traditional embroidery patterns into more diverse parts of clothing. For example, shoulders and waist can effectively break through the traditional mindset and give people a refreshing feeling. For designers, when using embroidery, they should also deal with the traditional embroidery art scientifically, and further optimize the effect of patterns according to the current consumers' needs and fashion frontiers, so that the overall decoration and color matching are more fashionable. For example, in some haute couture conferences, many design products will use bead embroidery, plate gold and other three-dimensional embroidery to decorate the whole clothing, which makes the three-dimensional effect of the whole clothing stronger and elegant.

Acknowledgments

This study was supported by the Innovation and Entrepreneurship Training Program for College Students at North China University of Science and Technology, project number: S202410081058.

References

[1] Heri Rakouth; Paul Alexander; Andrew Jr. Brown; Walter K. Kosiak; Masao Fukushima; L ali Ghosh; Chris Hedges; Henry Kong; Sven Kopetzki; Ramesh Siripurapu; Junqiang She n; "V2X Communication Experience Comparative ysisTechnology:FieldandAnal ", 2013.

[2] Z. Zhu; Jonathan Loo; Yue Chen; Kok Keong Chai; Tiankui Zhang; "Recent A indvances Connected Vehicles Via Information-Centric Networking ", 2016.

[3] Aljawharah Alnasser; Hongjian Sun; Jing Jiang; "Cy Security Cberhallenges And Solution s For V2X Communications: A Survey ", ARXIV-CS.IT, 2019.

[4] Wei Duan; Jinyuan Gu; Miaowen Wen; Guoan Zhang; Yancheng Ji; Shahid Mumtaz; "Eme rging Technologies for 5G-IoV Networks: Applications, Trends and Opportunities ", IEEE NETWORK, 2020.

[5] Shimaa A. Abdel Hakeem; Anar A. Hady; HyungWon Kim; "Current Futureand Develo pments to Improve 5G-NewRadio Performance in Vehicle-to-everything Communications ", TELECOMMUN. SYST., 2020.

[6] Chanyoung Jung; Daegyu Lee; Seungwook Lee; David Hyunchul Shim; "V2X-Communicat ion-Aided Autonomous Driving: System Design And Experimental Validation ", SENSORS (BASEL, SWITZERLAND), 2020.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202506_11(6).0040

[7] Anupama Hegde; Andreas Festag; "Artery-C -- An OMNeT++ Discrete Event SimBased ulation Framework For Cellular V2X", ARXIV-CS.NI, 2020.

[8] Shimaa A Abdel Hakeem; Mohamed A Abd El-Gawad; HyungWon Kim; "Comparative E xperiments Of V2X Security Protocol Based On Hash Chain Cryptography ", SENSORS (BASEL, SWITZERLAND), 2020.

[9] Lili Miao; John Jethro Virtusio; Kai-Lung Hua; "PC5-Based Cellular-V2XEvolution and Deployment ", SENSORS (BASEL, SWITZERLAND), 2021.

[10] Mohamed M G Farag; Hesham A Rakha; " ADevelopmentandEvaluationof CellularVehicle-to-Everything Energy-E icient Dynamic Routing App icationEnabledfl ", SENSORS (BASEL, SWITZERLAND), 2023.

[11] Qilei Ren; K. Man; Muqing Li; Bingjie Gao; Jieming Ma; " igent Design ImpIntelland lem entation of Blockchain and Internet of Things-based Trafic System ", INTERNATIONAL JOURNAL OF DISTRIBUTED SENSOR NETWORKS, 2019.

[12] Mirko Zichichi; Stefano Ferretti; Gabriele D'Angelo; "A Distri gerbutedLed Based Infrastr ucture For Smart Transportation System And Social Good", ARXIV-CS.CR, 2019.

[13] Osama Alfarraj; "Internet T ings witofh h Bio-inspired Co-evolutionary Deep-convolution Neural-network Approach for Detecting Road Cracks in Smart Transportation ", NEURA L COMPUTING AND APPLICATIONS, 2020.

[14] Jun Zhang; Yichuan Wang; Shuyang Li; Shuaiyi Shi; "An Architecture for IoT-Enabled S mart Transportation Security System: A Geospatial Approach ", IEEE INTERNET OF T HINGS JOURNAL, 2021.

[15] Neetesh Kumar; Sarthak Mittal; Vaibhav Garg; Neeraj Kumar; "Deep LearnReinforcement ing-Based Trafic Light Scheduling Framework for SDN-Enabled Smart Transportation S ystem ", IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, 2 021.

[16] Rachmat Suryadithia; Muhammad Faisal; Arman Syah Putra; Nurul Aisyah; "Technological Developments in The Intelligent Transportation System (ITS) ", 2021.

[17] Bhabendu Kumar Mohanta; Debasish Jena; Niva Mohapatra; Somula Ramasubbareddy; Bha rat S. Rawal; " ine Learning Acci iction in Secure IoTMachBaseddentPred Enable Trans portation System ", JOURNAL OF INTELLIGENT AND FUZZY SYSTEMS, 2021.

[18] Khodakhast Esapour; F. Moazzen; Mazaher Karimi; M. Dabbaghjamanesh; A. Kavousi-far d; "A Energy Management Incorporating ti-carrier EnergyNovelFrameworkMul Hubfo r Smart City ", IET GENERATION, TRANSMISSION & DISTRIBUTION, 2022.

[19] Ahmad Karim; " Secure Internet T ings IoVT SmartDevelopmentofofVehicleh()for Tra nsportation System ", COMPUT. ELECTR. ENG., 2022.

[20] Muhammad Hasanujjaman; Mostafa Zaman Chowdhury; Yeong Min Jang; "Sensor Fusion in Autonomous Vehicle with Trafic Surveillance Camera System: Detection, Localizatio n, and AI Networking ", SENSORS (BASEL, SWITZERLAND), 2023.