INNOVARE JOURNAL OF ENGINEERING & TECHNOLOGY

Vol 13, 2025 ISSN - 2347-1573

Review Article

A REVIEW OF AI-POWERED APPROACHES IN SMART CITY IN TRAFFIC MANAGEMENT VIA IOT

PRITHVIRAJ SINGH RATHORE

Department of Computer Sciences and Applications, Mandsaur University, Mandsaur, Madhya Pradesh, India.
E-mail: prathviraj.rathore@meu.edu.in

Received: 17 September 2025, Revised and Accepted: 22 November 2025

ABSTRACT

The growing speed of urban time is a significant challenge to the effective and sustainable transportation system, which resulted in the introduction of Smart Traffic Control solutions on the basis of Internet of Things (IoT) technology to address traffic jams, road safety, and transportation efficiency. IoT and artificial intelligence (AI) integration has become an attractive and complementary method to revolutionize traffic management in the world as smart cities are implemented on a global scale. This paper provides an overview of the latest AI-driven methods for smart city frameworks that are IoT enabled. It lists various technological backgrounds that help with decision-making, such as deep learning, computer vision, predictive analytics, and machine learning. The article discusses AI-enabled advancements in real-time congestion control, traffic signal control, predicting of travel time, incident detection, and video-based vehicle analysis. It also shows that there are vital issues related to the implementation of AI in IoT-based traffic systems such as limitations of data quality, privacy and security risks, intensive calculations, interoperability, and the necessity of strong real-time processing. In general, the survey offers an in-depth outlook of the partnership between AI and IoT in the field of intelligent traffic management by integrating the current research trends, technical knowledge, and barriers to implementation to help researchers and urban planners to design the smart cities with resilient, adaptive, and data-driven transportation networks.

Keywords: Internet of things, Smart cities, Traffic management, Artificial intelligence, Machine learning

 DOI: http://dx.doi.org/10.22159/ijet.2025v13.57905. Journal homepage: https://innovareacademics.in/journals/index.php/ijet

INTRODUCTION

Cities are getting bigger and more complicated, and the way people move around in cities is making normal traffic control methods fail. Vehicle ownership has increased at a very high rate, and adequate facilities have not been well established to manage traffic, which has created serious traffic congestion that has affected the economy and the living standards in the urban life [1]. Internet of Things (IoT) is a new phenomenon in the urban landscape and has become a transformational power that allows the network of physical objects to gather and share data instantly. Smart traffic lights, smart vehicles, and city sensor IoT technologies make it possible to monitor the traffic patterns and environmental conditions along with human behavior, continuously. Such a stream of real-time data offers a rich source for creating elaborate predictive models that can streamline traffic movement, decrease congestion, and improve general city mobility [2].

The migration also poses a big challenge, especially in the traffic management, because the cities are not able to accommodate more vehicles, pedestrians, and the people using the transport. Traffic congestions are a nuisance to commuters and have had significant implications for the sustainability of urban life, economic productivity, human health, and the quality of the environment [3]. The smart city concept has gained popularity as a means to tackle these issues; it enhances city life through the use of technology, data, and analytics. These innovations center around the IoT- a network of interlinked gadgets, which have the capacity of gathering and distributing real-time data. Artificial intelligence (AI) facilitates the study of the enormous data sets produced by IoT devices. AI is able to make educated guesses about future traffic flows by analyzing historical data for patterns and trends using machine learning (ML) algorithms. Using historical data to inform future traffic conditions, traffic management systems and city planners can optimize traffic lights, reduce congestion, and increase safety [4]. Combining AI and IoT can serve not only to manage traffic in real-time but also to plan and develop infrastructure in the long run. Cities are able to plan new infrastructure projects, allocate resources more efficiently, and enact policies aimed at encouraging the use of sustainable transportation resources by forecasting traffic trends and learn when infrastructure is used the most [5].

This paper's rationale is based on the necessity to find out how AI, in combination with IoT-related smart city systems, can react to such troubling problems, optimize transportation, and help to establish sustainable, data-driven urban mobility. This study aims to survey the current state of the art in AI solutions for smart city traffic management using IoT technology. The paper is also going to emphasize the role of AI combined with IoT in maximizing traffic movement, bettering congestion, and improving road safety as well as promoting sustainable and efficient movement of people in the city, detecting existing challenges and future areas of research to allow scaling and efficient city traffic solutions. The summary of this paper is as follows:

- IoT devices including smart sensors, radio frequency identification (RFID) systems, and linked vehicles enable intelligent traffic control in smart cities by gathering data in real-time while also monitoring traffic.
- ML, deep learning (DL), computer vision, and predictive analytics are some of the main AI approaches described next. The solutions then detail how they process the data provided by the IoT, allowing for adaptive signal management, congestion forecasting, and incident detection.
- The given particular comparison highlights the differences in the definitions, algorithms, applications, strengths, and weaknesses of each AI method to clarify how the different strategies are different in contributing to efficient traffic and urban mobility.
- Finally, the paper has covered the main obstacles to deployment, including data privacy, interoperability, computing demands, and maintenance issues, and it has suggested some potential opportunities, like digital twins, multi-agent systems, edge AI, and federated learning, to create traffic management solutions that are more scalable and long-lasting.

The paper is separated into seven sections; Section I introduce the topic and its interest; Section II describe the very concept of smart cities; Section III give an overview of the AI-controlling methods of the traffic in the urban environment; Section IV define the challenges of the AI-controlling traffic models; Section V presents the literature review; and, finally, Section VI provides the conclusion of the paper and define the directions of the research in the future.

SMART TRAFFIC MANAGEMENT SYSTEM USING IOT

The "Internet of Things" (IoT) is a system of interconnected computing devices that can access and share data via the Internet. To get real-time data about traffic, automobiles, and the environment, connected cars, cameras, and sensors (such as RFID tags and infrared sensors) collect this information. The IoT changes the traditional methods of traffic management by allowing real-time monitoring and data-driven decision-making. IoT integration with traffic systems enables cities to optimize routes, manage traffic lights dynamically, and improve transportation efficiency [6]. By analyzing traffic data in real-time, devices connected to the IoT can adjust signal timing accordingly. For instance, in the event that sensors detect heavy traffic at a junction, the system has the capability to extend the duration of the green light for that direction. There will be less congestion and shorter wait times as a result of this dynamic adjustment. Smart traffic control systems for large cities are built on top of the IoT, as seen in Fig. 1.

A smart traffic management system's administrative design may adjust the timing of intersection lights based on the current state of traffic from all directions, thereby reducing traffic congestion. At an intersection, multiple sensors are placed at equal intervals to collect this continuous data. A control framework receives this data and uses it to determine, autonomously, when the green light should appear for each particular direction at a junction to prevent traffic congestion [8].

Technical components of IoT traffic management systems

The effective implementation of these systems depends on a variety of technological factors:

- Sensors: Different varieties, for example, RFID tags to track vehicles and infrared sensors to measure crowding.
- Connectivity: Devices are able to communicate with one another using wireless networks or cellular networks.
- Data processing: Cloud computing can be used to perform intensive data analysis whereas edge computing can be used to do processing in real time and nearer to the location of data generation.

Challenges in implementing IoT traffic management systems

The advantages are significant, but it is important to overcome a number of challenges:

- Data privacy concerns: Strict security protocols are required to address privacy concerns brought up by real-time data collection.
- Infrastructure costs: Large sums of money are needed to upgrade the current infrastructure so that it can accommodate IoT technologies.
- Interoperability issues: Facilitating the efficient operation of various systems and equipment can be a challenging task.
- Maintenance needs: Continuous performance relies on regular software and sensor maintenance.

The role of AI in traffic management

The IoT is taken to the next level with the further integration of AI with TMS. AI systems for traffic management that can process massive amounts of data, identify trends, and forecast future outcomes. This is essential for making it through the unpredictable city traffic, which changes depending on things like the time of day, the weather, and special events. The most crucial aspect of transitioning cities to smart city programs is the interdependence of AI and IoT technology [9,10]. These smart city developments strive to improve city life by utilizing technological tools for sustainable development, resource management, and quality of life. Data inclusion, privacy concerns, and the supply of strong infrastructure are a few of the obstacles that arise when applying AI-based traffic flow prediction models. If smart city solutions are to live up to their promise, these obstacles must be overcome.

The previous several decades have seen significant advancements in traffic management, with the gradual replacement of manual systems by highly sophisticated technological ones, overseen by dedicated traffic control teams. The initial management of traffic was extensively based on human operators, road signs, and crude data gathering tools, including counts of roads and surveys. The late 20^{th} century saw the introduction of computerized systems which signified a major change where data processing and analysis became more efficient [5].

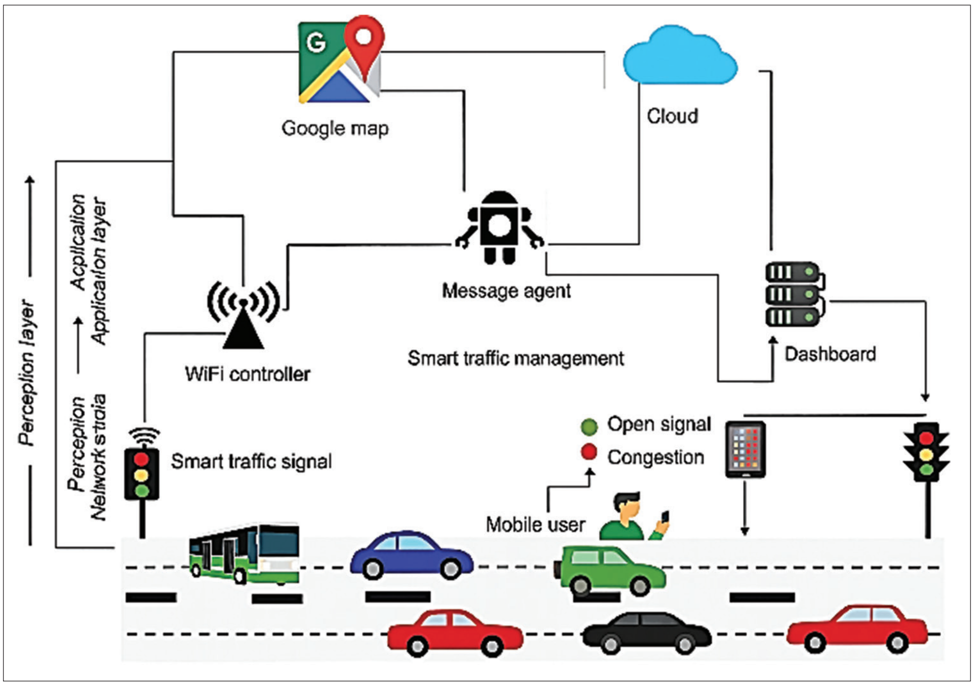

Fig. 1: Internet of things-based architecture of smart traffic management system for metropolitan cities [7]

Automated traffic management systems (ATMS)

The implementation of ATMS in the 1990s enabled cities to monitor traffic flow and manage congestion through the use of sensors and cameras. The main concern of these systems was real-time data gathering, and the predictive capability was limited [11]. They usually used past records as guidelines for traffic control techniques, which were inadequate in dynamic urban setups.

Intelligent transportation systems (ITS)

The development of ITS, which combined new communication technologies with the old traffic management systems, also took place in the 2000s. The traffic signals can be better coordinated, dynamic message signs can be installed, and real-time traffic information can be disseminated [12]. Nevertheless, a number of ITS applications continued to experience problems with regard to scalability and responsiveness to traffic fluctuations.

Data-driven approaches

As mobile gadgets and GPS technology were on the rise, data-driven methods started to become popular. Apps such as Google Maps and Waze can give users up-to-date traffic and give them the best route to take. Using crowd-sourced data, these websites were able to demonstrate the efficacy of combining user-generated content with conventional traffic statistics. However, rather than involving the broader traffic management ecosystem, these applications primarily involved individual users.

AI and machine learning integration

Traffic management has changed significantly in the last couple of years with the introduction of AI and ML methods. With the advent of algorithms, it is now possible to predict the traffic patterns based on the vast amount of data gathered and analyzed by various devices such as IoT devices in an unprecedent accuracy. The application of ML techniques for traffic flow forecasting and congestion point identification is on the rise. These models include clustering algorithms, regression analysis, and neural networks.

OVERVIEW OF SMART CITIES

The aim of integrating data into a city's physical infrastructure is to create a smart city that is more convenient, easier to navigate, efficient, energy-efficient, improves air and water quality, finds and fixes problems fast, recovers quickly from disasters [13], leverages resources effectively, collects data for better decisions, and allows collaboration across entities and domains through data sharing.

Roadmap of smart city systems

A preliminary examination is the first of four parts that make up a smart city roadmap. Fig. 2 displays the blueprint for smart cities.

- Define community: This includes things like location, the ways that people move between cities and farms, and the links between them.
- Study of community: Developed areas need to look at their needs carefully before choosing to build a smart city. Finding the benefits of such an effort is one way to do this [14,15]. Studying communities can helps and understand the people who live there, what businesses need, and what makes each community and its people unique, like age, education level, hobbies, and the aesthetic appeal of the place.
- Develop smart city policies: Policies should be put in place to assist individuals in defining their roles, responsibilities, objectives, and goals, and in developing strategies and plans to achieve those goals.
- Citizen interaction: Electronic government programs, open data, sports events, and other things can be used to get people involved in this. There are three main ideas that make a smart city plan work: people, process, and technology. Surveying people and communities is important for cities to learn about how things work and what drives businesses. Then, they can make policies and set goals that meet the needs of those people and communities [16]. To meet the needs of people, make life better, and open up real business opportunities, this technology can be used. To do this, need a universal and tailored method that takes into account city life, long-term city planning, and local rules.

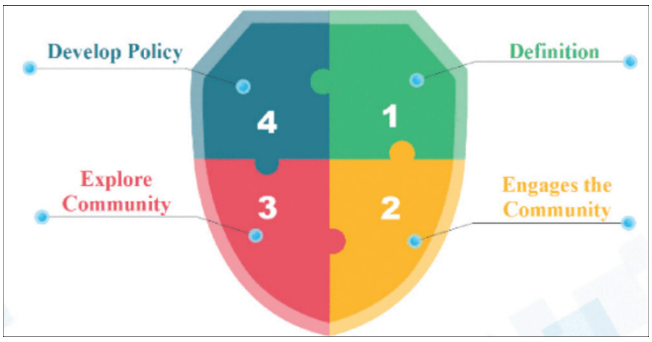

Fig. 2: Roadmap of smart city

Applications for smart cities

The following are some of the key focal areas for the development of a smart economy. Using Information and Communication Technology (ICT) tools to get more people involved is a must for any kind of fully working government. Using a range of technologies and tools on social and human capital definitely makes them better.

Waste management system

A smart environment is at the heart of a smart city and is mostly used for systems that deal with environmental damage. Trash collection in cities is a regular job that takes a lot of work and has effects on things like speed, social issues, the economy, and the environment [17]. The way people handle their trash has a big effect on their quality of life. Sensors, GPS, and LEDs could be used in the trash can to keep track of trash. When the trash can need to be picked up, the sensor tells the operator instantly when and how to get there while ignoring traffic. When the trash can is full, a warning is sent to the operator, who then tells the trash collector with a smartphone where the can is. Hence, the trash worker goes to the spot, picks up the trash, and puts the bin back where it belongs.

Smart parking system

The car parking information system tells drivers where and when garage spots are available. Time-sensitive problems arise when parking spaces are limited. To check if the information on which parking spots were occupied and for how long was analyzed using time series analysis methods. The automated parking device.

Smart traffic light system

The installation of smart traffic signals reduces pollution levels across the city. Energy savings and the elimination of dazzling lights-related mishaps are just two of the many benefits of brightness control, which eliminates light fading. One very useful IoT application is connecting drivers and warning them of upcoming road conditions [18]. Computer vision-enabled cameras frequently scan the road during the day-to-night cycle and when weather conditions worsen to detect oil spills and potholes [19]. Eventually, roadside light sensors will be able to pick up on these signals and turn the lights on and off appropriately. The cloud detection technology flags a violation when a driver goes faster than the posted speed limit, prompting the authorities to take appropriate action. An intelligent traffic signal system is shown in Fig. 3.

Smart building system

A smart building has characteristics shown in Fig. 4. Home automation through the IoT is the control of common domestic appliances through electronic means. A practical and inexpensive IoT application for users is support for smart buildings that are enabled by the IoT. With a single hub and an app on smartphone, and can control home's heating, lighting, and security systems from anywhere. Eliminating repetitive

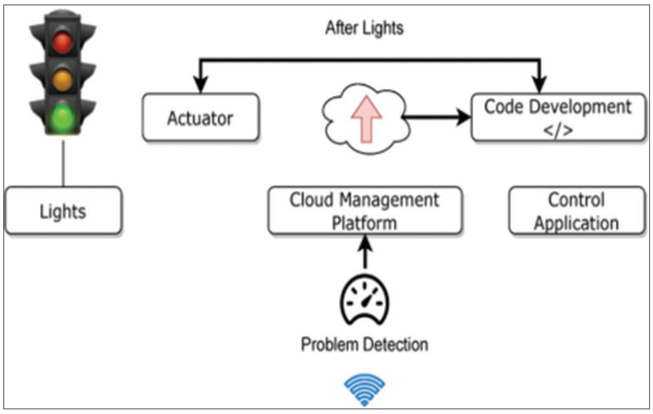

Fig. 3: Smart traffic lighting system in a smart city

Fig. 4: Elements of a smart building

human tasks is automation's main goal. Words like "FAN ON" and "LIGHT ON" can turn on lights and fans.

AI FOR URBAN TRAFFIC MANAGEMENT

The recent decades are characterized by the fast rate of urbanization across the world, and it has brought with it unprecedented challenges in the area of traffic management [20]. With urban centers growing in population, the pressure on the available transportation system has been felt with congested road systems, long commutes, and safety issues being experienced [19]. To curb this dramatic city dilemma, the introduction of AI into traffic monitoring systems has come as a groundbreaking and prospective solution.

AI in traffic management

The use of AI in traffic management is a revolutionary possibility that can solve the shortcomings of conventional systems [21]. AI allows us to optimize traffic flow by analyzing massive amounts of data, learning from trends, and making decisions in real-time. Some important AI tools are:

AI-based traffic monitoring systems

The use of AI technologies, including computer vision, image computing, and ML, is already being implemented in some cities to monitor and control the traffic [22]. The AI cameras are able to record the traffic density, vehicle number, and road condition in real-time. Through this data, AI systems are able to make decisions to maximize the traffic flow without human intervention.

Computer vision and object detection

AI systems, which utilize DL in particular, are able to recognize objects such as vehicles, pedestrians, and traffic signs in real time [23].

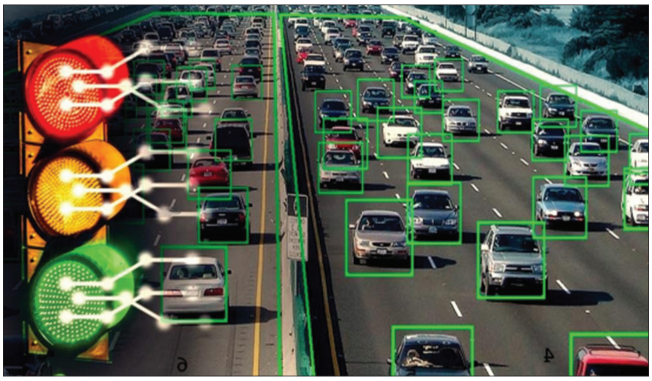

Fig. 5: Artificial intelligence-based traffic monitoring systems

Such systems are now being applied in real-time monitoring of busy intersections and highways (Fig. 5).

Example: Traffic cameras in some cities such as Singapore and Beijing are powered by AI and used to scan cars and pedestrians and monitor traffic flow. Such systems are able to automatically change the timing of the traffic lights as the traffic moves which makes the decisions of a traffic light much quicker than a human being.

The AI algorithms can optimize traffic lights on the basis of real-time traffic. The systems also minimize the waiting time at crossings and unnecessary stops, which in turn enhances the general traffic flow (Fig. 5).

Smart traffic lights and signal optimization

Reinforcement learning (RL) for traffic signals

The timing of the signals could be optimized based on the signal pattern in the long-term using reinforcement learning models that are enhanced using the trial-and-error method. These systems can guarantee a free traffic flow without the manual intervention of the traffic police (Fig. 6).

Example: The city of Pittsburgh has deployed AI-enabled smart traffic lights, positively claiming that it decreased traveling time by over 25% and vehicle emissions by over 20%.

AI for predictive traffic management

This can be facilitated by AI enabling predictive modeling, which enables the planners of the city to predict traffic before it becomes a problem [24,25]. These systems work with large data sets such as traffic history data, weather data, and incidents to make predictions on traffic patterns and allocate resources.

Machine learning models for traffic forecasting

Regression models, neural networks, and decision trees are ML models that can be used to predict traffic congestion, enabling proactive measures to be undertaken to reduce the impact, including route diversion and traffic signal modification.

Autonomous vehicles and AI-based traffic control

The introduction of autonomous vehicles into the current road systems is one of the most disruptive potentials of AI in the traffic management process [26,27]. These cars are able to communicate with other cars and with the infrastructure in place to make their movements properly organized without involving humans.

Vehicle-to-infrastructure communication

Driverless cars can improve their on-the-go decision-making by collaborating with traffic management systems powered by AI. They can, for instance, modify their route based on real-time information on things such as traffic, accidents, and congestion.

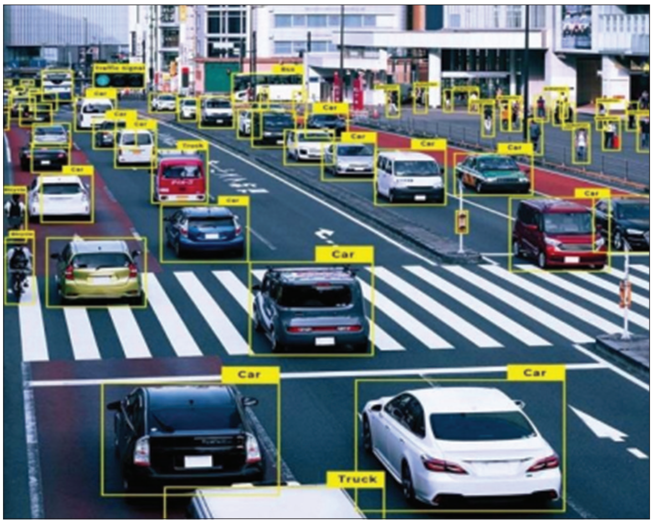

Fig. 6: Smart traffic lights and signal optimization

Example: AI systems constantly change signals and reroute traffic in areas such as Phoenix, Arizona, and sections of California to avoid accidents and bottlenecks involving both human-driven and autonomous vehicles.

Table 1 provides a useful reference that compares the various major forms of AI techniques used for smart city traffic management and includes definitions, examples of algorithms, common uses, strengths, and limitations of each type.

Benefit of using AI in traffic management

AI can be utilized in managing traffic in cities as it has transformative benefits because it allows systems to be more efficient, responsive, and predictive. AI helps emergency vehicles to pass through the traffic quickly, automates traffic law enforcers, and maximizes the sequences of traffic lights depending on real-time information. Moreover, it also supports intelligent parking, helps to realize more extensive smart city objectives, and improves the urban planning decisions. The visual representation of these multidimensional advantages of AI-powered traffic systems is Fig. 7, which displays the main spheres where AI technologies are making a significant impact on the control of traffic and urban infrastructure.

- Efficient traffic flow optimization: AI-based systems can improve traffic flow by looking at real-time data from GPS devices, traffic cams, and other sensors. However, the idea of such data processing and ML algorithms can be applied to evaluate the trends in the traffic and make certain changes to diminish the congestion and enhance the overall traffic flow.
- Predictive analysis: Authorities and commuters alike can benefit from deploying AI systems that can predict traffic conditions to plan routes more effectively [32]. "Artificial intelligence (AI) systems" may analyze past data, current weather patterns, and out-of-the-ordinary occurrences to generate accurate predictions of traffic congestion, allowing for the implementation of preventative actions.
- Adaptive traffic signals: The "AI-based traffic signal control" system can adjust the timing of lights in real-time according to the flow of traffic. Reduced fuel use and pollution are other benefits, as are reduced intersection wait times made possible by increased flexibility.
- Accident detection and response: AI applications facilitate the rapid detection of accidents and events; this data can then be shared with emergency services and traffic control centers, facilitating a prompt reaction and alleviating traffic congestion.
- Public transportation optimization: This AI concept has the potential to improve "public transport AV systems" through real-time situational awareness, demand forecasting, route optimization for buses, and scheduling adjustments. Nonetheless, this lessens traffic congestion caused by individual cars and promotes the use of public transport.

Fig. 7: Significance of applying artificial intelligence in traffic management

- Traffic enforcement: "Automated cameras and sensors" can be set up to monitor traffic violations using AI applications. With this in mind, it is possible to make the annotation that this can make roads safer and lessen the need for human enforcement of traffic laws.
- Environmental benefits: A cleaner and more sustainable urban environment can be achieved through the infrastructure of "AI-driven traffic management" by reducing pollution, fuel consumption, and traffic congestion while strengthening transit networks.

CHALLENGES IN AI-DRIVEN PREDICTIVE MODELS FOR TRAFFIC FLOW IN IOT-DRIVEN SMART

The use of AI to predict traffic flow in IoT-powered smart cities comes with a number of issues that need to be fixed before they can be used effectively and for a long time. Factors such as public acceptability, data-related problems, technical constraints, ethical and legal considerations, and other similar difficulties [5].

Data-related challenges

Data quality and reliability

Predictive models can only be as good as the data used to create them. IoT devices have the potential to produce extensive data with inconsistencies, noise, and missing values that can be barriers to model performance. To achieve data reliability, there is a need to ensure that the data collection and preprocessing methods are robust.

Data integration

There are various sources of traffic data which are sensors, GPS devices, and the system of the public transport. There are high difficulties in integrating these different datasets within a single framework. Data are represented in different formats, sampling rates, and frequencies of updates, which may complicate the integration process and cause gaps in the data that may influence the predictive accuracy.

Technological limitations

Computational complexity

The algorithms of AI and, in particular, DL are very intensive in terms of computational resources. These models require high-end infrastructure such as high-performance computing facilities to implement them in real-time management systems of traffic. Such infrastructure might not be feasible in many cities due to their inability to finance it and also due to a lack of technical knowledge.

Interoperability issues

Interoperability is a problem that usually affects the successful implementation of IoT devices and AI models within the current traffic

Table 1: Comparison analysis of artificial intelligence techniques for traffic management in smart cities

AI technique	Definition	Common methods/algorithms	Specific applications in traffic management	Strengths	Limitations
Machine Learning (ML) [28]	ML uses historical (data-driven) approaches and present (real-time) traffic data to create models that can make predictions or classifications based on what they've learned from previous patterns and may not require specific programming to accomplish those tasks.	SVM, Random Forest, Decision Trees, K-Means, Naive Bayes, Gradient Boosting	Traffic flow prediction Congestion classification Travel time estimation Incident detection Pattern clustering	Works with small/medium data Fast inference Easy to interpret Good for structured sensor data	Struggles with complex nonlinear relationships Requires manual feature engineering Not suitable for video/image analysis
Deep learning (DL) [28]	DL is an advanced type of ML that creates and employs multi-layered Neural Networks to learn the complex spatio-temporal characteristics of traffic through large volumes of data without human intervention.	CNN, LSTM, GRU, Autoencoders, GANs, Transformers	Vehicle detection Traffic density estimation Accident detection from CCTV Lane segmentation Time-series forecasting	High accuracy Learns features automatically Best for images/videos Handles massive datasets	Requires high computational power (GPU) Needs large labeled datasets Long training time
Reinforcement learning (RL) [29]	RL enables an agent to learn how to make informed decisions about its actions (e.g., signal timing) while interacting with an evolving traffic environment where the agent is rewarded for driving and enabling improved flow.	Q-learning, DQN, Double DQN, Policy Gradient, Multi-Agent RL	Adaptive traffic signal control Dynamic phase optimization Intersection control Congestion reduction	Learns optimal strategies over time Highly suitable for dynamic traffic Reduces delays and wait time	Requires long simulation training Difficult multi-intersection coordination Sensitive to environmental design
Computer vision (CV) [30]	CV enables the use of Artificial Intelligence to read visual data obtained from cameras or drones to determine real-time conditions on the road.	You Only Look Once, Faster R-CNN, SSD, DeepSORT, U-Net, Mask R-CNN	Vehicle detection & tracking Pedestrian detection Accident detection Lane & road segmentation License plate recognition (ANPR)	Real-time visual monitoring High detection accuracy Uses existing CCTV infrastructure	Affected by lighting & weather Privacy concerns High computational load
Predictive analytics [31]	Predictive Analytics combines both statistical and Artificial Intelligence-based models to project future traffic patterns and flows based on historical data, real-time data, and sensor feedback.	ARIMA, SARIMA, Prophet, LSTM, GRU, GNN, Hybrid Models	Short & long-term traffic forecasting Congestion prediction Peak hour estimation Travel time forecasting	Enables proactive planning Enhances navigation systems Improves traffic management decisions	Requires clean, high-quality data Sudden events affect accuracy Needs real-time data pipelines

management systems. Dissimilar systems can operate with inapplicable protocols or norms, hence creating a unified traffic management solution can be difficult.

Regulatory and ethical concerns

Privacy and data security

Real-time traffic information can be of great privacy concern because it can be used to monitor the movement of people. There is no easy way of implementing data privacy measures and ensuring effective use of data, as it is a complicated issue that has to be addressed based on legal and ethical requirements.

Regulatory compliance

The regulatory environment of data collection and traffic management technologies may be quite a challenge to navigate. The performance to comply with local, national, and international regulations needs in-depth knowledge and constant observation of the changing regulations.

Public acceptance

User acceptance and engagement

The AI-powered traffic management systems should be accepted by the population to work. Issues of surveillance, data security, and perceived invasiveness of surveillance technologies may be a barrier to community support. It is important to trust the stakeholders and promote transparency regarding the use of data to motivate people to participate.

These models, however, are not implemented without difficulties. The quality of data is also a burning issue; incomplete or unmatched data may cause wrong predictions, which could worsen the situation with traffic [33]. Furthermore, the financial and technical constraints present the problem of high costs of the advanced computing resources to many cities, and in particular, low-budget cities. Another challenge that should be overcome to establish a smooth traffic management system is interoperability among the various systems. The success of AI-based traffic systems also highly depends on the acceptance by the population. The citizens are to be concerned about their privacy and surveillance and it should be discussed as a transparent message of data usage and security measures [34]. The use of stakeholders such as community members and local agencies creates trust and makes the models to match the needs of the community.

LITERATURE REVIEW

The relationship between AI and IoT and traffic management has been studied extensively, with a number of articles providing valuable points of interest to predictive modeling of urban mobility. The literature review is a synthesis of the main findings of the pertinent research, with special emphasis on the progress and problems of the field. Predictive modeling is a technique that investigates a number of studies to come up with predictive models to express traffic flow through the application of different machine-learning algorithms in smart cities.

Ara and Ara (2025) the principal objective of the study is to provide research-based recommendations on incorporating field-based activities in the course of smart city education. To accomplish this objective, the study uses five in-depth case studies. Each of the three case studies is real case. The potential implication of the study is to transform urban planning education, thus enhancing the participation of citizens in urban and city development. The results are able to give a comprehensive solution through combining technology, urban planning, and sustainability to enhance the way people live in the city in a way that is sustainable and smart city developments in the future. This study intends to shed light on how new and existing technologies can develop better and more efficient cities throughout the world [35].

Adeleke *et al.* (2025) systematic review of 61 academic sources, with a focus on its advantages, issues, and the primary role of telecommunications in smart urban development. This systematic review cuts across the two-foldity of smart cities in terms of their revolutionary potential and inherent challenges. The gap in the literature identified by the study is notable in the aspects of long-term social impacts, particularly in terms of resource allocation, critical gaps in ethical governance, policies on resource distribution, and their long-term societal impact, and ethical governance underrepresentation of telecommunications as a key enabler, and suggests possible future research directions to fill these gaps [36].

Robinsha and Amutha (2025) invented a lightweight IoT-based energy consumption forecast system based on simple moving average (SMA) predictive methodology. The SMA approach is based on predictions of energy consumption that can be used in resource-constrained conditions using real-time node data of households and industries. An evaluation of the model through a model assessment using the mean absolute percentage error and R^2 scores demonstrates that the model has good continuity in terms of accuracy even when it is applied in different consumption volumes and also at minor costs of computation. The given research shows how the SMA technology can be used to accommodate the requirements of smart city energy management and provide an implementation plan for the improvement of urban energy systems in a sustainable way [37].

Shirulkar *et al*. (2025) developed a system of adaptive traffic signal control (You Only Look Once) algorithm, which is an object detector to estimate the signal timing in real-time traffic. The system uses dynamic management of green light time by detection and tracking of the vehicles in real-time at the crossing point based on the volume and the type of vehicle. The suggested solution renders the vehicle recognition very efficient and reacts promptly to the change in the traffic scenario. The paper has talked about the design, implementation, and evaluation of performance in a simulated environment. The experimental findings show better traffic control and lesser congestion which is a good solution to traffic control in smart cities [38].

Kishore *et al*. (2025) developed a smart automated traffic management system facilitated by cloud computing and big data analytics to further optimize the urban transportation and maximize traffic efficiency. The system receives and analyzes real-time traffic information using GPS devices, sensors, and social media using random forest algorithms on predictions modeling. The system also offers dynamic traffic control measures such as adaptive signal control and route optimization that are sensitive to real-time changes. Data and scaling are done through a cloud-based infrastructure. Simulation and monitoring of vehicles and real-time inputs are done over a user-friendly interface to use in predictive analysis and testing purposes. Such a combined strategy is bound to result in less congestion, shorter travel time, and increased traffic safety through a low-cost, scalable, and adaptable urban traffic control system [39].

Rathore *et al.* (2025) developed an ML-based system that forecasts and controls traffic congestion. The system builds on the uninterrupted traffic information of the IoT devices, including pictures, GPS, and inductive loop cameras, to observe the actual traffic situation. The Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) networks are combined to make predictions of traffic. Furthermore, geographic information system (GIS) technology is incorporated to provide spatial analysis and real-time dynamically controlled traffic lights so that the real traffic lights can change dynamically and provide alternate routes to the drivers to beat the congestion. The initial experiments indicate that intelligent traffic management systems can make traffic much faster and decrease congestion in big cities. The paper also discusses the issues associated with the privacy of data, scaling, and improvements in the future as the integration of self-driving vehicles and the implementation of reinforcement learning. It is very practical in the reduction of congestion and maximization of transportation systems in urban areas [40].

A detailed overview of the latest research studies addressing the topic of the integration of blockchain, IoT, and AI into smart cities is available in Table 2.

Table 2: Comparative analysis of AI and IoT-based frameworks for smart city traffic management

References	Study on	Approach	Key findings	Challenges/ limitations	Future directions
Ara and Ara (2025)	Smart city education and sustainable urban planning	Case study method with five field-based examples	Emphasizes integration of citizen engagement and field activities in smart urban planning education	Limited to educational reform; lacks technical system evaluations	Expand field-based smart city curricula; integrate with real-world tech implementations
Adeleke *et al*. (2025)	Role of telecom in smart urban development	Systematic review of 61 scholarly articles	Identifies telecom as underutilized in enabling smart city systems; discusses ethical and governance gaps	Underrepresentation of telecom; lack of empirical case implementations	Address long-term governance, fairness in resource distribution, and inclusive policies
Robinsha and Amutha (2025)	Smart energy consumption forecasting	Lightweight IoT infrastructure using Simple Moving Average (SMA)	Reliable energy forecasting under constrained resources; low computation cost	Limited to SMA model; no comparison with advanced forecasting methods	Integrate with ML-based prediction models and large-scale smart grid systems
Shirulkar *et al*. (2025)	Real-time adaptive traffic control	You Only Look Once-based object detection for traffic signal adjustment	Improved congestion control and responsiveness to vehicle volume/type	Tested only in simulations; real-world deployment not validated	Field implementation, integration with city-wide surveillance systems
Kishore *et al*. (2025)	Cloud-based smart traffic control	Big data analytics and Random Forest on cloud infrastructure	Enhances traffic efficiency using adaptive signals and route optimization	Complexity in integration with legacy systems; privacy concerns	Scale across multiple cities; test with autonomous vehicle data sources
Rathore *et al*. (2025)	AI-driven congestion management	CNN+LSTM+GIS+IoT integration	Real-time prediction and adaptive routing reduce congestion significantly	Challenges in data privacy, system scalability, and cost	Reinforcement learning, autonomous vehicle integration, and enhanced GIS precision

GIS: Geographic information system, IoT: Internet of Things, AI: Artificial intelligence

CONCLUSION AND FUTURE WORK

Smart city traffic operations have enabled the effective management of traffic due to the use of AI coupled with the implementation of IoT-based infrastructures that enable real-time monitoring and enable adaptive decision-making based on precise prediction instruments. The AI methods involved in smart traffic management solutions are ML, DL, RL, CV, and PA. With the help of these AI methods, the smart operations of traffic management can alleviate traffic jams, enhance the level of security, optimize the timing of signals, and improve the movement of people in cities overall. There are however considerable challenges with this degree of technological development that cannot be implemented in large scale including data privacy, interoperability, computational complexity, and the capability to process real-time data on the scale that is needed in many applications in smart cities like traffic. The direction of future research and product development should focus on developing lightweight AI models that are appropriate for edge devices, creating IoT infrastructures that are interoperable, developing techniques that maintain the privacy of user data such as federated learning, and integrating multi-agent AI systems that can coordinate across intersections and modes of transportation. Future research can also investigate the use of digital twins, 6G IoT networks, and hybrid AI model options to create more comprehensive, sustainable, and scalable solutions for future smart cities.

REFERENCES

1. Seetharaman KM. "Incorporating the internet of things (IoT) for smart cities: Applications, challenges, and emerging trends". Asian J Comput Sci Eng 2023;8:8-14.
2. Sathyan S, Jagadeesha SN. "Traffic flow prediction using machine learning techniques - a systematic literature review". Int J Appl Eng Manag Lett 2022;6:210-30.
3. Shah V. "Traffic intelligence in IoT and cloud networks: Tools for monitoring, security, and optimization". Int J Recent Technol Sci Manag 2024;9:138.
4. Prajapati V. "Enhancing supply chain resilience through machine learning-based predictive analytics for demand forecasting". Int J Sci Res Comput Sci Eng Inf Technol 2025;11:345-54.
5. Mitra S. "AI-driven predictive models for traffic flow in IoTdriven smart cities". Uncertain Discourse Appl 2024;1:170-8.
6. Garg S. "Next-gen smart city operations with AIOps & IoT : A comprehensive look at optimizing Urban infrastructure". J Adv Dev Res 2021;12:1.
7. Humayun M, Afsar S, Almufareh MF, Jhanjhi NZ, AlSuwailem M. "Smart traffic management system for metropolitan cities of kingdom using cutting edge technologies". J Adv Transp 2022;2022:1-13.
8. Tiwari A. "Smart traffic management system using IoT". Int J Res Appl Sci Eng Technol 2020;8:542-7.
9. Madugula SR, Malali N. "Adversarial robustness of AI-driven claims management systems". Int J Adv Res Sci Commun Technol 2025;5:237-46.
10. Dattangire R, Vaidya R, Biradar D, Joon A. "Exploring the Tangible Impact of Artificial Intelligence and Machine Learning: Bridging the Gap between Hype and Reality". In:2024 1st International Conference on Advanced Computing and Emerging Technologies (ACET). IEEE; 2024. p. 1-6.
11. Sagili SR, Kinsman TB. "Drive Dash: Vehicle Crash Insights Reporting System". In: 2024 International Conference on Intelligent Systems and Advanced Applications (ICISAA). IEEE; 2024. p. 1-6.
12. Sarraf G. "Resilient communication protocols for industrial IoT: Securing cyberphysical-systems at scale". Int J Curr Eng Technol 2021;11:694-702.
13. Montes J. "A historical view of smart cities: Definitions, features and tipping points". SSRN Electron J 2020.
14. Singh T, Solanki A, Sharma SK, Nayyar A, Paul A. "A decade review on smart cities: Paradigms, challenges and opportunities". IEEE Access 2022;10:68319-64.
15. Varma V. "Data analytics for predictive maintenance for business intelligence for operational efficiency". Asian J Comput Sci Eng 2022;7:1-7.
16. Swamy BV, Barmola PP, Thangavel S, Kaliappan S, Patel H, Abhyankar G. "Cognitive Twins for Predictive Maintenance and Security in IoT Software Systems". In: 2024 4th International Conference on Mobile Networks and Wireless Communications (ICMNWC). IEEE; 2024. p. 1-8.
17. Patel D, Tandon R. "Recent advances in distributed systems: Addressing latency, consistency, and scalability in modern applications". Int J Res Anal Rev 2021;8:1-7.

18. Whaiduzzaman M, Barros A, Chanda M, Barman S, Sultana T, Rahman S, *et al*. "A review of emerging technologies for IoT-based smart cities". Sensors 2022;22:9271.
19. Patel R, Patel P. "A survey on AI-driven autonomous robots for smart manufacturing and industrial automation". Tech Int J Eng Res 2022;9:46.
20. Akinade AO, Adepoju PA, Ige AB, Afolabi AI. "Artificial intelligence in traffic management : A review of smart solutions and Urban impact". IRE J 2024;7:511-22.
21. Pillai AS. "Traffic management: Implementing Ai to optimize traffic flow and reduce congestion". SSRN Electron J 2024;11:272-8.
22. Dodda S, Kamuni N, Nutalapati P, Vummadi JR. "Intelligent Data Processing for IoT Real-Time Analytics and Predictive Modeling". In: 2025 International Conference on Data Science and Its Applications (ICoDSA); 2025. p. 649-54.
23. Amrale S. "Anomaly identification in real-time for predictive analytics in IoT sensor networks using deep". Int J Curr Eng Technol 2024;14:526-32.
24. Prajapati N. "The role of machine learning in big data analytics: Tools, techniques, and applications". ESP J Eng Technol Adv 2025;5:16-22.
25. Majumder RQ. "Machine learning for predictive analytics: Trends and future directions". Int J Innov Sci Res Technol 2025;10:3557-64.
26. Musmade P, Rajas S, Khairnar SM. "Artificial intelligence (AI) in traffic management : Toward a future without traffic police". ADYPJIET 2024;1:17-23.
27. Raveendran S, Yalamanchi UB, Raveendran N. "Method, Apparatus, and Computer-Readable Medium for Dynamic Binding of Tasks in a Data Exchange". [US Patent 11,132,221]; 2021.
28. Heidari A, Navimipour NJ, Unal M. "Applications of ML/DL in the management of smart cities and societies based on new trends in information technologies: A systematic literature review". Sustain Cities Soc 2022;85:104089.
29. Maheshwari I, Tewari UP, Arora C. "Robust and Adaptive Traffic Signal Control for Unstructured Driving Scenarios in the Developing World". In: IEEE Intelligent Vehicles Symposium, Proceedings; 2020.
30. Cortez DE, Filho IM, Silva EM, Girão G. "Traffic Control System Development Based on Computer Vision". In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics); 2022. p. 323-39.
31. Wlodarczak P, Ally M, Soar J. "Data Mining in IoT Data Analysis for a New Paradigm on the Internet". In: Proceedings - 2017 IEEE/WIC/ACM International Conference on Web Intelligence; 2017.
32. Patel R, Patel PB. "Mission-critical facilities: Engineering approaches for high availability and disaster resilience". Asian J Comput Sci Eng 2023;8:1-9.
33. Hakak S, Khan WZ, Gilkar GA, Imran M, Guizani N. "Securing smart cities through blockchain technology: Architecture, requirements, and challenges". IEEE Netw 2020;34:8-14.
34. Alahi ME, Sukkuea A, Tina FW, Nag A, Kurdthongmee W, Suwannarat K, *et al*. "Integration of IoT-enabled technologies and artificial intelligence (AI) for smart city Scenario: Recent advancements and future trends". Sensors (Basel) 2023;23:5206.
35. Ara A, Ara A. "Smart Synergies: Integrating Technologies for Sustainable Urban Planning and Smart City Education - A Case Study". In: 2025 22nd International Learning and Technology Conference (L&T); 2025. p. 95-102.
36. Adeleke OJ, Jovanovich KD, Ogunbunmi S, Samuel O, Kehinde TO. "Comprehensive exploration of smart cities: A systematic review of benefits, challenges, and future directions in telecommunications and Urban development". IEEE Sensors Rev 2025;2:228-45.
37. Robinsha DS, Amutha B. "A Simple Moving Average-Based Predictive IoT Architecture for Energy Consumption in Smart Cities". In: 2025 International Conference on Computing and Communication Technologies (ICCCT). IEEE; 2025. p. 1-5.
38. Shirulkar S, Makode R, Khandelwal R. "Adaptive Traffic Signal Management Using Real-Time Vehicle Detection and Tracking." In: 2025 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI); 2025. p. 1-6.
39. Kishore MN, Prabavathi AB, Rohith S, Karthick RP. "Dynamic Traffic Optimization Through Cloud-Enabled Big Data Analytics and Machine Learning for Enhanced Urban Mobility." In: 2025 International Conference on Computing and Communication Technologies (ICCCT). IEEE; 2025. p. 1-8.
40. Rathore SP, Farhaoui Y, Aniebonam EE, Nagpal T, Thanuja M, Kaushik P. "AI-Driven Traffic Congestion Management: A Predictive Analytics Approach for Smart Cities". In: 2025 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI); 2025. p. 1-6.