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REVIEW ARTICLE
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Navigating the Future of Secure and Efficient Intelligent Transportation Systems using AI and Blockchain

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Abstract:

Introduction/Background : This study explores the limitations of conventional encryption in real-world communications due to resource constraints. Additionally, it delves into the integration of Deep Reinforcement Learning (DRL) in autonomous cars for trajectory management within Connected And Autonomous Vehicles (CAVs). This study unveils the resource-constrained real-world communications, conventional encryption faces challenges that hinder its feasibility. This introduction sets the stage for exploring the integration of DRL in autonomous cars and the transformative potential of Blockchain technology in ensuring secure data transfer, especially within the dynamic landscape of the transportation industry.

Materials and Methods : The research methodology involves implementing DRL techniques for autonomous car trajectory management within the context of connected and autonomous CAVs. Additionally, a detailed exploration of Blockchain technology deployment, consensus procedures, and decentralized data storage mechanisms.

Results : Results showcase the impracticality of conventional encryption in resource-constrained real-world communications. Moreover, the implementation of DRL and Blockchain technology proves effective in optimizing autonomous car subsystems, reducing training costs, and establishing secure, globally accessible government-managed transportation for enhanced data integrity and accessibility.

Discussion : The discussion delves into the implications of the study's findings, emphasizing the transformative potential of DRL in optimizing autonomous car subsystems. Furthermore, it explores the broader implications of Blockchain technology in revolutionizing secure, decentralized data transfer within the transportation industry.

Conclusion : In conclusion, the study highlights the impracticality of conventional encryption in real-world communications and underscores the significant advancements facilitated by DRL in autonomous vehicle trajectory management. The integration of Blockchain technology not only ensures secure data transfer but also paves the way for a globally accessible transportation blockchain, reshaping the future landscape of the industry.

Keywords: Internet of things (IoT), Connected vehicles (CV), Internet of vehicles (IoV), Cognitive internet of vehicles (CIoV), Connected and automated vehicles (CAVs), AI.

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1. INTRODUCTION

In the changing field of transportation, the use of technologies has ushered in a new era that promises significant improvements in efficiency, safety and connectivity. The study mentioned in [1] thoroughly examines how transportation systems interact with concepts like security, privacy and trust [2]. As we stand at the forefront of this revolution, it becomes crucial to protect data, ensure personal privacy and build trust within these systems. While having access to information is beneficial for optimizing traffic flow and enhancing safety, it also raises concerns regarding data security and individual privacy [3, 4].

The emergence of Intelligent Transport Systems (ITS) envisions a potential in which vehicles seamlessly communicate, organization dynamically adapts and mobility progresses towards increased autonomy. The systems harness a myriad of data sources and encompass real-time traffic conditions and vehicle-to-vehicle communications to individual travel patterns. The customer seeks assurance that the data they share remains secure, the system operates with reliability, and their privacy is diligently preserved. As vehicles and infrastructure accumulate massive data on individual travel behaviours, locations and preferences, the ethical controlling of this information becomes of Paramount importance. Striking a delicate balance between the advantage of data-driven insights and an individual right to confidential navigation. The liable management of this wealth of information is imperative to ensure that the benefit derived from and enhanced Transportation system doesn't compromise the fundamental right to privacy.

Furthermore, the credibility of Intelligent Transportation systems plays a pivotal role in their widespread acceptance and adoption. The interconnected nature of the systems introduced potential vulnerabilities to cyber threads, data, and unauthorised access, emphasis the need for a vigilant cyber security approach. Privacy, identified as another cornerstone in this research, emergence as a critical consideration in the era of intelligent transportation. Trust goes beyond technology robustness; it encompasses the transparency of system operations, the accountability of stakeholders and the adherence to ethical standards. The objective of this research is to unravel the complexities inherent in the harmonious coexistence of intelligent transportation and the imperatives of security, privacy, and trust [5]. Through a multidimensional analysis, the study aims to delineate the challenges and opportunities arising from the integration of intelligent technologies into transportation.

The interdisciplinary character of this study in entails and exploration of technological innovations, policy frameworks, and ethical considerations. This demands a comprehensive approach that involves the active participation of stakeholders across industries, academic, and regulatory bodies. Collaboratively, they aim to define the perimeters of responsible, innovative, and intelligent transportation [6, 7]. The envisioned future goes beyond showcasing technological prowess; it aspires to see these systems adhering to ethical standards, thereby earning the trust of both users and stakeholders alike [8].

The research delves into cutting-edge technologies driving the evolution of ITS. It critically examines the integration of artificial intelligence, machine learning, and sensor technologies, providing a nuanced understanding of their impact on mobility management, safety, and connectivity. In response to the heightened importance of security, privacy, and trust in ITS, the study investigates state-of-the-art security protocols and privacy-enhancing measures. It identifies emerging trends and innovative solutions, shedding light on how these advancements contribute to safeguarding data and ensuring user privacy.

The significance of this research extends beyond theoretical exploration, aiming to actively contribute to the enhancement of mobility management and urban planning. By meticulously examining the intricate intersection of intelligent transportation systems with security, privacy, and trust, the study seeks to provide actionable insights that can be applied to real-world scenarios.

As intelligent transport systems become integral to the urban landscape, the research endeavors to offer solutions for optimizing traffic flow and enhancing safety. By leveraging data-driven insights from real-time traffic conditions, vehicle-to-vehicle communications, and individual travel patterns, the study aims to propose strategies that streamline mobility within urban environments.

Our research employs a robust and multidimensional methodology designed to provide a thorough understanding of the complex intersection between Intelligent Transportation Systems (ITS) and key considerations of security, privacy, and trust. Beginning with a comprehensive review of existing literature and state-of-the-art technologies, our study establishes a solid foundation. The primary data collection involves real-world case studies, surveys, and in-depth interviews with stakeholders across industries, academia, and regulatory bodies. This qualitative data is complemented by quantitative analyses, leveraging advanced statistical methods to extract meaningful insights from large datasets. Furthermore, our research incorporates an interdisciplinary lens, integrating technological perspectives with ethical considerations and policy frameworks. This holistic approach not only allows for a nuanced exploration of the challenges and opportunities within the realm of ITS but also positions our study to contribute practical recommendations for the responsible and sustainable development of intelligent transportation systems.

The objectives of this research are as follows:

1.1. Technological Advancements in Transportation

The manuscript underscores the transformative impact of technology on the transportation sector, heralding a new era of enhanced efficiency, safety, and connectivity. It draws attention to a comprehensive study that delves into the intricate interactions between transportation systems and crucial concepts such as security, privacy, and trust.

1.2. Challenges in Data Security and Privacy

As Intelligent Transport Systems (ITS) become pivotal in shaping a future where vehicles communicate seamlessly, organizational dynamics adapt dynamically, and mobility leans towards increased autonomy, the study highlights the challenges surrounding data security and individual privacy. It emphasizes the need for ethical management of the wealth of information gathered, striking a delicate balance between data-driven insights and the fundamental right to privacy.

1.3. Critical Role of Security, Privacy, and Trust in Intelligent Transportation

The manuscript underscores the pivotal role of security, privacy, and trust in the widespread acceptance and adoption of intelligent transportation systems. It recognizes potential vulnerabilities to cyber threats, data breaches, and unauthorized access, emphasizing the importance of vigilant cybersecurity approaches. Trust, extending beyond technological robustness, encompasses transparency in system operations, stakeholder accountability, and adherence to ethical standards.

In summary, the manuscript aims to unravel the complexities at the intersection of technological innovation and ethical considerations in intelligent transportation systems. It seeks to guide the future development of these systems, emphasizing the importance of security, privacy, and trust as the cornerstones for sustainable and responsible innovation. The study aspires to contribute to a future where intelligent transportation not only revolutionizes mobility but also prioritizes ethical foundations for long-term success [7, 8].

2. RELATED WORK

Many ITS technologies exist to improve transportation in various ways. Technology, applications, and services that can communicate with one another are included [9]. The goal of an Intelligent Transport System (ITS) is to allow vehicles and the infrastructure around them to monitor their surroundings and respond appropriately constantly. Vehicles and infrastructure along the highway can communicate wirelessly to share data. A vital component of the modern smart city is ITS. Data-driven ITS, as it is used now, operates in this fashion. ITS processes this information using a variety of algorithms, including those for optimal traffic signal decisions and traffic data analysis [10]. Contrast this with data-driven ITS, which prioritizes efficiency and predictability in transportation. It optimizes pre-existing transportation facilities to achieve this goal, improving traffic flow and security on roadways [11]. These items are crucial because they are a system component that plays a vital role in keeping people safe. ITS improves traffic flow and safety by allowing vehicles to generate and disseminate their communications.

An unreliable environment or network makes verifying the integrity of a message delivered to a user more difficult but not impossible. Also, there is no way to recognize who consistently sends the most forthright communications [12]. In response, the academic community devised Smart Coin, an incentive scheme for automobiles built on a blockchain technology platform known as a consortium blockchain. Researchers thought that more cars participating in-network improvisation would lead to a safer and more efficient system [13]. The suggested plan seeks, among other things, improved mobility, less traffic, fewer road accidents, and a transportation network devoid of scam and deception messaging. It would be helpful if vehicles could rate the reliability of their communication sources. Intelligent Coins are deposited into a driver's blockchain account proportionally to how well they decode a message.

Simply put, this is known as the Internet of Things (IoT) or Internet-enabled devices. It integrates intelligent, networked objects into everyday life [14]. As a result of their internet connectivity, they may get and distribute information. Since more gadgets can connect to the Internet of Things, using it has become increasingly exciting. The Internet of Things-based devices alter people's daily routines. The Internet of Things can spark a battle, a problem in a critically crucial industry like healthcare. There have been many discussions regarding the Internet of Things (IoT) applications in healthcare; this research zeroes in on those dealing with obesity, excess fat, and persistent illnesses. These days, all Health Records Management solutions, whether homemade or purchased, must use the cloud due to its pervasiveness and service orientation. The reason for this is the widespread adoption and focus on services provided by cloud computing [15, 16]. Not surprisingly, growing numbers of cloud users are concerned about their personal information and the reliability and safety of their services. When managing electronic health records (EHR), privacy and faith in the cloud service's ability to keep data safe are crucial [5]. People who rely on an electronic health system are understandably concerned about their data's safety and privacy. Both on-premises and cloud-based encryption, such as that provided by advanced encryption standards (AES) and elliptic curve cryptography (ECC), are implemented to protect the confidentiality and integrity of your data. A belief or reasoning model based on subjective logic was also employed to determine how credible the medical team was. Satellite broadcasting and 6G wireless technologies can assist the network in a box (NIB) in better use of its spectrum. With an NIB that supports 6G, the Internet of Vehicles (IoV) might improve its ability to communicate with other vehicles. IoV is a viable option for more innovative mobility in the real world [17].

Unfortunately, because it relies on the vulnerable Rivest–Shamir–Adleman (RSA) and elliptic-curve cryptography algorithms, Quantum computers can easily breach IoV. Improving IoV's robustness is crucial for protecting it from quantum computing assaults [18]. IoV devices may exchange data and coordinate with one another and other devices. Many studies and experiments suggest that this approach is safe and effective for IoV. Because IoV enables wireless communication between vehicles, it has simplified several processes. To maintain a secure network, nodes in vehicles must exchange data. Due to rapid topological shifts and the high mobility of cars, the web is vulnerable to disruptions. Finding a central hub or group of people to store and relay information across vehicles might be challenging. Potential security and privacy issues for IoV include unauthorized access to location data and the theft of intelligent vehicles. The ability to identify and penalize malicious nodes in vehicular communication is becoming significant. Another consideration is that it may be challenging to provide anonymity and trackability simultaneously [19].

3. CRYPTOGRAPHIC APPROACHES IN INTELLIGENT TRANSPORTATION SYSTEM

The automotive sector is one of the world's most dynamic markets. Since ancient times, it has played a significant role in global trade [20]. They're also capable of pairing with devices like cell phones. Connected vehicles provide numerous advantages, but they also simplify automobile theft and break-ins for hackers. Many popular automakers have been compromised. Integrated network nodes keep people linked and offer valuable services, which improves people's quality of life. Serial-number-specific gadgets can be linked together using this service. The Radio-Frequency Identification (RFID) tag on the device communicates with the RFID reader through radio waves so that the reader may read the tag. They discuss several wireless gadgets with varying capabilities. In today's vehicles, the driver is afforded more excellent protection and convenience than ever [21], thanks to integrating a wide variety of sophisticated technological devices. Individuals and businesses place a premium on amenities like automobile ownership and driving ability (*i.e.*, starting the car). A key fob may have a mechanical device that must be rotated to lock and unlock the automobile.

3.1. Physical Keys

The usage of physical keys dates back centuries and is far from obsolete. Access control, authorization, and locking mechanisms were vital to ensure that only those with the correct keys could enter and operate a vehicle. People have begun to utilize different strategies in the last ten years [22]. It is now possible to unlock one's automobile from a distance just by pushing a button on one's key fob. The most common method through which these systems allow individuals to operate motor vehicles is using physical keys and locks.

3.2. Physical Keys with the Immobilizer

Key duplication is also impossible because immobilizer chips in actual keys prevent a vital recurrence. The key is fitted with a mechanism that prevents it from being inserted into the lock (RFID transponder). The fuel injection system might restart when the immobilizer communicates with the steering column [23]. An immobilizer is a device used to prevent a vehicle's engine from starting. For static effects, it employs electro magnetic induction. To avoid thefts of automobiles like hotwiring, it was designed.

3.3. Keyless Remote Entry (RKE)

An RKE can be used as a standard key to lock a door or trunk, increasing safety. An RKE can take the place of a conventional mechanical key [24]. A RKE antenna, Radio Frequency (RF) transponder, immobilizer, buttons, and a battery make up the bulk of the key fob. The use of RFID is fundamental to RKE's operation. A signal is transmitted from the key fob to the car's receiver whenever the user pushes a button. The gadget picked up these signals and sent them on a specific frequency.

3.4. Passive Remote Keyless Entry (PRKE)

The PRKE technology works while the user is near the car. Simply walking up to the vehicle or pushing the doorknob will unlock it. The door may shut and lock itself as soon as the driver exits the car [25]. On the other hand, if you have an old-fashioned. The PRKE gadget is small enough to fit in a user's pocket or purse. Passive keyless entry systems typically consist of several components, the most prominent of which are radio frequency (RF) key fobs. Smart cards and applications for mobile devices are also compatible with the system. They can locate each other because of the built-in transceivers in their respective instruments, allowing them to connect wirelessly and pinpoint their whereabouts. The car's transmitter constantly transmits cryptic, difficult-to-decipher information [26].

3.5. Remote Keyless Ignition Systems (RKIS)

These systems have a few other names, but RKIS is the most common. Owners of such vehicles must reach into their pockets for the key to open the door. For this purpose, they need not use the key buttons [27]. A key fob may start a car even if the user forgets to keep it. The theft of a vehicle, even if no one is inside, might be risky if the owner is nearby (*i.e.*, filling up fuel or loading the trunk).

3.6. Asymmetric or Public-Key Algorithms

They are notoriously challenging to answer because they involve complex numerical and theoretical issues. It is considered to use asymmetric cryptographic techniques to secure network communications and aid in identifying network nodes. A Public Key Infrastructure (PKI)-based security protocol was included in the security above scheme [28]. It takes too long to process vehicles. Therefore, it is inefficient and has a limited capacity. On the downside, this technique requires a significant investment of time and resources to create anonymous keys.

4. BLOCKCHAIN-BASED INTELLIGENT TRANSPORTATION SYSTEM

Blockchain, a new technology developed after the

Internet, is employed due to its immutability, traceability, and highly trustworthy, decentralized ledger system. Across the globe, the results of recent scientific and industrial advancements are becoming apparent to the general public. The combination of blockchain technology and intelligent traffic systems holds great promise for unifying the transportation industry's regulatory bodies, enterprises, and commuters on a single blockchain [29]. Many individuals have previously investigated blockchain technology, credit systems, and the expenses associated with blockchain transactions. Research on the potential applications of blockchain technology in intelligent transportation is still in its infancy. Blockchain is being studied for its potential applications in transportation, such as developing energy-trading protocols for electric vehicles and exchanging traffic safety data. Such studies are the norm in academia. The lack of knowledge on how to build intelligent transportation on the Blockchain means that no one is doing it. Since blockchain technology interacts with every aspect of the intelligent vehicle simultaneously during the application process, it isn't easy to describe its usage on a single level [30].

To those who place a premium on the process, it is nevertheless rare to encounter a development system that more than one person oversees. Most studies focus on internal blockchains. On the social, economic, and environmental fronts, this is the first time blockchain technology has had such a profound effect on the future of intelligent transportation. Assisting those in need is a driving force for Blockchain's continued development in the wise transportation sector. Intelligent contracts become increasingly crucial in the commercial sphere when blockchain technology is used to improve transportation, and they also become increasingly important in the social sphere. Constant attention must be paid to environmental issues, which must be resolved for the sake of the environment and society. In conclusion, the blockchain-based innovative transportation application system must have three distinct levels, representing respective roles played by the government, businesses, and end users [31]. The proper operation looks like this: How it ought to be constructed: The report has several significant discoveries that will aid the development of blockchain-based smart transportation for years to come.

4.1. Intelligent Transportation under Blockchain: Economic Aspect

Immutable blockchain technology can halt opportunistic behavior that has been carefully prepared. Develop a low-transaction-cost economy by using trustworthy ledgers [20]. Using smart contracts and information-sharing technologies, people may increase their trust in one another and reduce the potential risks associated with financial transactions. There are no additional fees because transactions are processed and stored in a decentralized manner. By doing this, the expenses associated with paying middlemen are mitigated. Due to these factors, conducting business amongst all parties involved is simplified. It costs money to monitor, regulate, and authorize the global circulation of currency [23].

4.2. Intelligent Transportation under Blockchain: Environmental Aspect

The combined effects of these measures can significantly reduce vehicular air pollution in urban areas [24]. Users may utilize Blockchain for traffic routing, speed management, and reduced idle and acceleration. Blockchain also facilitates or mandates that long-distance truck routes minimize aerodynamic drag and fuel consumption. In a V2G setting, consumers care more about how electricity is transferred from recharging stations to electric vehicles. Because of the enhancements to the public transit system, more people can now venture out and participate in community activities. An urban reforestation strategy with heavy input from the transportation group Furthermore, Blockchain is beneficial to urban ecosystems [27].

5. AUTOMOTIVE INTELLIGENT TRANSPORTATION SYSTEM (ITS)

Using Blockchain might be the answer to specific current issues in ITS. Those who share the same technological platform can utilize this tool to communicate better and work together. Many problems plague ITS systems, and Blockchain offers the most excellent solution. Because of their limited processing capacity and data centers, they cannot do much in the way of hostile assaults on cars [24]. Because it is sometimes difficult to determine whether or not an individual is engaging in criminal behavior, onboard gadgets and the methods by which they are operated are gaining prominence in modern automobiles. The driver and the passenger are at risk if the car's internal software or control systems are attacked. Any of the issues above can be remedied by swiftly adjusting transportation policy. The strategy works well for undesirable outcomes but may not be appropriate for minor problems. In another scheme, existing roads and bridges are expanded or replaced to accommodate more significant traffic. Nonetheless, the environment's personnel, systems, and procedures have undergone significant shifts, making accurate predictions increasingly challenging [18].

6. COOPERATIVE-ITS (C-ITS)

ITS aims to improve safety, reduce pollution, streamline traffic management, and increase transportation's economic and social advantages for everyone who uses it [32]. Transport efficiency is enhanced for both enterprises and the general public thanks to ITS. Those who rely on their driver-aid systems are more likely to maintain a constant pace, stay in their lane, and avoid risky overtaking situations [33]. If vehicles could communicate with one another and the road, that would be much better. Many studies have been conducted on Cooperative ITS, which involves vehicles exchanging information with one another and with the roadways. It significantly impacts the accuracy and precision of data regarding cars, their locations, and the routes they take. It will improve conditions for drivers and eventually lead to additional services, further enhancing the situation [34]. As shown in Fig. (**1**), there are many kinds of ITS cooperatives.

7. INTELLIGENT TRANSPORTATION SYSTEM CONFIGURATION PATTERNS

Low-income driver populations in countries with the infrastructure to support introducing new car technology [35]. Because of their exorbitant cost and the need for drivers to purchase a new onboard device whenever a program is installed, backyard systems are not as popular as they once were. Fig. (**2**) shows the pattern of ITS configuration.

7.1. The Varieties of Radio Communication

There are several alternatives to mobile phones for in-vehicle communication on roads, including Dedicated Short-Range Communications (DSRC), FM multiplex broadcast, and others (ITS onboard unit). When using the radio to communicate, it's wise to stick with what's proven effective rather than trying something new. There is no shortage of communication channels in today's technologically evolved society. It's silly to buy a gadget that can handle every potential kind of communication. When designing an ITS, it's crucial to consider the aesthetics of the interface and the program's actual usefulness. There would be no roads or cars without the ubiquity of communication and broadcasting networks [36, 37]. For instance, a steady flow of information is necessary for toll collection and traffic safety. For vehicles on the road to share information, dependable and quick-to-respond technology is required. For many reasons, including security and efficiency, cars need to be able to communicate with one another while driving (such as DSRC). Due to the sensitive nature of the data Electronic Funds Control (EFC) systems process, such as toll payments and traffic reports, users should proceed with caution while engaging with these systems. In addition, an EFC system needs to be flexible enough to work with a wide variety of toll road designs.

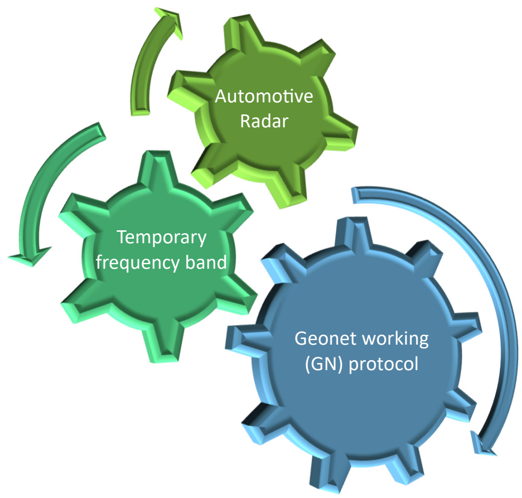

Fig. (1). Types of cooperatives-ITS.

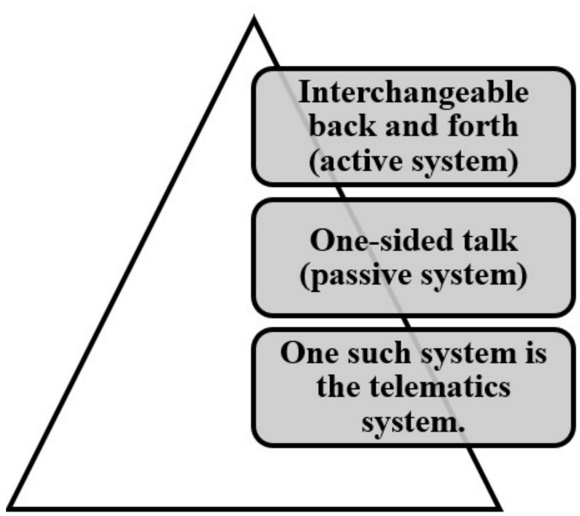

Fig. (2). ITS configuration.

7.2. Positional Information is Fundamental for ITS

An aging population, urban difficulties, tourists, economic growth, pollution, and increased car use all play a role. ITS is meant to deal with all of these things, not just traffic or cars; thus, sometimes, moving is required for maximum effectiveness [38]. Sensing, positioning, mapping, communication, and networking are the five core components of ITS, and they all function together.

7.3. Precision in Positioning for use in Intelligent Transportation Systems

The ability to travel across great distances of water is made possible by ships and airplanes. In densely populated places, where cars are the norm for getting about, clusters of buildings are common. This class includes structures like parking garages, tunnels, and underground roadways [39]. However, because most vehicles are privately owned, there is still a requirement for cost-effective location identification technology in the automobile industry.

8. INTELLIGENT TRANSPORTATION SYSTEMS WITH USER-FRIENDLY SMART SERVICES

This prototype shows how the ITS could be helpful in practice. The future trajectory of any given service is amenable to prediction [40]. The company's ideology and the high degree of technical feature overlap between services inform the division of labor inside the services.

8.1. Traffic Management and Transportation

The group plans to employ real-time data to enhance the existing transportation system. These services can typically communicate with one another, which boosts the transportation system's efficiency.

8.1.1. Travel-related Details

Using this service, customers will have a much easier time determining departure times, travel plans, and optimal routes. Information can be accessed from any location with a computer or mobile device. They can access it anytime, from any place, at home, in the workplace, or out and about. At each station, real-time information about parking, public transit routes and schedules, fare pricing, transfers, and more are updated.

8.1.2. Directions for Travelers

This information can be gathered through channels, including in-car displays, head-up displays, and head-mounted displays. In-car displays alert drivers to hazards such as stop signs, restricted lanes, posted speed limits, and wet pavement. Drivers will easily be able to spot the warnings.

8.1.3. Provided Route Suggestions

A few examples are places to go and things to do there. They are also given an in-depth synopsis of the future twists and turns. Access to real-time information regarding the state of the transportation network, such as traffic and road closures, benefits passengers of all forms of transportation. This service has several benefits, but reducing drivers' wait time and tension during a move is particularly noteworthy [41, 42].

8.1.4. Coordinating Rideshare Bookings with Passengers

This website provides information about public transportation services available in the user's area (home, workplace, *etc*.). As soon as the traveler enters their knowledge, the service center will provide options that best fit their needs [43].

8.1.5. Traveller Service Information

The meal and hotel costs can be broken down for the reader. Numerous tourist amenities and services can be reserved.

8.1.6. Traffic Control

Customers using this service will find it much easier to collect and utilize data from the transportation system in real-time [40]. This data is used to determine which vehicles and individuals should be given priority at any given time. Giving public transportation and other vehicles carrying numerous passengers precedence or adjusting the timing of signals to accommodate the flood of cars helps improve traffic flow. In this configuration, several different user services benefit from the data-collecting operations performed by the Traffic Control service [44].

8.1.7. Controlling Emergencies

Customers for this product or service are primarily found in the towing and recovery industry, as well as in law enforcement and the transportation sector. Today's rapid and accurate scenario evaluations and projections of how such situations will affect people and the environment depend primarily on technology. Technology advance ments in processing and transmission, such as closed-circuit television cameras, aid in collecting this data [45].

8.2. Commutes with Public Transportation

Part of their job is to make riding the bus or train less hassle and more pleasure. Listed below are all the services that fit within this category.

8.2.1. Data on Transit Along the Way

In addition, it offers up-to-the-minute details on where and when to catch public transportation, including bus and train stops. It is becoming increasingly common for drivers to make judgments and changes to their plans while on the road.

8.2.2. Safeguarding the Public Transportation System

Thanks to this service, riders of public transportation can rest easy. Manual or automatic alarms can be activated at the stations where passengers enter and exit the train or bus. Major transportation network monitoring infrastructure is also protected [46].

8.3. To Pay *via* the Internet

The same simple electronic payment method is available to travelers regardless of the transportation mode utilized or the trip's purpose. There would be a wide variety of uses for such a system. Payment for parking, public transit, and tolls can all be made through the same automated system [47].

9. IMPORTANCE AND ROLE OF INTELLIGENT TRANSPORTATION SYSTEM

This is possible at a lower cost and with less effort than ever because of big data, enhanced processing, and the capacity to collect, store, analyze, utilize, and disseminate information from various sources. A new generation of real-time transportation network management and control systems has arisen to deal with the increasing complexity of the world's infrastructure [48]. Improvements in transportation management and control are needed. Because of the interconnected structure of modern society, the general public needs to understand the full extent of the current innovative transportation system. Public transit's safety and consistency will suffer due to these alterations. The ITS is highly dependent on vehicular traffic. Intelligent transportation systems aim to do things like cut down on congestion and pollution. These apps and programs use data on traffic in real-time to improve accessibility and reduce harmful environmental effects in densely populated places. Cloud-based transportation networks are already struggling to keep up with the surging demand for traffic monitoring. The ITS has expanded dramatically over the previous five years [49]. The following is essential information for all travelers to remember: Many people are being encouraged to reduce their carbon footprints by ITS programs to increase their use of public transportation. These advancements have boosted environmental quality, reduced reliance on foreign energy sources, and shortened commute times.

Sensors can be found all over the infrastructure, in buildings, in public transit, and even in users' electronics. It makes use of a wide variety of data kinds. Users, traffic managers, data analysts, and academics interested in traffic operations receive these data flows from software running on automatic devices, actuators, or control systems. A willingness to learn and the ability to adapt quickly are essential qualities. When data from several sources is applied, new understandings can be gained, and improvements can be made. The findings of this study will demonstrate that this is indeed feasible. The three interrelated stages that make up this data modeling pipeline for ITS are described along with their features, engineering needs, and problems. Three of these steps are fusing data, adapting the learning process, and assessing the results. Data-based ITS modeling may soon be doable and applicable in real-world settings thanks to developments in data science. 6G is crucial for IoT applications because it streamlines sensor-to-sensor communication.

CONCLUSION

To make wise choices in multi-lane merging zones, CAVs employ a technique known as the “coalitional game.” An intuitive one-track vehicle model is used to construct a motion prediction module that improves accuracy and dependability. The purpose and constraints of the decision-cost maker are then developed with protection, convenience, and effectiveness in mind. To design an intelligent mobility model that looks and acts like a human, it is also essential to consider individual differences in driving styles. When numerous lanes intersect, CAVS additionally supports four typical coalition models. It's a device that can be mounted on a window and is used to monitor the status of school buses, which is helpful for both children and the administration. Examining student data is essential to maintaining the bus service. As a result of these experiences, people tend to be more adaptable than usual. In light of this aid, The system generates several reports, including the amount of money paid in fees and dues and the total number of bus routes and stops. The college administration can do much better regarding the various transportation services and other aspects. The system requires memory, I/O devices, and disc space to function.

Additionally, we want to implement a fingerprint-based attendance tracking system to monitor how long children are in class and when they depart. Businesses implement TMSes to streamline transportation operations, reduce travel time and costs, and maximize fuel efficiency. There is still a great deal of ground to cover in developing innovative urban transportation. It isn't easy to create blockchain-based smart transit in cities where the technology is in use. Crypto-equity built on the Ethereum blockchain is being considered a potential solution to the labor issues confronting ridesharing firms. Due to the ambiguity around payment, this is a particularly challenging issue. Everything may change if and when bitcoin and other cryptocurrencies become universally used. It would make that individual or group more trustworthy, responsible, and credible.

LIST OF ABBREVIATIONS

IoT	=	Internet of Things
CV	=	Connected Vehicles
IoV	=	Internet of Vehicles
CIoV	=	Cognitive Internet of Vehicles
CAVs	=	Connected and Automated Vehicles

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

[1] T-M. Chen, Y. Li, and W. Zhao, "Building a secure and trustworthy intelligent transportation system: A blockchain-based architecture and consensus mechanism design", *IEEE Trans. Intell. Transp. Syst.,* vol. 25, no. 8, pp. 5982-5995, 2023.

[2] M.H. Chinaei, T.H. Rashidi, and T. Waller, "Digitally transferable ownership of mobility-as-a-service systems using blockchain and smart contracts", *Transp. Lett.,* vol. 15, no. 1, pp. 54-61, 2022.

[3] M-Y. Chen, and H-T. Wu, "An automatic-identification-system-based vessel security system", *IEEE Trans. Industr. Inform.,* vol. 19, no. 1, pp. 870-879, 2023.

[4] C. Zhang, X. Liu, and Y. Zhang, "An attribute-based encryption scheme for secure and traceable data sharing in intelligent transportation systems", *Comput. Secur.,* vol. 136, p. 102924, 2023.

[5] K. Habib, Z. Li, and S.H. Rizvi, "Trustworthy intelligent transportation systems: A privacy-preserving and verifiable framework for data sharing", *IEEE Trans. Vehicular Technol.,* vol. 72, no. 10, pp. 10206-10217, 2023.

[6] M. Lu, X. Lin, and H. Zhu, "Security and privacy challenges in intelligent transportation systems: A survey", *IEEE Access,* vol. 11, pp. 15947-15962, 2023.

[7] A.K. Mishra, K.K. Bhartiy, S. Aluvala, P. Singh, and K. Kishor, "Unlocking the power of natural language processing through journaling with the assistance", *2023 3rd International Conference on Innovative Sustainable Computational Technologies (CISCT)* Dehradun, India, 2023, pp. 1-5 [http://dx.doi.org/10.1109/CISCT57197.2023.10351450]

[8] L. Zhiqiang, J. Li, C. Dong, H. Li, and Z. Xu, "Deep learning in the COVID-19 epidemic: A deep model for urban traffic revitalization index", *Data Knowl Eng.,* vol. 135, p. 101912, 2021.

[9] C. Schwarz, and Z. Wang, "The role of digital twins in connected and automated vehicles", *IEEE Intell. Transp. Syst. Mag.,* vol. 14, no. 6, pp. 41-51, 2022. [http://dx.doi.org/10.1109/MITS.2021.3129524]

[10] Lv Zhiqiang, X. Wang, Z. Cheng, J. Li, H. Li, and Z. Xu, 4"A new approach to COVID-19 data mining: A deep spatial–temporal prediction model based on tree structure for traffic revitalization index", *Data Knowled. Eng.,* vol. 146, p. 102193, 2023.

[11] J. Li, L. Zhiqiang, Z. Ma, X. Wang, and Z. Xu, "Optimization of spatial-temporal graph: A taxi demand forecasting model based on spatial-temporal tree", *Informat. Fus.,* vol. 104, p. 102178, 2024.

[12] Z. Lv, Z. Cheng, J. Li, Z. Xu, and Z. Yang, "TS-STNN: Spatial-temporal neural network based on tree structure for traffic flow prediction", *Transp. Res. E: Logist. Transp. Rev.,* vol. 177, p. 103251, 2023.

[13] D. Indoria, and Y.P. Rubi, "Utilizing sentiment analysis for assessing suicidal risk in personal journal entries", *2023 3rd International Conference on Innovative Sustainable Computational Technologies (CISCT),* 2023 Dehradun, India, 2023, pp. 1-5 [http://dx.doi.org/10.1109/CISCT57197.2023.10351354]

[14] P. Kumar, R. Kumar, G.P. Gupta, R. Tripathi, and G. Srivastava, "P2TIF: A blockchain and deep learning framework for privacy-preserved threat intelligence in industrial IoT", *IEEE Trans. Industr. Inform.,* vol. 18, no. 9, pp. 6358-6367, 2022. [http://dx.doi.org/10.1109/TII.2022.3142030]

[15] D. Kirli, B. Couraud, V. Robu, S.M. Bravo, S. Norbu, M. Andoni, I. Antonopoulos, N.M. Pincetic, D. Flynn, and A. Kiprakis, "Smart contracts in energy systems: A systematic review of fundamental approaches and implementations", *Renew. Sustain. Energy Rev.,* vol. 158, p. 112013, 2022. [http://dx.doi.org/10.1016/j.rser.2021.112013]

[16] A. Didouh, "Novel centralized pseudonym changing scheme for location privacy in V2X communication", *Energies,* vol. 15, no. 3, p. 692, 2022. [http://dx.doi.org/10.3390/en15030692]

[17] M.A. Rahman, M.A. Rahim, M.M. Rahman, N. Moustafa, I. Razzak, T. Ahmad, and M.N. Patwary, "A secure and intelligent framework for vehicle health monitoring exploiting big-data analytics", *IEEE Trans. Intell. Transp. Syst.,* vol. 23, no. 10, pp. 19727-19742, 2022. [http://dx.doi.org/10.1109/TITS.2021.3138255]

[18] C. Arya, N. Yamsani, M. Kumar, P. Singh, and V.K. Bhagat, "A concise review of MRI feature extraction and classification with kernel functions", *2023 3rd International Conference on Innovative Sustainable Computational Technologies (CISCT)* Dehradun, India, 2023, pp. 1-5. [http://dx.doi.org/10.1109/CISCT57197.2023.10351471]

[19] S. Sellamuthu, S.A. Vaddadi, S. Venkata, and R. Dhanapal, "AI-based recommendation model for effective decision to maximise ROI", *Soft Comput,* vol. 2023, 2023.

[20] K. Shamshuddin, and G.N. Jayalaxmi, "Privacy-preserving scheme for smart transportation in 5G integrated IoT", In: *ICT with Intelligent Applications.,* Springer: Singapore, 2022, pp. 59-67. [http://dx.doi.org/10.1007/978-981-16-4177-0_8]

[21] E.M. Abounassar, "Security and interoperability issues with the internet of things (IoT) in healthcare industry: A survey", In: *Security and Privacy Preserving for IoT and 5G Networks.,* Springer: Cham, 2022, pp. 159-189. [http://dx.doi.org/10.1007/978-3-030-85428-7_7]

[22] L. Vishwakarma, and D. Das, "SmartCoin: A novel incentive mechanism for vehicles in intelligent transportation system based on consortium blockchain", *Vehicul. Communicat.,* vol. 33, p. 100429, 2022. [http://dx.doi.org/10.1016/j.vehcom.2021.100429]

[23] S.S. Kute, A.K. Tyagi, and S.U. Aswathy, Security, privacy and trust issues in the internet of things and machine learning based e-healthcare.*Intelligent Interactive Multimedia Systems for e-Healthcare Applications.,* Springer: Singapore, 2022, pp. 291-317. [http://dx.doi.org/10.1007/978-981-16-6542-4_15]

[24] O. Alabi, "Privacy and trust models for cloud-based EHRs using multilevel cryptography and artificial intelligence", In: *Artificial Intelligence for Cloud and Edge Computing.,* Springer: Cham, 2022, pp. 91-113. [http://dx.doi.org/10.1007/978-3-030-80821-1_5]

[25] H. Yi, "A secure blockchain system for Internet of Vehicles based on 6G-enabled Network in Box", *Comput. Commun.,* vol. 186, pp. 45-50, 2022. [http://dx.doi.org/10.1016/j.comcom.2022.01.007]

[26] M. Sajid, M.S. Jawed, S. Abidin, and S. Ahamad, "Capacitated vehicle routing problem using algebraic harris hawks optimization algorithm", In: *Intelligent Techniques for Cyber-Physical Systems,* CRC Press, 2023, pp. 183-210.

[27] P. Singhal, and S. Gupta, "An integrated approach for analysis of electronic health records using blockchain and deep learning", *Recent Adv. Comput. Sci. Commun.,* vol. 16, no. 9, p. 2023, 2023.

[28] A. Goswami, D. Sharma, H. Mathuku, S.M.P. Gangadharan, C.S. Yadav, S.K. Sahu, M.K. Pradhan, J. Singh, and H. Imran, "Change detection in remote sensing image data comparing algebraic and machine learning methods", *Electronics,* vol. 11, no. 3, p. 431, 2022. [http://dx.doi.org/10.3390/electronics11030431]

[29] C-T. Lin, M. Prasad, C-H. Chung, D. Puthal, H. El-Sayed, S. Sankar, Y-K. Wang, and A.K. Sangaiah, "IoT-based wireless polysomnog-raphy intelligent system for sleep monitoring", *IEEE Access,* vol. 6, pp. 405-414, 2017.

[30] K.N. Qureshi, "A blockchain-based efficient, secure and anonymous conditional privacy-preserving and authentication scheme for the internet of vehicles.", *Appl. Sci.,* vol. 12, no. 1, p. 476, 2022. [http://dx.doi.org/10.3390/app12010476]

[31] A.J. Perez, and S. Zeadally, "Secure and privacy-preserving crowdsensing using smart contracts: Issues and solutions", *Comput. Sci. Rev.,* vol. 43, p. 100450, 2022. [http://dx.doi.org/10.1016/j.cosrev.2021.100450]

[32] K.S.K.P Saurabh, "A comprehensive study of XSS attack and the digital fo-rensic models to gather the evidence", *ECS Trans.,* vol. 107, no. 1, 2022.

[33] Aditi Sharan, "Term co-occurrence and context window based combined approach for query expansion with the semantic notion of terms", *Int, J. Web Sci. ,* vol. 3, no. 1, pp. 32-57, 2017.

[34] R. Chaudhari, "A review on key technologies of industry 4.0 in manufacturing sectors", In: *Recent Advances in Mechanical Infrastructure.,* Springer: Singapore, 2022, pp. 417-426.

[http://dx.doi.org/10.1007/978-981-16-7660-4_37]

[35] C.S. Yadav, J. Singh, A. Yadav, H.S. Pattanayak, R. Kumar, A.A. Khan, M.A. Haq, A. Alhussen, and S. Alharby, "Malware analysis in IoT & android systems with defensive mechanism", *Electronics,* vol. 11, no. 15, p. 2354, 2022. [http://dx.doi.org/10.3390/electronics11152354]

[36] K. Upreti, A.K. Gupta, N. Dave, A. Surana, and D. Mishra, "Deep learning approach for hand drawn emoji identification", *2022 IEEE International Conference on Current De-velopment in Engineering and Technology (CCET)* 2022, Bhopal, India, pp. 1-6. [http://dx.doi.org/10.1109/CCET56606.2022.10080218]

[37] Y.A. Aruna, "A review of physical unclonable functions (PUFs) and its applications in IoT environment", In: Y.C. Hu, S. Tiwari, M.C. Trivedi, K.K. Mishra, Eds., *Ambient Communications and Computer Systems. Lecture Notes in Networks and Systems.,* vol. Vol. 356. Springer: Singapore, 2022. [http://dx.doi.org/10.1007/978-981-16-7952-0_1]

[38] M. Arienmughare, A.S. Yoshimura, and M.A. Al Momin, "Survey of automotive cyber-physical system security", In: *Security, Data Analytics, and Energy-Aware Solutions in the IoT,* IGI Global, 2022, pp. 78-97.

[39] P. Dadhich, and E. Acharya, "Role of cloud computing in vehicular NETs to design smart ITS", In: *Internet of Things and Its Applications.,* Springer: Cham, 2022, pp. 451-465. [http://dx.doi.org/10.1007/978-3-030-77528-5_23]

[40] A. Ali, "An industrial IoT-based blockchain-enabled secure searchable encryption approach for healthcare systems using neural network", *Sensors,* vol. 22, no. 2, p. 572, 2022. [http://dx.doi.org/10.3390/s22020572]

[41] A.K. Tyagi, and N. Sreenath, "Vehicle localization and navigation", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Technologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_5]

[42] A.K. Tyagi, and N. Sreenath, "Intelligent transportation system services using internet of things devices", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Technologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_11]

[43] A.K. Tyagi, and N. Sreenath, "Autonomous vehicles and intelligent transportation systems—a framework of intelligent vehicles", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Technologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_4]

[44] A.K. Tyagi, and N. Sreenath, "Intelligent transportation system: Need, working, and tools", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Technologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_9]

[45] E.D.T. Jaspers, and E. Pearson, "Consumers' acceptance of domestic Internet-of-Things: The role of trust and privacy concerns", *J. Bus. Res.,* vol. 142, pp. 255-265, 2022. [http://dx.doi.org/10.1016/j.jbusres.2021.12.043]

[46] T Liu, "Artificial intelligence-enabled ddos detection for blockchain-based smart transport systems", *Sensors,* vol. 22, no. 1, p. 32, 2022.

[47] D. Kianersi, "Evaluation of a reputation management technique for autonomous vehicles", *Fut. Inter,* vol. 14, no. 2, p. 31, 2022. [http://dx.doi.org/10.3390/fi14020031]

[48] A.K. Tyagi, and N. Sreenath, "Intelligent transportation system: Past, present, and future", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Technologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_2]

[49] A.K. Tyagi, and N. Sreenath, "Applications of vehicles and its related technology in previous and the next decade", In: *Intelligent Transportation Systems: Theory and Practice. Disruptive Tecnologies and Digital Transformations for Society 5.0.,* Springer: Singapore, 2023. [http://dx.doi.org/10.1007/978-981-19-7622-3_3]