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A Review and Analysis of IoT Enabled Smart Transportation Using Machine Learning Techniques

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ABSTRACT

This study represents the complex terrain of smart transport applications, focusing on the synergistic potential that emerges from the strategic confluence of Machine Learning (ML) and Internet of Things (IoT) methodologies. This review provides insight into how the dynamic nature and large volume of data created by IoT systems make them an excellent environment for the integration of ML approaches by exploring the interplay between these areas. Notably, a wide range of ML algorithms have been reviewed and suggested in the context of smart transportation, with a focus on critical areas such as route optimization, parking management, and accident detection/prevention. A crucial finding from this investigation is the noticeable gap in ML coverage throughout the range of smart lighting systems and parking applications. This highlights the need to refocus on these topics from an ML standpoint, opening the path for future investigation and innovation. This research tackles important topics including sustainability, cost-effectiveness, safety, and time efficiency, highlighting the fascinating possibilities of fusing IoT, ML, and smart mobility. Proactively preventing accidents, expedited parking reservations, cutting-edge street lighting, and accurate route suggestions are just a few benefits of the integration of these technologies. The study does, however, highlight the need for more research, particularly in unexplored areas like parking applications and smart lighting. By bridging these gaps and improving ML and IoT cooperation, smart transportation will be greatly improved and creative solutions for improved urban mobility will be offered.

1. INTRODUCTION

The Internet of Things (IoT) is starting to alter the game by combining technological prowess with social effects to solve significant concerns. It functions as a vast, worldwide network that is ideal for meeting all of human requirements. Through the cooperation of digital and physical links, this complex system produces a world that provides several intelligent services. The most recent developments in information and communication technology have made all of this feasible (ICT). The term “Internet of Things” refers to the harmonic amalgamation of data streams gathered from a pantheon of separate things into a virtual terrain, all handled within the framework of the widespread digital infrastructure that underpins the Internet. As a result, every artefact, regardless of typology, that has the fundamental on/off binary and whose operation is inextricably linked to the enormous expanse of the internet ascends to the echelons of an IoT entity [1].

The integration of the Internet of Things (IoT) and transportation has recently emerged as a critical topic, with major consequences for urban planning, environmental sustainability, and social mobility. Several relevant issues highlight the need for a thorough analysis and evaluation of IoT-enabled smart transportation:

- Technological Advancement: The fast growth of IoT and Machine Learning (ML) technology demands frequent reviews to synthesize new breakthroughs, ensuring that academic and industrial practices stay current.
- Unexplored difficulties and potential: Despite substantial progress, there are still undiscovered difficulties and potential in bringing IoT to transportation. These include issues with data security, scalability, and interaction with existing infrastructure—all of which are critical for the actual deployment of smart transportation systems.
- Emergence of Smart Cities: The global proliferation of smart cities highlights the growing necessity for urban planners and politicians to understand how IoT might enhance transportation—a critical aspect of urban infrastructure.
- Environmental and Social Implications: Addressing transportation's environmental and social implications, such as emissions and accessibility, is critical. While IoT offers possible answers, they require extensive investigation and research.

This article aims to fill these gaps by providing an in-depth study and analysis of current IoT applications in smart transportation, with an emphasis on integration, obstacles, and prospective improvements. The goals are as follows:

- Present a current synthesis of the most recent research in IoT-enabled transportation, offering a condensed overview of current trends and developments.
- Identify and ponder on topics that have gotten scant attention in previous literature, such as the function of IoT in smart lighting and parking in the transportation industry.
- Provide Practical Insights: Provide insights and recommendations that are immediately useful to practitioners, policymakers, and field researchers.
- Set a Research Direction: Propose future research directions, focusing on areas where IoT and ML may further develop smart mobility.

1.1 Internet of Things (IoT)

Applications based on mobile devices, sensors, and actuators have become more sophisticated over the last decade, enabling inter-device communication and the execution of complicated tasks. In 2008, the number of networked devices overtook the world population, and this statistic has risen at an exponential rate since then. Intelligent mobile phones, embedded frameworks, wireless sensing units, and virtually any electronic equipment may connect to a local network or the global internet, ushering on the Internet of Things (IoT) era [2]. According to United Nations projections, the global urban population will reach roughly 4.9 billion people by 2030. This population expansion brings with it a raft of new concerns, such as pollution, transit congestion, resource allocation, and so on. As the Internet of Things (IoT) has grown in popularity, a plethora of interconnected IoT entities have arisen, building a massive network. These organizations contribute to the ongoing collection of diverse datasets, which are subsequently directed to computational nodes for in-depth study. Figure 1 resembles the framework of the IoT-enabled smart transportation system. Numerous applications leverage the ability of deep learning paradigms to methodically examine the amassed datasets, achieving the combined goals of "intelligence" and "automation" made possible by considerable advances in deep learning techniques. As a result, the concept of "Smart Cities" has arisen as a global paradigm based on the convergence of data analytics foundations and the bedrock of IoT infrastructures. Figure 2 depicts the various IoT Application Areas in Smart Cities. Intelligent grids, smart transportation systems, imaginative manufacturing processes, sophisticated architectural structures and a variety of other characteristics are included [1].

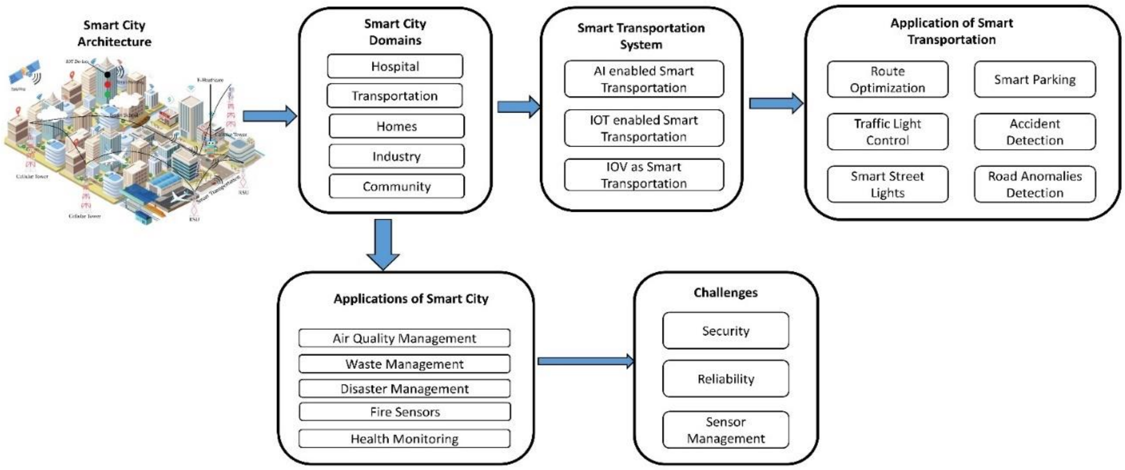

Figure 1. IoT-enabled smart transportation framework

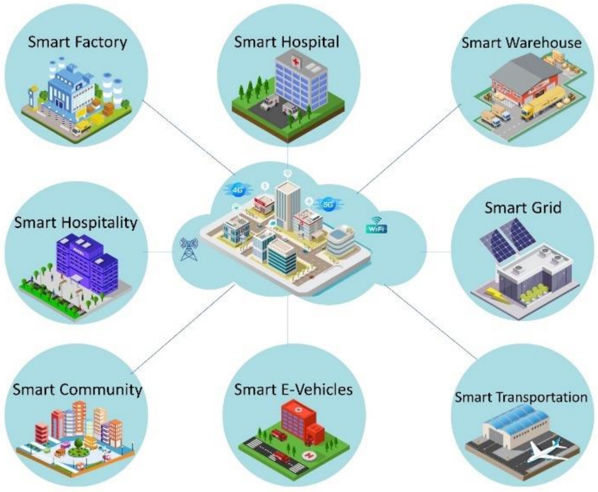

Figure 2. Different domains of IoT enabled smart city

1.2 Key elements of IoT infrastructure

Each embedded apparatus is recognized as an entity inside the world of the Internet of Things (IoT). These entities often include tangible aspects like as physical sensors, actuators, and a merged embedded structure holding a CPU. It is the responsibility of these entities to develop intercommunication, hence facilitating Machine-to-Machine (M2M) interaction. This communication interplay, in turn, divides into proximity-based manifestations enabled by wireless modalities such as Wi-Fi, Bluetooth, and ZigBee, as well as expansive spectrums of communication via mobile networks such as WiMAX, LoRa, Sigfox, CAT M1, NB-IoT, GSM, GPRS, 3G, 4G, LTE, and the most recent iteration, 5G [3]. With the growth of IoT devices infiltrating all sectors of daily life, optimizing the cost-efficiency quotient connected with these IoT entities has become critical.

The rest of the paper is structured as follows. Section II explains related work in the field of IoT. Section III contains a presentation and in-depth examination of smart transportation employing IoT applications. A discussion of smart transportation applications is presented in Section IV. Real-world examples of smart transportation systems are provided in Section V. Sections VI and VII explain the Challenges and Conclusion.

2. BACKGROUND WORK

This section establishes a fundamental comprehension of the principal technologies that underlie smart transportation enabled by the Internet of Things (IoT), with a focus on clarity and direct relevance to the study. Table 1 compares different Smart transportation system that uses IoT.

Table 1. Smart transportation system using IoT

Reference	Methods	Merits
[4]	Environmentally friendly transportation	Manages traffic effectively, Optimizes traffic flow
[5]	Eco-friendly transportation	Focuses on ecologically sound traffic handling
[6]	Reliable and environmentally friendly transportation	Effectively addresses traffic bottlenecks
[7]	Crash-resistant transportation	Crash-preventive system design with collision warnings
[8]	Eco-friendly transportation	Introduces a method for zero-emission vehicular transportation

- **Foundations of IoT**: Smart transportation relies on the robust infrastructure provided by the Internet of Things (IoT). The components of IoT—sensors, actuators, and network connectivity—are succinctly delineated, emphasizing their respective roles in the real-time collection of data and decision-making within transportation systems.
- **Communication Technologies**: Crucial for ensuring seamless communication in smart transportation, technologies such as RFID, NFC, and WSNs play a pivotal role. The descriptions of these technologies are refined to underscore their specific functions in facilitating both vehicle-to-infrastructure and vehicle-to-vehicle communications.
- **Data Processing and Machine Learning**: The utilization of Machine Learning (ML) to process extensive datasets generated by IoT devices is of paramount importance. Key ML techniques pertinent to transportation, including predictive analytics for optimizing traffic flow, are outlined concisely.

Organizations get more data when they add more devices. These data are analyzed by new applications, which draw conclusions and make recommendations. This results in the use of Machine Learning (ML) techniques to create Artificial Intelligence (AI) [9]. Many IoT technologies are described in the literature, including:

2.1 Radio-Frequency Identification (RFID)

Readers and tags work together in RFID, which is a very important part of the IoT system [10]. Giving everything in a company a unique digital name helps with automatic identification. The real world and the internet world are linked by this complicated network. RFID can be used in smart systems, to keep track of things, in healthcare, to manage parking, and to protect valuables. It doesn't just store data that you enter by hand; it's also a good monitor that gathers data about its surroundings.

2.2 Near Field Communication (NFC)

Near Field Communication (NFC), visible in smartphones, offers two-way communication across short distances, notably in smart cities [11]. NFC, which operates within a few millimeters, transforms electronics, notably smartphones, into digital wallets. This revolution lets the smartphone do more than simply authenticate your identification; it now manages financial transactions, regulates access, and trades data. The two-way nature of NFC gives up numerous options. For example, by positioning NFC nodes strategically at home, you can set up coordinated actions like turning on Wi-Fi immediately when you enter, illustrating how NFC may substantially affect how devices interact with one other.

2.3 Low-Rate Wireless Personal Area Network (LWPAN)

Low-Rate Wireless Personal Area Network (LWPAN) is a sort of efficient wireless communication that operates over small distances yet may span a vast range, up to 10-15 km [9]. One of its major benefits is how it saves energy, keeping sensor networks operational for approximately a decade on a single battery. When it's paired with IEEE 802.15.4, it creates a cost-effective means for devices to interact. LWPAN is intended for the physical and medium access levels and effortlessly links with other technologies like 6LoWPAN and ZigBee [12]. This makes it particularly critical for developing powerful and long-lasting sensor networks.

2.4 Wireless Sensor Networks (WSNs)

Wireless Sensor Networks (WSNs) are like helpful assistants utilized in numerous domains including healthcare, governance, and keeping an eye on the environment [13]. When they operate along with RFID systems, they grow better at gathering data by demonstrating where objects are, how they move, and what temperatures are like. Each wireless sensor contains pieces like a communication item, a converter altering information, a lot of sensors, a memory, and a power supply [11]. It's built up in a manner that various sensors may be utilized, transforming the measurements they collect into digital data. To communicate this material, there's a system with memory, a little computer, and a method to speak wirelessly, all powered up to keep operating properly.

2.5 3G and Long-Term Evolution (LTE)

3G and Long-Term Evolution (LTE) are like large waves in wireless communication, enabling robust connectivity for dozens of things [9]. This type of link spreads everywhere, even to locations that aren't highly developed. While 3G and LTE thrive in large-area Wide Area Networks (WANs), their appropriateness reduces in short-range settings. Financial concerns for data supply by service providers, as well as the conceptual complexity of permitting communication across various devices, are challenges that must be carefully considered.

2.6 IoT applications areas

The landscape of Internet of Things (IoT) applications has already left its mark on various aspects of the “smart city” concept. Figure 3 represents the design of a smart city using IoT concepts. These applications may be effectively classified by delineating them into six different categories [11]:

1. **Smart Homes**: This category includes standard domestic appliances, such as refrigerators and washing machines, as well as light fixtures, that have experienced a revolutionary development to achieve inter-device communication and network connectivity. This capability provides not only enhanced control and administration of these devices, but also results in energy usage optimization. Beyond the confines of traditional domestic utilities, emerging technologies have spread, giving rise to intelligent home aids and inventive inventions such as smart door locks.
2. **Health-Care Facilitation**: In the field of medicine, new technologies have had a huge influence on aiding patients. For example, there are specific bandages with microscopic sensors that keep an eye on how wounds are doing. These sensors provide critical information with physicians even when they're not right there. There are plenty of sensors, some you can wear and others that are inserted within you, that can monitor things like your pulse, how much oxygen is in your blood, the sugar in your blood, and even your body temperature.
3. **Mobility Ecosystems**: Sensors used in transportation are highly beneficial. They're installed in automobiles or even on phones and in city objects like streetlights. This helps in lots of ways including giving you the best route to travel, making it simple to reserve a parking place, making streetlights smart, boosting public transit, reducing accidents, and making self-driving vehicles conceivable.
4. **Environmental Surveillance**: When we deploy lots of wireless sensors in cities, we acquire heaps of knowledge about the environment. These sensors can monitor things like air pressure, humidity, and wind speed. They join together to build weather stations, although these are more sophisticated. Smart sensors also let us evaluate how clean the air is and whether there's pollution in the water in major cities.
5. **Streamlined Logistics and Supply Chain Governance**: Smart usage of special tags called RFID tags helps manage things from where they're manufactured to where they're sold. This notion offers a lot of benefits, notably in saving time and money. Furthermore, the scope of intelligent packaging reveals a variety of capabilities such as trademark protection, quality assurance, and the tailoring of customer interactions.
6. **Improved Security and Surveillance Paradigms**: Intelligent camera deployment pervades the urban environment, where the convergence of real-time visual object identification crystallizes into a strategic tier of security systems. These technologies demonstrate their worth by identifying suspects and preventing dangerous situations, so advancing the cause of urban security and preservation.

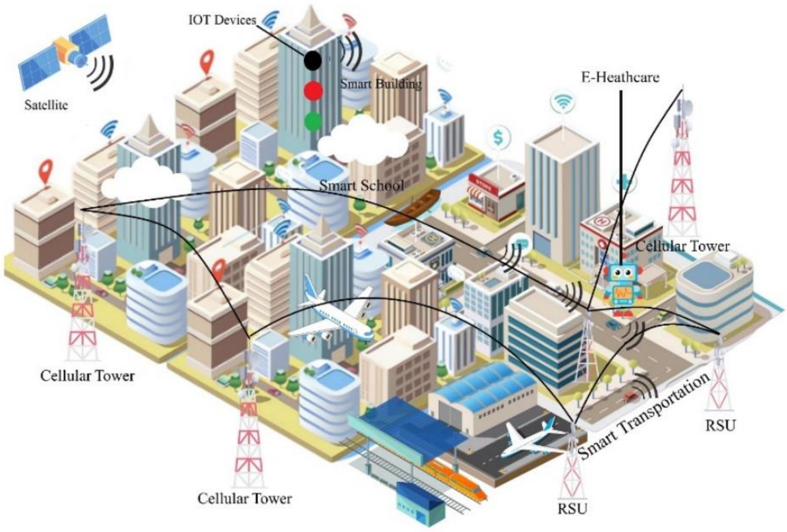

Figure 3. IoT-enabled smart city architecture

Smart transport is a smart city application that has piqued the interest of academics because of its ability to drastically revolutionize modes of transportation for both people and commodities. The incorporation of IoT technology into transportation systems gives various benefits for motorists in an intelligent urban environment, including improved traffic management, optimized logistical operations, efficient parking infrastructures, and increased safety measures. Smart transport is the incorporation of all of these benefits into transport system applications. The study reviews current research that is based on these areas and gives a full overview of the advances in the applications described previously. The authors also investigate the communication protocols that enable intelligent transportation, such as Wi-Fi, Bluetooth, and cellular networks, as well as their function in allowing seamless data interchange. The study dives into the various smart transportation systems and frameworks, such as cloud computing, edge computing, and fog computing. Overall, the study presents a thorough examination of the technology and applications employed in smart transportation systems, as well as their potential to increase transportation efficiency and safety in smart cities [14].

3. SMART TRANSPORTATION SYSTEMS

Transport network development is deeply woven into the fabric of modern living, leading persons through the intricacies of urban life. However, increased urbanization to accommodate expanding populations has resulted in an increase in motor vehicles, releasing a slew of multifaceted issues on urban landscapes [10, 12]. The increase in automotive presence, which is symbolic of society development, has resulted in adversities such as traffic congestion, extensive noise pollution, dangerous road accidents, and widespread commuter difficulties. By the end of 2022, there will be roughly 290 million registered vehicles in the United States alone, with nearly 40% of the population spending at least an hour everyday traversing streets [15, 16]. This increased reliance on transportation infrastructure has resulted in modern challenges ranging from traffic congestion issues to the intricate task of parking within spatial confines, all while dealing with long commutes, increased carbon emissions, increased accident rates, and a slew of other issues. Traffic congestion emerges as an unrivaled fiscal giant, siphoning over 101 billion dollars annually from the US economy and more than 2% of the GDP of the European Union. Notably, metropolitan thoroughfares account for 50-60% of all traffic delays, highlighting the necessity for novel solutions that incorporate information technology into the sphere of transportation [17].

Embracing this clarion call for revolution, Intelligent Transportation Systems emerge as the paragons of transformational trajectories [18], a monument to the synergistic convergence of improved sensors, computational finesse, electronic orchestration, and communication truthfulness. Smart Transportation is like a well-blended cocktail, making traffic smoother and safer. It's like establishing a beautiful pattern where traffic goes nicely, resulting to shorter journeys and less gasoline utilized.

The future seems hopeful as we embrace seamless integration, particularly with the emergence of the Internet of Things (IoT), which is likely to revolutionize how we think about transportation. This transition mixes information and communication technology (ICT), establishing a sustainable foundation for smart transportation that matches our current lifestyle. It's like a perfectly choreographed symphony of cutting-edge communication, electronics, and computational dynamics, giving life to information exchange, traffic control, and network coordination. The tale of embracing and applying technology is headed towards new boundaries in transport systems, led by essential principles: sustainability, integration, safety, and responsiveness. These concepts will play a vital role in fulfilling the aims of smart transportation - providing access and mobility, supporting environmental sustainability, and stimulating economic development [19].

In the complicated realm of urban development and its problems, intelligent transportation applications stand out as leaders in tackling the concerns produced by the ongoing rise of metropolitan populations. This breakthrough is not just conjecture; it marks an era of complete coordination where diverse traffic control technologies come together effortlessly. This symphony of invention operates on diverse scales, dealing with vast volumes of data from numerous sources. New technologies are like a rescuer, giving remedies to transportation systems on the edge of insufficiency. In this scenario, new techniques of obtaining information, converting data, and distributing knowledge arise, creating an atmosphere where current transportation systems are expertly exploited to control, organize, and manage vehicle traffic efficiently. The outcome is an improvement in congestion dynamics, revealing the potential to lessen its broad influence [19].

3.1 ML in IoT for smart transportation

Artificial intelligence (AI) is a vast field of computer science that aims to provide robots human-like cognitive skills. AI, which evolved from a critical 1956 Dartmouth College workshop, addresses complicated problems that classical computing cannot answer. Artificial Neural Networks (ANN), a popular AI method, simulates the human brain by modeling linked artificial neurons. ANNs analyze data via connections similar to biological synapses, and use non-linear functions to generate numerical outputs. At its foundation, Machine Learning enables computers to make intelligent judgments without explicit programming, relying on data as its life force. Table 2 lists down the use of ML in IoT for Smart Transportation. This cognitive process entails a careful interaction of systems and training data, which is coordinated by numerous algorithms. Machine Learning algorithms rely on attributing characteristics to sample data, which serves as the foundation for intelligent analysis of nuances and links. This technique, which is based on tangible qualities, enables pattern detection and informed decision-making based on new data [20, 21].

Table 2. Machine Learning techniques are used in Internet of Things (IoT) smart transportation applications

Reference	Models Used	Learning Type
[22-26]	Random Forest (RF)	Supervised
[27]	Fully Connected Networks	Reinforcement
[28]	Fuzzy C-Means (FCM)	Unsupervised
[6, 22, 25,26,29,30]	Support-Vector Machine (SVM)	Supervised
[23, 30]	Regression Tree	Supervised
[22, 23, 31-33]	Feed Forward Neural Networks	Supervised
[24, 34, 35]	K-Means	Unsupervised

Even as the tide of Machine Learning surges in modern significance, signal led by a crescendo of exponential data collection and technical advancement, it is critical to recognize its origins, which go deep into history. Its ancestors can be dated back to the 17th century when fledgling inklings of data understanding and instantaneous insights began to emerge

[36]. Throughout history, the human mind has been infused with an insatiable need to decipher the enigmatic codes of data, stitching the very tapestry of insight acquisition.

Transportation has tremendous problems, particularly when it comes to forecasting and modelling travel patterns, due to the complexities of network dynamics and user behaviours. Given these difficulties, which include increasing travel demand, environmental degradation, safety concerns, and CO2 emissions, the integration of Artificial Intelligence (AI) and Machine Learning (ML) appears as a viable option for transportation systems. This argument is especially relevant in developing countries, where the continual increase of urban and rural traffic, driven by population development, is at the heart of these multiple difficulties.

3.2 IoV as a part of smart transportation

The Internet of Vehicles (IoV) combines mobile internet with the Internet of Things (IoT), resulting in a complex web of vehicle intelligence for improved safety, traffic management, and entertainment. This criticism investigates present and new IoV paradigms, with a focus on application in smart cities' sophisticated infrastructures. Figure 4 depicts the IoV architecture and its function in satisfying various smart city demands. The presentation provides a thorough IoV architectural design that addresses communication issues. The vehicle identification layer, which provides individual identity, and the object layer, which encapsulates IoV entities, are both part of the seven-layered framework. The communication layer acts as an intermediate between the inter-intra devices layer and the communication layer. The servers and cloud services layer manage intelligent distribution as the cerebral center. The big data and multimedia processing layers make use of enormous datasets, while the application layer contains IoV usefulness in the implementation of smart city features [37].

The Internet of Vehicles (IoV) emerges as a fledgling technical marvel set to reshape the fundamental foundation of the transportation industry. The current study methodically navigates the contours of IoV's relevance, particularly within the context of smart urban agglomerations, within the fabric of this discourse. IoV unfolds as a potential remedy within these intelligent metropolises, its tendrils weaving a narrative of enhanced traffic safety, unrivalled traffic efficiency, and a unique spectrum of passenger-centric diversions. However, the scope of IoV extends beyond conventional metropolitan panoramas; it is developing as a musical entity capable of orchestrating large-scale data acumen, sensory absorption, cognitional synthesis, and cognitive reservoirs. The conference presents a complete review of the current paradigms in the Internet of Vehicles (IoV) and expects further advancements. It provides a conceptual masterpiece, presenting a universal architectural system that strengthens numerous communication models to tackle various challenges [38].

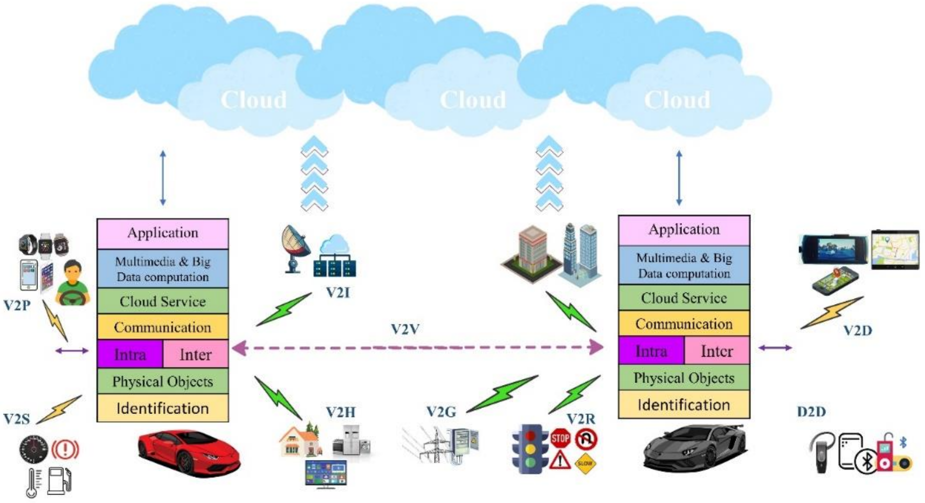

Figure 4. Internet of vehicle (IoV) architecture

3.3 Architecture of IoV

The Vehicle Identification Layer plays a critical function in the Internet of Vehicles (IoV), delivering a unique identification to each vehicle. This procedure guarantees that every vehicle is clearly identified inside the IoV network. This identification system functions as a complete repository, storing a real-time record of each vehicle linked to the network. Additionally, this powerful identification system boosts security, establishing a harmonic system where only authorized cars may access network entry points [37].

The Inter-Intra Devices Layer acts as a central communicator, enabling communication among cars and components in the Internet of cars (IoV). This organizational structure controls both communications between cars and those occurring inside a vehicle. The core of this system rests in building a secure network where only authorized devices engage in interactions, bringing an approved and secure atmosphere to the network's environment [39, 40].

The Layer of Servers and Cloud Services serves a significant function as the control center for administering cloud services in the Internet of Vehicles (IoV). This digital hub holds multiple cloud services and provides vital operations including storing, processing, and analyzing data. It works as a sanctuary for digital activity, maintaining the security of the network by adopting safety measures [13].

Application Layer: In the IoV system, we have the Application Layer. At the apex of this tier is Nexus, the pinnacle of network application organization. Imagine it as a workshop where creative ideas become tangible implementations. Different frameworks come together to develop apps that function for both vehicles and cloud services. Security is like a powerful defense, guaranteeing that only authorized individuals take part in this symphony of programs [37].

3.4 Smart transportation communication protocols

3.4.1 4G and 5G

In modern world, where people and things are closely linked, is seeing a massive growth in the transit of information. The present method we utilize wireless mobile communication is straining to manage this enormous demand. To handle this difficulty, there's a big effort from both industry and education industries to set standards for the next generation of wireless connectivity, popularly termed 5G. It's a powerful reaction to the expanding necessities of our contemporary scenario [41, 42].

Cellular connectivity is crucial in the realm of smart transportation systems. 5G, as a forerunner, plays a critical role in linking individual vehicles through the notion of Cooperative Intelligent Transport Systems (CITS). This strategic connection of 5G and smart transport fosters the possibility of ushering in automated transport ecosystems that are defined by a higher safety quotient and higher operational efficiency as compared to their predecessors. Furthermore, the scope of public transit is expanded, tackling endemic difficulties such as traffic jams, environmental stressors, and road mishaps [41]. The revolutionary potential of 5G is significant and ready to oversee the creation of a truly intelligent transportation network. With a ubiquitous high-speed internet connection, a “Linked Traffic Cloud” arises, collecting and examining live data from a network of linked cars, infrastructure elements, and gadgets. This data reservoir facilitates a variety of operational insights, emphasizing aspects such as informed decision-making, optimized fuel and temporal resource utilization, and enhanced navigation paradigms [43].

A primary cause of motor vehicle accidents is sudden deceleration, which is frequently induced on high-speed roads with poor sight. Causal variables might range from previous accidents and construction zones to congested peak-hour traffic. Although existing motorways fortified with fixed traffic sensors connecting with drivers’ mobile applications through 4G networks may minimize the problem in part, this precaution is still localized and unevenly distributed. Celesti et al. [44] propose a novel solution based on mobile traffic sensors embedded in private automobiles and volunteer-operated vehicles. In a successful trial sortie, their hypothesis revealed an effective system characterized by rapid alert propagation, hence increasing anticipatory awareness and avoiding possible mishaps.

3.4.2 Connected vehicle technologies

The complicated fabric of vehicular communication unfolds over four separate dimensions: vehicle-to-infrastructure (V2I), pedestrian-to-vehicle (V2P), vehicle-to-vehicle (V2V), and network-to-network (V2N). V2V and V2P communication domains, for example, focus on interactions between vehicular entities and vulnerable road users, providing a way to transform location, velocity, and directional data into proactive accident-averting broadcasts [45]. V2X (vehicle-to-Everything) Communication V2X communication is critical for safe and efficient transportation. This study investigates V2X technologies, addressing a research gap in comparative studies of their efficacy, particularly in complicated metropolitan situations. The outlined schematic view explains the components incorporated inside the vehicular communication protocol. The concept of direct interaction between vehicles and roadside infrastructure, illustrated by Roadside Units (RSUs), is encapsulated within V2I. The latter acts as a conduit for extending the communication range. In tandem, V2N communication drives communications between cars and the V2X application server, launching services ranging from entertainment streaming to dynamic navigational path orchestration. This path of wireless interconnection creates pathways for improved driver safety and mobility, giving rise to a wide range of applications such as cooperative driving assistance, decentralized probe vehicular systems, and fluid information distribution frameworks. One notable expression is the ability to send warnings among cars, therefore preventing accidents during lane changes [45]. Thus, vehicle-to-vehicle communication, facilitating connectivity between cars, roadside entities, and pedestrians, emerges as a critical component of the Advanced Transportation System.

Table 3. Comparison of communication technologies

Technology	Features	Advantages	Challenges
4G and 5G	- High-speed internet - Low latency - Broad coverage	- Enhanced safety and operational efficiency - Broad coverage and low latency - Potential for diverse applications	- Initial deployment cost - Compatibility with existing system
Connected Vehicle Technologies	- Focus on interactions with vulnerable road users - Facilitates direct interaction with roadside infrastructure	- Proactive accident-averting broadcasts - Improved driver safety and mobility	- Dynamic environment - Integration with existing infrastructure - Privacy and security concerns
VANET	- Highly decentralized - Constrained bandwidth and range - Self-organizing, and dynamic network	- Enhanced passenger comfort and safety - Real-time traffic data utilization	- Network scalability - Security concerns with direct peer-to-peer communication

The shadow of location privacy and impenetrable communication hovers large within the orbit of this emerging area. Gupta et al. [46] spotlight a pioneering path, providing a safe and confident solution to V2V and V2I communication supported by edge infrastructures. This novel approach brings together trustworthy cloudlets, who are in charge of authorizing, scrutinizing, and verifying message authenticity, integrity, and anonymity. The architectural shift away from traditional peer-to-peer communication ushers in a new era of dynamism. The concept directs automobiles and roadside nodes to occasionally tether with neighboring cloudlets, fostering an environment of enhanced message security. Table 3 shows the comparison of the different communication technologies.

3.4.3 VANET

A Vehicle Ad-Hoc Network (VANET) emerges as a collection of movable cars linked together via wireless networks, allowing for the smooth interchange of information. This highly decentralized, self-organizing, and dynamic network functions within constrained bandwidth and range, making it ideal for direct peer-to-peer interactions [47]. The raison d'être of enhancing passenger comfort and safety, based on the dissemination of real-time knowledge, is engraved into its core. Al-Dweik et al. [48] present a trio of essential contributions supported by VANET technology in a landmark overture. A Vehicular hoc network-based Algorithm (VBA) triumphantly deciphers routes buoyed by the dual harbours of decreased journey time and fuel usage. A novel blend of real-time traffic data sources aids in this navigation quest.

4. APPLICATIONS OF SMART TRANSPORTATION

A thorough analysis of today's smart transport networks is provided in the section that follows. As shown in Figure 5, our analysis of these systems divided them into six separate groups, each of which defined a unique functional domain. Figure 6 offers a comparison study, contrasting the application of various Machine Learning algorithms along with IoT in the context of smart transportation applications. These systems' systematic classification helps provide a structured understanding of the many typologies present in smart transportation domains. Our understanding of the complexities of smart transport systems is improved by this comparative demarcation, which permits a detailed investigation of their distinct features.

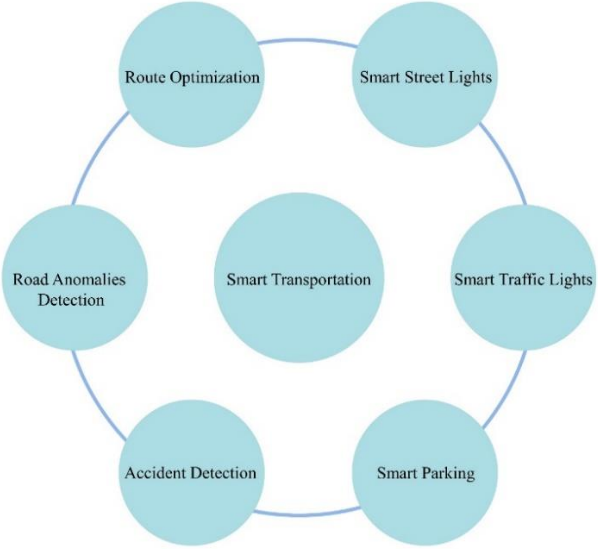

Figure 5. Different applications of smart transportation using IoT

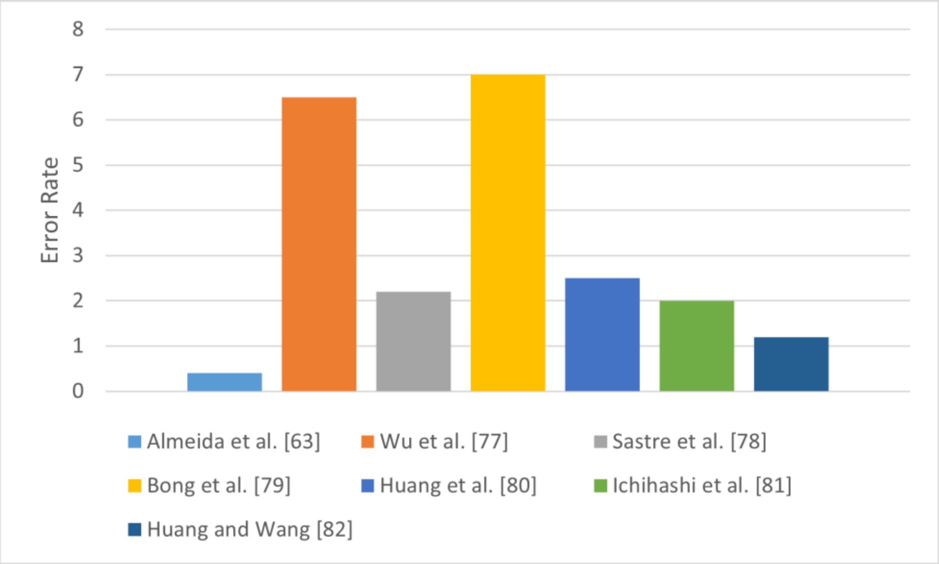

Figure 6. Performance comparison of different approaches using Machine Learning and IoT for smart transportation

Smart transportation solutions that use IoT and Machine Learning are critical to revolutionizing urban mobility. This section goes into these systems, relating each feature directly to our study aims and identified gaps in the literature.

- Traffic Control Systems: IoT-enhanced modern traffic management provides real-time data analysis for effective traffic flow. The research fills a knowledge gap on how ML algorithms might further enhance these systems, particularly under dynamic traffic conditions that are frequently disregarded in previous studies.
- Intelligent Parking Solutions: Smart parking facilitated by IoT minimizes congestion and pollutants. Unique ML-based methods to parking management are investigated, a topic that is frequently treated in isolation in the literature, thereby offering a holistic viewpoint critical for complete urban mobility solutions.
- Transportation Smart Lighting Systems: The coupling of smart lighting with transportation networks is a novel and uncharted topic. This study analyzes how IoT and Machine Learning may improve this junction, filling a major gap in existing smart city programs.
- Optimization of Public Transportation: Most research have focussed on IoT applications for individual automobiles. This study, however, widens its attention to include public transit networks. By examining how Machine Learning may optimize the timetables and routes of buses and trains, the research tackles a critical gap in enhancing the efficiency of mass transportation.

4.1 Traffic management and optimization

4.1.1 Route optimization

The issue of traffic bottlenecks is a serious worry in cities, particularly with more automobiles on the roadways. To solve this problem and enhance travel efficiency while decreasing emissions, there's a heavy emphasis on route optimization. This entails selecting the optimal route to a location with the aim of saving time and cutting down on emissions [48]. Scholars have dug into the complexity of route optimization, particularly within the Internet of Things (IoT) framework. Google has innovatively exploited crowdsourcing, a vital part of current service innovation, via Google Maps. This popular software for mobile devices incorporates real traffic information, providing consumers a handy solution since 2009. This includes employing navigational sensors like GPS, accelerometer, and gyroscope in mobile devices. This novel method, unlike traditional traffic monitoring systems, does not rely on fixed sensors [49]. Instead, it uses the aggregate mobility data created by users when their devices anonymously ping position and velocity insights into the digital ether. This wealth of information enables Google Maps to foresee alternate routes that will avoid congested roads.

Afidis at al. [50] delve deeper into the world of vehicular quandaries, conducting a comprehensive investigation into the interconnection of congested traffic, environmental emissions, and user-generated data from Google's "peak hours" characteristic. The study gear consists of a combination of on-road cameras and automobiles equipped with a Global Navigation Satellite System (GNSS) data logger. The Vehicle Specific Power (VSP) model is used to calculate emissions, which combines with Google Maps' popular time intelligence. The study corpus reveals a strong association between the crowdsourced "popular times" dataset and emissions, while the future route calls for more data refining, calibrated using an adaptive learning schema to provide fine-grained correlations.

In keeping with the crowdsourcing spirit, the study [51] guides the path towards optimizing routes by utilizing a swarm intelligence algorithm—an antithesis of individualism that celebrates the collective. This proposal embodies a Modified Crowd-Sensing form of the Ant Colony Optimization algorithm, an endeavor resembling ants travelling in unison, pushed by chemical traces. In this case, users' mobile interactions serve as chemical trails, channeling communication and assisting fellow travelers in wandering towards less busy routes. Further examining the various junctures of route planning, the study [52] sets out on a mission to improve navigation precision, particularly over the final mile to a destination—a juncture frequently fraught with sophisticated maneuvering. Common techniques, such picking the shortest route or the fastest time, don't properly represent the problems of this last section of the voyage. The authors offer a novel approach considering the limits of existing algorithms.

CrowdNavi, a genuine app, illustrates how crowdsourced navigation systems operate. It solves challenges identified in existing navigation systems, notably in the latter half of the route near the destination. While standard navigation delivers basic directions, the last mile sometimes creates obstacles, such locating a drive-through coffee shop near a freeway. CrowdNavi handles this by aggregating actual driving data to analyze local driving trends. Users then obtain crowd-sourced ideas, enhancing their navigation in tough last-mile scenarios.

4.1.2 Smart traffic light control

Controlling traffic at junctions is done using traffic lights to regulate vehicle entrance effectively, particularly in crowded situations. The efficacy of these crossings generally depends on employing sensors to modify the traffic signal sequences. These sensors act as discriminating sentinels, noting areas where traffic concentration occurs as the intersection approaches. When a green light is detected, the length of the green light is dynamically extended, allowing for a larger vehicle passing opportunity. Furthermore, transponders placed inside intersections can be used to provide priority to particular entries, most notably emergency vehicles and public transport, ensuring quick passage. Intersection control techniques strive to maximize throughput while minimizing instances of pausing by arranging the precise synchronicity of traffic signal timings and approaching vehicle velocity. Figure 7 demonstrates an intelligent traffic signal control system using the Internet of Things (IoT).

Tubaishat et al. [53] suggest a novel decentralized architecture for traffic light control that takes advantage of the capabilities of wireless sensor networks. Within the system architecture, this paradigm emerges across three hierarchical strata: the wireless sensor network, the localized traffic flow model policy, and the elevated coordination mediated by the traffic light agents. The Nearest Intersection Control Agent (ICA), which operates at the nucleus, interacts with data gathered from wireless sensors. This data repository contains characteristics such as vehicle count, velocity, and other relevant properties, allowing the flow model of the junction to be derived. Real-time adaptive control of traffic lights, resulting in an enhanced vehicular mobility experience, is a significant achievement. The Intersection Control Agent is responsible for managing greater regions by talking with other agents. Its job entails approved control of traffic lights in this attempt.

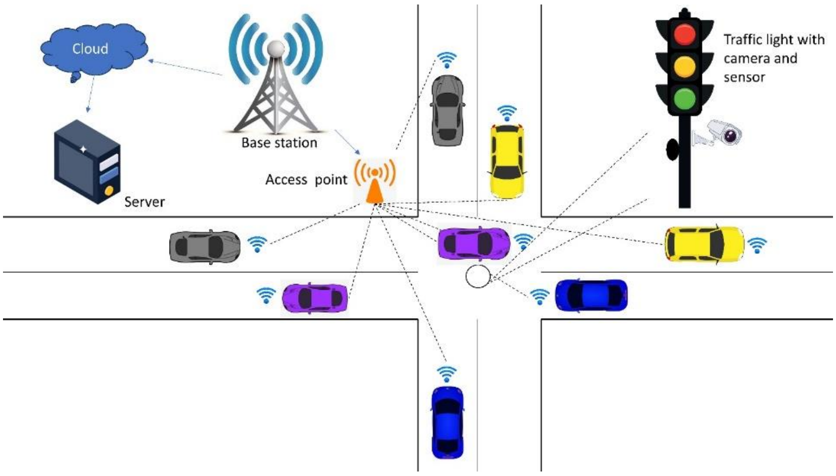

Figure 7. Smart traffic light control system using IoT

The study underscores the necessity for flexible routing approaches and resilient infrastructure to handle the expanding data from traffic management devices. It brings out issues in vehicle-to-vehicle (V2V) communication, asking for additional security measures to protect the safety of communication networks. With the integration of multiple sensors in automobiles, security risks develop, including the potential of illegal control and data manipulation, which may lead to accidents. To handle these issues in the developing area of traffic management and V2V communication, inventive solutions are necessary.

4.2 Safety management

4.2.1 Road anomalies detection

Recognizing road concerns is vital for smart mobility, particularly in spotting problems like potholes and uneven surfaces. This system tries to notify drivers to possible dangers posed by bad road conditions, which may lead to traffic bottlenecks, vehicle damage, and accidents. Addressing this, revolutionary research by Cha et al. [54] established a Convolutional Neural Network (CNN) to recognize concrete fractures in photographs acquired with handheld cameras under varied lighting situations. The CNN, trained on a dataset of 40,000 photos, attained an astonishing 98% accuracy. Notably, it excelled at identifying tiny fractures in low-light circumstances, an area where standard approaches like Canny and Sobel edge detection fail.

As explained in study [55], the strategic combination of knowledge transfer and pre-existing deep learning models appears in the domain of crack damage diagnosis inside Unmanned Aerial Vehicle (UAV) photographs recording civil infrastructure, including a subset of road surface portrayals. The effectiveness of this method was amply supported by results demonstrating a remarkable accuracy threshold of up to 90% for crack identification under real-world situations without the requirement for augmentation or complex preprocessing methods.

4.2.2 Accident detection

Accident detection and prevention are critical objectives in the field of intelligent transportation, given their ability to avoid fatalities. Driver attention on the road may be a powerful preventative measure against accidents. An effective accident prevention device can alert drivers of approaching risky situations, allowing for quick and decisive action. Furthermore, proactive detection of accident-prone areas or real-time problems inside the traffic network adds to a reduction in the number of accidents and traffic congestion. Figure 8 represents an accident detection system using IoT as an application of smart transportation. The benefit of Machine Learning is most seen in the detection of traffic events, outlining patterns that indicate the possibility of future mishaps, and then notifying drivers, allowing for preventative maneuvers.

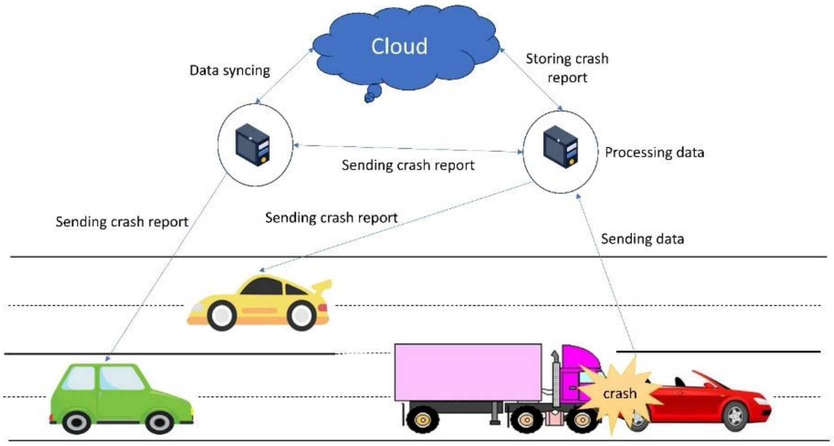

Figure 8. Accident detection system using IoT

Kokilavani and Malathi [56] propose a complete IoT cloud infrastructure designed to provide real-time traffic visualization and early alarms, preventing unplanned slowdowns that might lead to accidents. The proposed architecture combines Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), as well as the novel addition of IoT as a Service (IoTaaS). Volunteer automobiles will be supplied with GPS data gathering equipment, which will then be sent to a cloud-based server over a 4G network conduit. The cloud server orchestrates and manages GPS data expertly thanks to the combination of the OpenGTS platform and OpenStreetMaps. Data is designed in SQL format and consolidated within a Distributed MongoDB database for faster examination. The use of Docker containers improves backend scalability, which aligns with the need for quick response times. The temporal metric of system response is critical to the effective realization of this implementation since the suggested approach broadcasts an alarm traversing a distance of 1 kilometre in a mere 120 ms.

4.3 Energy efficiency and environment

4.3.1 Smart lights

The domain of Smart Street Lights (SSLs) gently weaves a vital component of the new smart city scene, congruent with the wide tapestry of smart mobility services. These dazzling sentinels herald a new age of intelligent urban lighting solutions, situated at the crossroads of energy efficiency and dynamic operability. This study [57] is a powerful example of SSL implementation in the account of IoT-driven urban innovation.

The combination of a constellation of sensors—illumination sensor, infrared (IR) sensor, global positioning system (GPS), and wireless connectivity module — allows this orchestration to infuse streetlights with a tapestry of cognitive capacities. The augmentation of streetlights' reactivity to their surroundings is the litmus test for this integration. Their natural ability to detect heavily inhabited areas results in dynamic regulation of luminance, making high-density areas safer while also conserving energy. The GPS provides a centralised orchestrator with the ability to scan the geographical and operational states of each luminaire, enabling a more rapid restoration regime in the event of a malfunction. The symbiotic relationship between SSLs and the management nexus is maintained by the umbilical thread of the Narrowband IoT (NB-IoT) network, which is tethered to this paradigm. The management fortress, fortified by a slew of Fog nodes, serves as an agora for data aggregation and state validation, orchestrating the harmonic symphony of streetlight coordination. The capacity to remotely manage SSLs under the auspices of the installed administrative dais is an expressive witness to these infrastructural symphonic. The Raspberry Pi, an enigmatic orchestrator, wears the role of microcontroller [56], a modern-day maestro managing the interplay between luminaire and sensors. Light sensors transcend their usual role in this context, signaling the beginning of a new epoch—a record in which solar conjunctions announce luminous onsets and descents. The light repertoire of these lights attunes to the circumambulating presence of passing automobiles and people in a dynamic crescendo, producing an energy-efficient performance.

Through smart street lighting (SSL) [57], the article demonstrates a realistic example of IoT-driven urban innovation. This entails combining numerous sensors onto streetlights, including as lighting and infrared sensors, GPS, and wireless communication modules, to improve their cognitive capabilities. Dynamic brightness adjustment based on detected population density, GPS-enabled centralized orchestration for speedy fault response, and a symbiotic interaction with management systems are notable characteristics. This SSL solution demonstrates how new technology for responsive and energy-efficient urban lighting may be effectively integrated. The study [57] identifies a limitation in the SSL system wherein, in certain instances of a broken bulb, the server erroneously indicates an offline status instead of accurately reporting the broken bulb condition. This highlights a challenge in precisely detecting and communicating the status of individual street lamps within the SSL system.

Tripathy at al. [58] focus their gaze towards a bright nexus intertwined with Wi-Fi hotspots as the scene grows. Each lamp post transforms into a connectivity emissary, a portal for broadcasting various insights to a central web server. The luminous tapestry orchestrates an elaborate ballet, launching light, regulating brightness, or embracing darkness in response to the flux of the surroundings. These light-bearing sentinels' tendency for transformation extends to their enhanced vestments, which are swathed with cameras and environmental probes. They reign over regions of safety during emergencies and monitor environmental conditions through these sentient extensions, converting formerly commonplace light posts into stewards of urban vitality.

4.3.2 Smart parking

Smart parking system deployment allows for continuous monitoring of arrival and departure times for various cars across the metropolitan environment. The study [59] investigates the deployment of smart parking systems for effective vehicle arrival and departure management in urban environments. The system continually monitors parking facilities by utilizing wireless sensors, considerably contributing to smart parking. Notable contributions include the development of a data-driven parking management system that makes use of vehicle count and velocity data. This data repository is critical for understanding and controlling traffic movement inside parking lots. Real-time adaptive control based on data obtained improves vehicular mobility and maximizes parking space use. Furthermore, data from the smart parking system help to design and build additional facilities in heavily populated locations. This holistic strategy enhances accessibility, shortens the time it takes to find parking, and helps to overall urban mobility.

As a result, rigorous planning is required for the creation of parking facilities capable of successfully accommodating the traffic inflow within various zones [60]. Furthermore, locations with high vehicle density need the construction of unique parking lots to meet the increased demand [61]. As a result, the repository of data created by smart parking systems provides benefits that pervade both customers' everyday lives and the business interests of vendors inside smart cities. This service's operating paradigm is based on the synergy of road sensors and intelligent displays, which adeptly leads cars into ideal parking paths inside the metropolis [44]. Figure 9 compares different approaches used for Smart Car parking system using IoT. This service provides a slew of benefits, including faster parking spot finding, which correlates to lower carbon monoxide emissions and less traffic jams, fostering a sense of happiness among city people. Notably, this service is easily integrated into urban IoT frameworks.

Furthermore, the use of short-range communication technologies such as RFID and NFC enables electronic validation of parking authorizations, ushering in a practical mechanism for the granting of parking privileges. This new solution, supported by secure and technologically sophisticated protocols, enables rapid and convenient access to parking facilities.

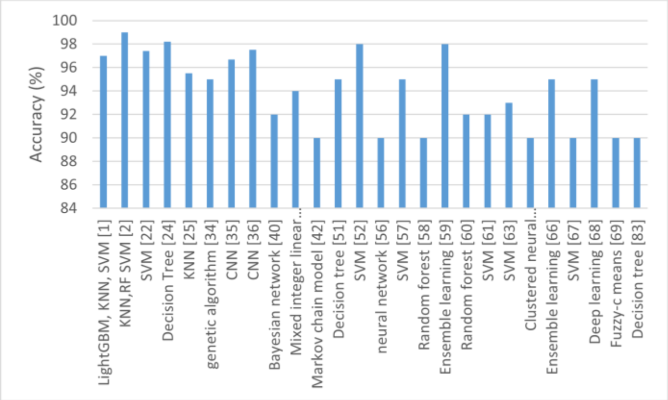

Figure 9. Error rate of different approaches used for smart parking management

5. REAL-LIFE EXAMPLES OF SMART CITIES WITH SMART TRANSPORTATION AROUND THE GLOBE

5.1 Amsterdam

In 2006, Amsterdam, The Netherlands, launched a series of initiatives relating to smart cities, focused on networked public lighting. The brightness of artificial lighting has a dual role in metropolitan settings, illuminating the night and molding the city's mood, impacting its attraction for companies and visitors. The combination of LED street lighting and sophisticated controllers developed as a novel technique, offering a comprehensive strategy for decreasing energy usage. This invention might lead to huge energy savings, up to 80%, leading to economic advantages of roughly 130 billion euros. Besides energy efficiency, this remodeling promotes public safety and general visibility. Internet-based controls strengthen the interconnection of these systems, supporting the energy-conservation paradigm. Remote monitoring replaces typical human defect checks, reporting lighting defects immediately. The measurement of energy usage has advanced with the precision of smart meters, enabling a detailed insight of energy use. An adaptive decrease of brightness during times of less traffic activity illustrates a sophisticated energy-saving strategy. The integration of LED-based smart lighting with digital interfaces signals a paradigm leap in urban lighting management, accomplishing energy-efficiency objectives while increasing civic security and well-being [62].

5.2 Malaga

The study [63] speaks about a smart parking system in Malaga, Spain, which is part of the city's smart urban programs. In this system, drivers may use their NFC-enabled smartphones as digital permits to enter and leave parking lots and make payments. This example highlights how NFC technology may be a beneficial tool in smart city settings. Malaga has invested in its urban infrastructure, including a fiber optic network, citywide Wi-Fi, and geographic information systems for displaying municipal data. Over 17,000 active smart meters are part of the continuing installation. Malaga’s smart city programmes aim to reduce carbon dioxide emissions by 6,000 tons per year. The paper, however, does not go into greater detail about the smart parking system in Malaga. Table 4 showcases the various real world applications of Smart Transportation.

Table 4. The outcomes of cities in relation to smart transport

City or Country	Application
Nice, France [64, 65]	Smart parking management system
Korea [66]	Smart street lighting
Amsterdam [67]	Smart traffic control
Barcelona [68]	Control traffic flow and design new bus networks
Groening [69]	Enhanced public transportation system
Santander [69]	Smart parking systems

The study [62] highlight Malaga's smart parking system, which is an important component of the city's larger smart urban ambitions. This system's notable characteristics include the use of NFC (Near Field Communication) technology. Drivers in Malaga may use NFC-enabled cellphones as digital passes for easy entry and departure from parking spaces. In addition, NFC enables a digital payment system by expediting transactions with a contactless method. This example exemplifies the successful application of NFC technology in smart urban surroundings, with an emphasis on better user experience and ease.

Aside from the smart parking program, the article explores additional smart city initiatives in Malaga, Spain. These applications demonstrate Malaga's commitment to leveraging innovative technology and smart city concepts for sustainability, increased energy efficiency, and reduced environmental impact. These applications include:

- Smart Energy Management Systems and Smart Grids: These systems are designed to maximize energy use and distribution, resulting in more efficient energy consumption and control.
- Diverse Energy Efficiency efforts: Malaga has implemented many energy efficiency efforts, most likely including infrastructure renovation and the incorporation of renewable energy sources.
- Carbon Dioxide Emission Reduction: A key component of Malaga's smart city plans is a concentrated attempt to reduce carbon dioxide emissions, with a 6000-tonne yearly reduction goal. This pledge is consistent with environmental sustainability goals and contributes to climate protection efforts.

5.3 Nice

Nice has begun on a huge effort to capture important information across several service areas. As an example, transportation data has shown to be a beneficial input for optimizing the city’s parking management. Nice’s intelligent transport infrastructure facilitates a broad spectrum of services, including driver advice and parking management. In 2012, a smart parking management system was established, which leverages a network of sensors discretely placed along public streets. These data streams are efficiently transmitted to drivers, leading them to the most appropriate path using GPS-based mobile applications [70-74].

The well-known Nice Grid demonstration project is an important component of Nice's comprehensive strategy. The Nice Grid concept is a ground-breaking endeavour that creates a smart solar-centric neighbourhood within urban areas. This project smoothly incorporates diverse features such as distributed electrical resources, thermal storage systems, solar power generation projections, and load control algorithms [35, 67]. The city of Nice demonstrates its commitment to encouraging innovation, sustainability, and improved quality of life in accordance with smart urban development principles through these multifarious initiatives.

6. CHALLENGES AND FUTURE WORK

In spite of the fact that shrewdly transportation frameworks have picked up favour for their capacity to offer quick, user-friendly, and compelling administrations, they are not void of flaws. An essential concern lies within the blockage of remote systems, stemming from the rising utilization of gadgets for the observation and organization of activity, which presents an eminent obstacle to communication. With the acceleration within the number of gadgets, there emerges a comparing request for an adaptable steering convention that enables the assignment and positioning of assets, at the side a foundation able of overseeing and put away broad street activity information [75-77].

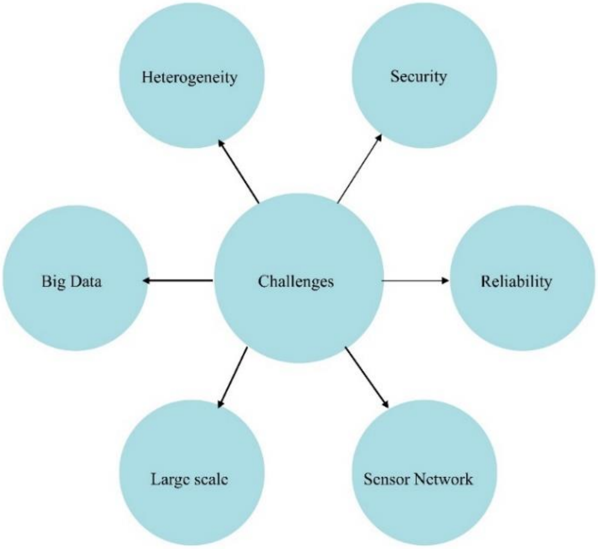

Figure 10. Major challenges faced in IoT for smart transportation

Figure 10 outlines key impediments existing inside this space to think about. Additional problems are around vehicle-to-vehicle (V2V) communication. To protect the integrity, safety, and secrecy of infrastructure communication networks, new certificate management frameworks must be developed [78, 79]. V2V communications are still vulnerable to transmission interferences and other intrusions, for instance, expecting control of vehicle operations or changing transmitted data to associated versatile peers, possibly coming about in collisions. The incorporation of a plethora of sensors and actuators within vehicles has introduced the difficulty of harmonizing data collecting via a uniform procedure. Furthermore, data collection and transmission to network access points (usually Road Side Units) are intertwined. Investigating this necessitates the acquisition of sensor descriptions and settings [80-82].

Although progress in smart transportation systems has been notable, difficulties remain, needing further study and novel solutions. The next sections detail possible future research directions to overcome these difficulties.

- Improved IoT Communication Protocols: As the number of IoT devices in transportation grows, more adaptive and resilient communication protocols are required. Future research might concentrate on establishing smart routing algorithms that adaptively manage and utilize network resources effectively.
- Elevated V2V Communication Security: Keeping vehicle-to-vehicle (V2V) communication secure is critical for the safety and efficacy of smart mobility. Even though it's crucial, V2V still suffers security difficulties and interference with transmissions. To make V2V communication safer, future research should focus on building better systems for handling certificates and enhancing encryption technologies.
- Machine Learning for Predictive Maintenance: Exploring how Machine Learning may anticipate when transportation infrastructure requires repair is a new research subject. Future research might focus on establishing algorithms to forecast maintenance needs, decrease downtime, and increase the dependability of the system.
- Autonomous Vehicle Integration: Research in the future might focus on creating standardized protocols and implementing the required infrastructure upgrades to facilitate the widespread usage of autonomous automobiles in smart transportation networks.
- Data Privacy and Ethical Considerations: Future research should concentrate on building rules and frameworks to address concerns about data privacy and ethical data usage as data collection grows in smart transportation systems.
- Compatibility Among Systems: A significant difficulty is ensuring compatibility among various smart transportation technologies and systems. Future work might focus on developing universal standards and protocols that allow for the smooth integration of various technologies and systems within the smart transportation ecosystem.
- Smart Transportation Sustainability: Future research should concentrate on making smart transportation systems more environmentally friendly. This entails figuring out how to reduce emissions, optimize energy consumption, and incorporate renewable energy sources into transportation infrastructure.

The Smart mobility provides rich data insights, it has substantial hurdles in protecting data privacy and security. Cyberattacks represent a significant danger, putting critical information and even people's lives at risk. Data aggregation challenges arise when integrating smart devices into transportation owing to diverse formats and a lack of specified techniques. Interoperability is difficult to achieve, particularly in places with minimal technical competence [83, 84]. Furthermore, high implementation costs and technical complications are impediments to acceptance, especially in smaller cities and rural areas. Keeping smart transportation running smoothly requires competence in data analytics, artificial intelligence, and Internet of Things (IoT) technologies.

7. CONCLUSION

This research looks on the successful use of Machine Learning (ML) and the Internet of Things (IoT) in smart transportation. It reveals numerous Machine Learning methods and their applications in areas such as improving traffic flow, smart parking, and accident detection systems utilizing IoT data. One important discovery is the identification of a huge gap in the use of ML, notably in smart lighting systems and parking applications. This disparity indicates the need for more study and development in these areas, giving chances for innovation. These developments have the potential to make cities more efficient, safe, and sustainable.

This study analyzes the successful application of Machine Learning (ML) and the Internet of Things (IoT) in smart transportation. It reveals several ML algorithms and their applications in domains like improving traffic flow, smart parking, and accident detection systems utilizing data from IoT. A noteworthy conclusion is the detection of a considerable gap in implementing ML, notably in smart lighting systems and parking applications. This gap emphasizes the need for greater research and development in these areas, giving chances for innovation. These developments might lead to more efficient, safe, and sustainable urban settings.

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