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Smart Cities: An In-Depth Study of AI Algorithms and Advanced Connectivity

[1]Raparthi Yaswanth, [2,*]M Rajasekhara Babu, [3]Borra Vineetha, [4]Shaik Mahamad Shakeer, [5]Vivekananda Potti
[1,3,4,5]Research scholar, School of Computer Science and Engineering
Vellore Institute of Technology (VIT)
Vellore, Tamil Nadu, India
[2]Professor, School of Computer Science and Engineering
Vellore Institute of Technology (VIT)
Vellore, Tamil Nadu, India
[1]yaswanthraparthi@gmail.com, [2,*] mrajasekharababu@vit.ac.in, [3]borravineetha97@gmail.com,
[4]sm.shakeer05@gmail.com, [5]pottivivekphd@gmail.com

Abstract—The goal of smart city development is to improve the quality of life by incorporating technology into daily activities. Artificial intelligence (AI) is critical to the ongoing development of future smart cities. The Internet of Things (IoT) idea connects every internet-enabled device for improved access and control. AI in various domains has changed ordinary towns into highly equipped smart cities. Machine learning and deep learning algorithms have proven indispensable in a variety of industries, and they are now being implemented into smart city concepts to automate and improve urban activities and operations on a large scale. IoT and machine learning technology are frequently used in smart cities to collect data from various sources. This article delves deeply into the significance, scope, and developments of AI-based smart cities. It also addresses some of the difficulties and restrictions associated with smart cities powered by AI. The goal of the study is to inspire and encourage academics to create original smart city solutions based on AI technologies.

Keywords- Internet of Things, , Advanced connectivity, Smart Cities, Urban Sustainability, Machine Learning, Deep Learning.

I. INTRODUCTION

Modern life is increasingly reliant on artificial intelligence (AI) and the Internet of Things (IoT) to automate repetitive jobs and boost productivity in so-called "smart cities." The population of the world is growing quickly [1], and in the last 50 years, the population of cities around the world has doubled. The urban and rural areas must be developed for scientific transformation in order to offer new possibilities for human safety. [2] Future urban development, safety, health, and security challenges will arise when the bulk of the world's population moves into cities [3]. Even in developed nations, smart cities struggle to accommodate a sudden surge in population. The infrastructure of smart cities has grown to be one of the most complex systems on the globe as the demand for and supply of services and resources has increased. A smart city's infrastructure cannot be built without first including intelligent devices. Administrative challenges have grown in importance as the city's population has increased over time. The ability to teach these subjects has been made possible by recent technology developments. A smart city is essential, and everyone will gain from the changes it makes to the living conditions and the provision of human services. More sophisticated information systems that make use of cutting-edge technology must be created in order to produce cleaner settings. Infrastructure design, transportation, and security protocols are all examples of technical skill in smart cities. To provide convenient, empirical, and independent framework establishment for smart cities, IoT devices and solutions must be taken into consideration during planning. The IoT is a crucial component of the applications for smart cities that are capable of producing a ton of data. It's challenging to choose the most accurate and fruitful course of action when faced with such a wealth of complex information. Modern methods like deep reinforcement learning (DRL), machine learning, and artificial intelligence can analyze huge datasets and come up with the best results. With a system that comprises a variety of sophisticated devices like cameras and actuators, data collection has never been simpler. The idea of a smart city has become a reality because to the development of IoT, big data analytics, ML, and DL. The goal of a smart city is to serve its residents by leveraging cutting-edge technology and data analytics on information gathered by sensors. A city's technical infrastructure, intelligent public transit, environmental sustainability, use of technology to reduce theft and crime, and provision of safety for residents are just a few examples of what makes a city smart. A crucial step toward creating intelligent infrastructure that can support cities' ever-growing populations is incorporating deep learning and machine learning

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algorithms into urban building. In terms of accomplishing your goal, this can be a significant step in the correct way. A societal tendency is being sustained by artificial intelligence. All thanks to artificial intelligence, the world is different now than it was ten years ago. Cities all over the world are using AI technology to become smarter, and the main governing functions include communications, water, smart networks, public safety, education, and health. The important elements of these smart cities support urban rejuvenation and growth. Big data and AI have the potential to work together to increase the efficiency of cities, their operational resources, and their expenses.

There are very few state-of-the-art reviews of the widely used ML and DL techniques in the literature. The development of ML and DL provides the notion that they are using outfit and half-breed techniques. Numerous studies have been conducted on the applications of ML, DL, and IoT techniques, general strategies, a precise and profound understanding of techniques in the order, and improvement in future pattern and inventive strategies, but they are not provided at this time. These studies are being considered in the context of the examination in brilliant urban communities.

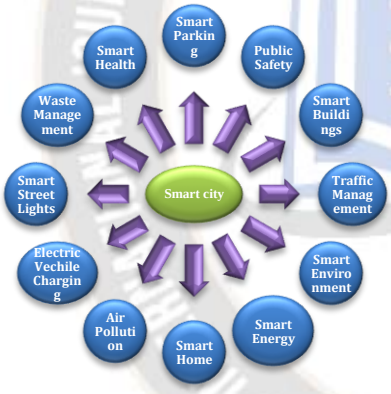

Figure 1. An AI view on Smart Cities.

The current study focuses on smart cities as a never-ending method of metropolitan solidification by utilizing the most effective Deep Learning and Machine Learning techniques. The information presented in this examination is not intended to be updated prior to employment. All things considered, the goal is to provide a review of smart urban communities, which is the most recent advancement in programming from an information science oriented perspective.

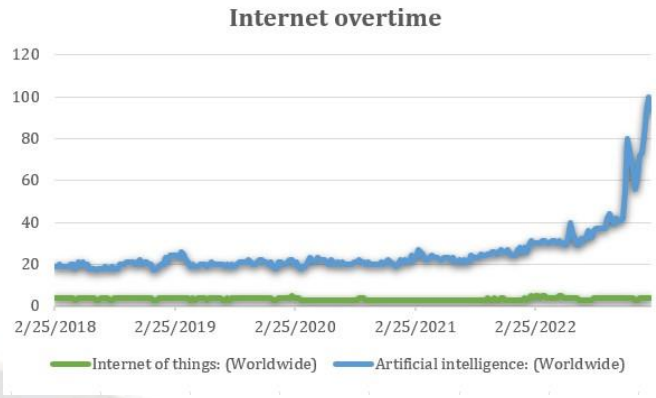

Figure 2. Internet overtime on AI and IoT

An illustration of how Google Trends may be used to depict the ebb and flow of a topic's popularity over time can be found in Figure 2 in the Google Trends help center [4]. This particular instance highlights the exploding interest in AI, which, when used in conjunction with other Internet of Things gadgets, has the potential to be a game-changing resource. However, there hasn't been much study done on integration of books and products, smart city technology, or AI technology. It is critical to investigate the possible effects of current developments in artificial intelligence and "smart" city planning because of the wide range of applications for architecture. The findings of this study reveal trends in pertinent literature and goods, as well as information about the local and worldwide state of the smart cities business. As a result, you must use this term's definition as a reference in your essay. The reference in this instance is essential.

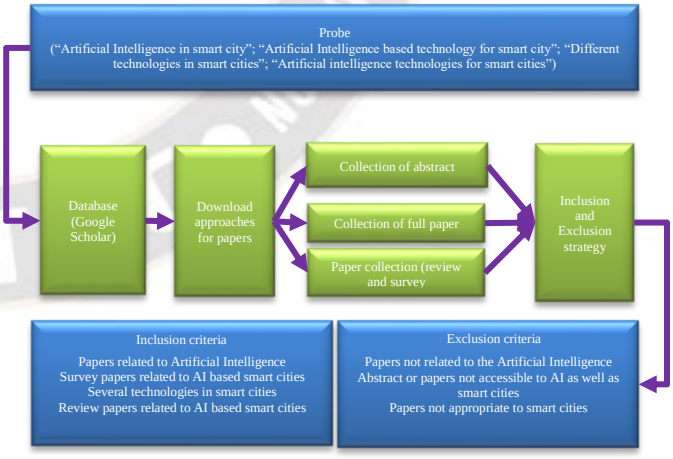

Figure 3. Papers extraction approach for this Systematic Review

This process is demonstrated in Figure 3. The study's findings indicate that artificial intelligence has developed into a useful technology that is crucial to the success of smart cities. As can be seen, there are numerous factors that

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are thought to be reasons for creating and improving smart cities. Intelligent security, smart energy, smart buildings, smart mobility, clever technology, smart citizens, smart infrastructure, smart health care, and smart education are the driving forces behind smart cities.

The rest of the paper is organized as follows: Section 2 provides various applications of AI and ML in smart cities. Section 3 of this study contains a literature review of several algorithms utilized in smart city concepts. Section 4 of this paper concludes the paper.

II. THE USE OF AI IN SMART CITY APPLICATIONS

The figure 4 details recent advances in the use of AI in smart cities across a variety of different areas.

A. Smart Environment

Smart environment application merges a large actual setting given an enormous number of committed and non-committed actuators, sensors, showcases, and components with preparing power. These components are consistently bound together with day-by-day protests and related through a worldwide organization stage. Adaptability, independence, and pragmatic client collaboration are the principal prerequisites to accomplish innovative conditions [5]. Moreover, assuring connection among essential

Figure 4. Applications of AI in Smart cities

empowering agents of present-day climate correspondence resembles an excellent test for different applications. The authors of Reference [6] develop a flexible structure that uses the artificial Application Protocol over a framework of IPv6 low-power remote individual region organization and authentic state move (REST) to ease correspondence among these respecting advances. A captivating application in Reference [7] set up a study hall (named Smart Classroom) in which a bunch of cameras and microphones accomplish a moderator's (either an understudy or an instructor) video and sound. This data is pre-prepared and embedded into acknowledgment calculations.

B. Buildings and Smart Homes

These are two significant parts of smart urban communities. Smart homes allocate control abilities to the human to establish a quiet living climate at home. Smart Structures can highlight intelligent structures at two distinct levels: (I) an actual level, which is made up of a slew of eye-catching designs capable of remote and wired system management, is linked to the transportation strategy and force system, and has a dazzling appearance, and (ii) a virtual level, the partnership between private persons and government authorities at the local level of information exchange and collaboration. The intelligent structure proposed in Reference [8] can be used to detect solid material erosion. The authors of Reference [9] propose a Bluetooth Low Energy-based approach for managing the amount of energy utilized in a smart home (BLE). Their purpose is to reduce the quantity of power used. It is beneficial to turn off certain devices during periods of high energy use. The sensors consider a variety of factors when estimating how the HVAC system should perform, including stickiness, light, temperature, and presence. In the event of a gas leak, extra smoke alarms will sound, alerting occupants to the possible danger. The authors suggest that Bluetooth Low Energy (BLE), which can be used on workstations and smartphones, is better suited for distant innovation than 802.15.4 since it can be utilized on numerous devices.

C. Smart Surveillance

Continuous—still consistent—decrease in sensor energy utilization, which is controlled by the advancement of detecting advances, has covered the route for executing numerous arrangement of observation administrations. In Reference [10], the authors planned an execution that follows many clients in a high thickness area using low-value coin battery-charged BLE-based labels, which run for a year without a battery substitution. The framework needs a tag for each client. A subset of the clients can test these labels utilizing their cell phones and giving the information into the cloud for refining (using cell organizations or Wi-Fi). One more illustration of a smart observation framework is introduced in Reference [11], which utilizes BLE innovation. This investigation expects to recognize gatherings of individual's dependent on their closeness, authorizing the ID of people who socialize. Wi-Fi and BLE signals are used as a sign of distance between people.

D. Smart Transportation and Driving

As a result, automobiles will be able to better converse, identify, handle, and figure out, improving the

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efficiency, safety, and quality of administration for passengers and drivers. An intra-vehicular remote sensor organization (IVWS) will diminish vehicle load by trying avoid more wire [12]. An IVSN can work with ZigBee or BLE and is expected to arrive at the accompanying objectives: low deferral, satisfactory transmission rate, fixed sensors, and steadiness to challenges in the conveyed environmental factors. Through a possibility concentrate on remote access instruments for an IVWS, BLE has demonstrated to be advantageous. It has more data rate than different components, improves low deferral, and it is versatile with compact devices.

E. Smart Health

Overall utilization of actuators and sensors, and the connection of tactile information with an investigation, advance a more intelligent method of giving medical care administrations to expand personal satisfaction and secure better networks for reasonable urban communities. Existing innovative wellbeing applications length numerous conduct, social, and clinical fields. An overall innovative wellbeing application region is human advance action acknowledgment, which is significant for seeing every individual's muscular strength, for the most part, the senior ones. The authors in Reference [13] built up a strategy to distinguish human advance action by including more than 40 inserted sensors, a whirligig, accelerometers, and a gauss meter in a brace-like component. Sensors assist with the computation of step tally, swing time, moving speed, and pressing factor. BLE transfers the information which is caught to a cell phone for perception and preparation. Security and Privacy of the clinical data are fundamental parts of Smart Health.

F. Smart Lighting

Central qualities of LED-based light assets permit shading temperature, ghost power, transient balance, spatial dispersion, and polarization, which confer themselves well to different brilliant city applications. Illumination can be demonstrated in a number of ways, one of which is the use of road signs to warn drivers of potential hazards. Altering the brightness of the light throughout the course of time is another typical practice. The authors of Reference [14] planned a reformist calculation to build up lights' power as individuals' inhabitance changes. One really empowering framework for lighting is Visible Light Communication. While considering many compound access arrangements for VLC networks, which are given hereditarily directional sources.

III. OVERVIEW OF MACHINE LEARNING AND DEEP LEARNING

The main goal of machine learning in smart cities is to use data from various sources, such as sensors, cameras, and social media, to make urban systems more intelligent and responsive. For example, machine learning can be used to analyze traffic patterns and optimize the timing of traffic lights to reduce congestion and improve safety. It can also be used to predict and prevent crime, improve waste management, and monitor air and water quality. Machine learning can also be used to create more personalized and efficient urban services.

Researchers have concentrated their efforts on computer models known as "artificial neural networks" (ANNs) for decades. These simulations were motivated by scientifically derived neural networks of the human brain. It is a network of artificial neurons that mimics how natural neurons in the human brain communicate with one another. In order to compute the weights that are shared between layers of neurons, a nonlinear transformation function is used. The weighted sum for each layer is computed using nonlinear activation functions such as tanh, sigmoid, and modified direct unit. To do this, the formula W x + b is used, where W represents the weight vector and b represents a bias (ReLU). Because of the substantial amount of processing work required, ANNs with totally connected layers have not been widely used in a wide range of practical applications. Deep learning models, which are intended to imitate the natural processes that occur within biological creatures, may now be implemented as a result of advances in high-performance computing technologies. Deep neural networks can use tens of thousands of neurons to do a single calculation at each layer of the network due to the incredible parallelism provided by graphics processing units (GPUs). This is made possible by efficiently parallelizing vast volumes of input data.

One of the main applications of deep learning in smart cities is in the area of urban mobility. Deep learning algorithms can be trained on large amounts of data from sensors, GPS devices, and other sources to analyze traffic patterns, predict congestion, and optimize routes for different modes of transportation. This can help reduce travel times, improve air quality, and enhance the overall efficiency of the transportation system. Deep learning can also be used to improve public safety and security in smart cities. By analyzing video footage from surveillance cameras, deep learning algorithms can automatically detect anomalies and alert security personnel to potential

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threats. This can help reduce crime rates and enhance public safety.

A. ML and DL Models for Smart cities

In this section, the popular Machine and Deep Learning models are recognized and discussed in the tables.

1) Support Vector Machine

Support Vector Machine (SVM) is a machine learning algorithm that is being increasingly used in smart cities to solve various problems related to traffic management, energy management, waste management, public safety, and environmental monitoring. SVM is particularly effective in predicting patterns and analyzing large data sets, making it a valuable tool for optimizing city operations and improving the quality of life for residents. In smart cities, SVM is used to predict traffic flow and congestion on roads and highways, optimize energy usage, predict waste generation patterns, and monitor air and water quality. As technology continues to advance, the use of SVM and other machine learning algorithms is likely to become more widespread in smart cities.

Table advances the article and space utilization of machine learning in the intelligent urban communities, where rampheri [15] presented the advancement of remote sensing technology has allowed for a new perspective on GDEs in ecosystems that are changing due to the combined effects of climate change and other types of human activities. Chithaluru [16] In light of the inherent challenges associated with IoT resource management, they developed the Dynamic Clustering Routing (DCR) protocol to address these issues. This protocol employs neuro-fuzzy algorithms to limit the total amount of resources that any one Internet of Things device can consume. The proposed model's results show that neuro-fuzzy logic can be useful for resource management and dynamic clustering in the context of environmentally friendly IoT devices and green applications for smart Arab[17], organized hierarchically with regional and international levels. Nizetic [18] presented the various key conferences for smart city, Environment, Energ, e-health, Engineering Modelling and Decarbonization of build environment. The table 1 presents smart city research applications in various domains.

TABLE I. A VIEW ON DIFFERENT APPLICATION DOMAINS IN SMART CITIES

Literature References	Contributions	Application Domains
Rampheri, M. B. 2023	"Advances have been made in the remote sensing of ecosystems that rely on groundwater in semi-arid environments. "[15]	Water supply
Chithaluru, P. 2023	"The creation of environmentally friendly, long-lasting, Internet-of-Things-based smart cities using a neuro-fuzzy dynamic clustering scheme." [16]	Management and Evaluation of smart cities
Arab, M. B. 2023	"A unified strategy with seven tiers of importance for the use of environmentally friendly technologies in energy management" [17]	Energy
Nižetić, S. 2023	"Future Energy Technology That Is Both Smart and Sustainable" [18]	Health

2) Decision Tree

Decision trees are a machine learning algorithm used in smart cities to analyze and process data related to various urban systems. Decision trees create a tree-like model of decisions and their possible consequences, allowing for the exploration of multiple possible scenarios and outcomes. Decision trees can be used to solve many problems in smart cities, such as predicting traffic flow and congestion, identifying the optimal routes for waste collection and disposal, and analyzing energy usage patterns. For instance, in traffic management, decision trees can be used to predict the likelihood of congestion on certain roads, based on factors such as time of day, weather, and special events. Decision trees can also be used to optimize waste collection routes by analyzing data related to the location and type of waste generated. In energy management, decision trees can be used to identify patterns in energy usage and predict future energy demands, allowing for the optimization of energy production and consumption.

In table 3 Kutyauripo [19] conducted a survey on all the stages of food to assess the applications of AI which are helpful for the better prediction and analysis. Savastano [20] discussed the need of smart mobility solutions and the implementation of digital services for communication in smart cities. Kaginalkar [21] designed a stakeholder analysis to estimate air quality for a smart city air quality data governance ecosystem. Wang [22] proposed a lightning-scale transformation method that has been developed for digital vehicle-to-grid infrastructure with decentralised electrical energy storage.

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TABLE II. A VIEW ON GENERALIZED APPLICATION DOMAINS IN SMART CITIES

Literature References	Contributions	Application Domains
Kutyauripo, I. 2023	"Artificial Intelligence in Agribusiness, the Food Industry, and Other Sectors." [19]	Food
Savastano, M. 2023	"Analysed how advanced are urban transportation options? Investigating how people's perceptions of the value of government services change as they rely more on new forms of information and communication technology." [20]	Businesses
Kaginalkar, A. 2023	"Investigates the participants in the smart city air quality data governance ecosystem." [21]	Air Pollution
Wang,A. 2023	"Space-variable scale scheduling is a method that can be useful for digital platforms that combine distributed electric energy storage and connect automobiles to the grid.." [22]	Urban transport

3) Ensembles, Bayesian, Hybrids and Fuzzy

Ensemble methods, Bayesian networks, Hybrid models, and Fuzzy logic are all machine learning techniques that are used in smart cities to analyze complex data and make predictions or decisions. Ensemble methods combine multiple machine learning models to create a more accurate and reliable prediction

In table 3 Arya [23] Integrates IoT, BIM, and AI into a unified system for automating the monitoring and regulation of eCO2 emissions from existing assets, and validates the solution's viability through an analysis of a real-world use case. A. Luo [24] invented double frequency-up conversion for use in vibration energy harvesters (VEH). This method converts energy from extremely low frequency vibrations into usable power (FUC). Wang's comprehensive framework includes building attributes, building geometry, and urban morphology, allowing for the prediction of energy consumption and greenhouse gas emissions. Characteristics of buildings, building geometry, and urban morphology are all accounted for in Zang [25] framework. Beheshtikhoo [26] designed smart home energy by combining electric vehicle and renewable energy using type-2 fuzzy logic. Finally, Han [27] created and presented a vision system for detecting white blood cells (WBCs) and a one-stage, lightweight convolutional neural network (CNN) detector with an attention mechanism for recognizing very small WBC images to enhance the precision and efficacy of diagnostic procedures.

TABLE III. A VIEW ON AVAILABLE DESIGNING AND DEVELOPMENT APPLICATION IN SMART CITIES

Literature References	Contributions	Application Domains
Arva, A. 2023	"Combining Machine Learning and a Digital Twin for Real-Time Predictive Monitoring of CO2 Emissions from Existing Buildings." [23]	Management and Evaluation of smart cities
A Luo 2023	"Vibration energy harvesters with a two-stage frequency-up conversion mechanism allow for the autonomous operation of smart city sensing systems..." [24]	Energy
Zhang, Y. 2023	"Estimating a structure's energy use and GHG emissions using data and interpretable machine learning." [25]	Management and Evaluation of smart cities
Beheshtikhoo, A. 2023	"Building a smart home energy management system that includes renewable energy sources and electric vehicles using type-2 fuzzy logic." [26]	Management and Evaluation of smart cities
Han, Z. 2023	"CNN detection method that is one-stage and lightweight Application to WBC detection in microscopic images" [27]	Health

4) Artificial Neural Networks in Smart Cities

Machine learning algorithms based on the structure and function of the human brain are called Artificial Neural Networks (ANNs). An ANN's primary function in a smart city is to sift through mountains of data on urban infrastructure and come to some sort of conclusion or forecast. ANNs have several applications in smart cities, including but not limited to traffic management, energy management, trash management, and public safety. The table 4 presents research applications of the eco-friendly for smart cities

TABLE IV. A VIEW ON ECO-FRIENDLY APPLICATION FOR SMART CITIES

Literature References	Contributions	Application Domains
Li, W. 2023	"Used the energy system transition model as a case study to explore the ramifications of several scenarios for the future course of carbon emissions in Sichuan Province." [28]	Energy
Rendón-Segador, F. J. 2023	"The goal of the CrimeNet system is to identify violent events through the use of Neural Structured Learning and the Vision Transformer." [29]	Security
Zhou, D. 2023	"Deep learning with several agents for scalable perimeter metering of metropolitan networks" [30]	Urban Transport
Chithaluru, P. 2023	"Smart cities that use IoT and are also good for the environment and can last will need a new way to group things	Energy

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	together that takes energy efficiency into account." [31]	
Mohapatra, S., 2023	"Impact of Predictive Analytics and IoT on Healthcare" [32]	Healthcare
Gupta, P. 2023	"Used deep learning for predictive purposes in health care while also utilising edge computing." [33]	Healthcare
Sapnken, F. E. 2023	"Techniques of machine learning are utilised by the algorithms during the planning phase of a project in order to make predictions regarding the amount of energy that will be required to keep a structure operational." [34]	Management and Evaluation of Smart cities

IV. NATIONAL AND INTERNATIONAL PROJECTS ON SMART CITIES

TABLE V. A VIEW ON ECO-FRIENDLY APPLICATION FOR SMART CITIES

Criteria	Indian Projects	International Projects
Country/Region	India	Europe, United States, Japan, Canada, etc.
Scope and Objectives	Develop smart cities using AI and IoT to enhance urban infrastructure, energy efficiency, citizen services, etc.	Promote sustainable urban development using AI and IoT technologies for energy efficiency, transportation, etc.
Technologies and Solutions	IoT, AI, big data analytics, cloud computing, etc.	IoT, AI, smart sensors, blockchain, etc.
Key Features and Benefits	Improved urban planning, traffic management, public safety and environmental protection, citizen engagement, etc.	Reduced carbon emissions, enhanced quality of life, etc.
Funding Sources and Budget	National and local governments, private sector, etc.	European Union, United Nations, public-private partnerships, etc.
Timeline and Progress	Varies by project	Varies by project
Challenges and Opportunities	Technology adoption, interoperability, data privacy, etc.	Scaling and replicating successful models, standardization, etc.

A. National Projects

India has several ongoing AI and IoT projects on smart cities. Here are some of the notable ones:

1) Smart City Mission

In 2015, the government of India embarked on a programme called the Smart City Mission, with the goal of creating 100 "smart cities" across the country. Project aims to make Indian cities citizen-friendly and sustainable by using technology and data analytics. The initiative has resulted in the implementation of various projects such as intelligent transport systems, smart parking systems, and smart waste management systems [35].

2) Pune Smart City

The Pune Smart City project is a collaboration between the Pune Municipal Corporation and private partners. The project aims to make Pune a smart and sustainable city by using IoT sensors and data analytics. The project includes the implementation of a city operations center, smart street lighting, and intelligent transport systems [36].

3) Surat Smart City

The Surat Smart City project is another initiative under the Smart City Mission. The project aims to use technology to improve the quality of life for the citizens of Surat. The project includes the implementation of smart water management systems, intelligent transport systems, and a city operations center [37].

4) Hyderabad City Wi-Fi Project

The goal of the Hyderabad City Wi-Fi project is to make Wi-Fi service available for no cost in public places including parks and transportation hubs. The project is a collaboration between the government of Telangana and private partners. The project includes the installation of Wi-Fi hotspots and the use of data analytics to optimize network performance [38].

5) Intelligent Transport System, Ahmedabad

The Intelligent Transport System (ITS) project in Ahmedabad aims to use technology to improve the efficiency and safety of the city's public transport system. The project includes the implementation of a city-wide GPS-based vehicle tracking system, electronic ticketing, and real-time passenger information systems [39].

B. International Projects

Here are some of the notable ones and ongoing AI and IoT international projects on smart cities.

1) Smart Dubai

Dubai's Smart initiative is a city-wide push to make the city more technologically advanced through the use of cutting-edge tools like artificial intelligence and the internet of things. The project aims to enhance the quality of life for residents, visitors, and businesses in the city by using smart technologies to provide efficient and seamless services [40].

2) City Brain in Hangzhou, China

City Brain is an AI and IoT-based project implemented in Hangzhou, China. It is a city management platform that uses real-time data to optimize traffic flow, emergency responses, and public services. The project uses advanced AI

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algorithms to analyze and predict traffic patterns, which can help city officials to better plan for future development [41].

3) Amsterdam Smart City, Netherlands

Amsterdam Smart City is an initiative that aims to create a more sustainable, livable, and connected city through the use of advanced technologies such as AI and IoT. The project focuses on five key areas: mobility, energy, circularity, digital city, and social city. It brings together various stakeholders, including the government, businesses, and residents, to create a collaborative and innovative smart city ecosystem [42].

4) Smart City Barcelona, Spain

Using cutting-edge technology like AI and the Internet of Things, "Smart City Barcelona" aims to improve the standard of living in the city. The project focuses on a range of areas, including mobility, energy, open data, and citizen participation. It has implemented several smart city solutions, such as a real-time parking management system and a smart lighting system [43].

5) Songdo International Business District, South Korea

A South Korean smart city project, Songdo International Business District is designed and constructed with the latest in technological advances in mind. It is designed to be a sustainable, eco-friendly, and connected city that uses advanced technologies such as AI and IoT to enhance the quality of life for residents. The project has implemented several smart solutions, including an automated waste management system and a smart transportation system [44].

6) Smart Nation Singapore

Smart Nation Singapore is an initiative that aims to leverage the latest technologies such as AI and IoT to create a more connected, efficient, and sustainable city. The project focuses on a range of areas, including transportation, healthcare, and public services. It has implemented several smart city solutions, such as a national digital identity system and a smart transportation system [45].

V. USE CASES OF SMART CITY USING AI

A. Education and Learning

Smart cities are incorporating AI-powered technologies to improve the quality of education and learning experience for students, teachers, and other stakeholders. Here are a few examples:

1) Personalized Learning

AI algorithms are being used to analyze students' learning patterns, interests, and abilities to create personalized learning experiences. This can help students learn at their own pace, reinforce learning, and ultimately achieve better outcomes.

2) Predictive Analytics

Smart cities are using predictive analytics to identify students who may be at risk of dropping out, falling behind, or experiencing other academic difficulties. This can help educators intervene early and provide targeted support to ensure students' success.

3) Virtual Learning

AI-powered virtual learning platforms are being developed to provide students with access to high-quality education, regardless of their physical location. These platforms use advanced technologies such as virtual reality, augmented reality, and natural language processing to create immersive and engaging learning experiences.

4) Public Safety and Security

Smart cities can leverage AI to improve public safety and security. One example of a use case for smart cities in this domain is the implementation of intelligent video surveillance systems. These systems use AI algorithms to analyze video footage from security cameras in real-time, detecting anomalies or suspicious behavior that may indicate criminal activity or potential security threats. Another use case for smart cities in public safety and security is the use of predictive policing algorithms, which use machine learning to analyze crime data and identify patterns that can help law enforcement agencies to allocate their resources more effectively. This approach can help to reduce crime rates and improve public safety. Smart cities can also use AI-powered emergency response systems, which can detect emergencies and automatically alert first responders. These systems use a combination of sensors, machine learning algorithms, and real-time data analysis to identify potential emergencies, such as fires, floods, or traffic accidents, and notify the relevant authorities immediately.

Additionally, smart cities can use AI to improve transportation safety. For example, AI-powered traffic management systems can help to reduce the risk of accidents by analyzing traffic patterns and identifying potential hazards. These systems can also help to optimize traffic flow and reduce congestion, which can have a positive impact on public safety and quality of life.

5) Tourism and Hospitality

Smart city technology can also be used to enhance tourism and hospitality. With AI-based solutions, cities can offer personalized recommendations to tourists, including suggesting the best local attractions and events, based on their interests and preferences. Smart tourism kiosks and

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mobile apps can provide visitors with real-time information about local events, transportation, and activities. Smart cities can also use AI-powered security and surveillance systems to ensure public safety in tourist areas and monitor crowds during large events. Additionally, smart city technology can be used to manage and optimize hotel and restaurant operations, from automating room service requests to predicting demand for specific dishes at restaurants.

6) Urban Planning and Design

Smart cities can leverage AI to improve urban planning and design. With AI, it is possible to predict urban growth and make plans accordingly. By analyzing data from sensors, cameras, and other sources, AI algorithms can detect patterns and make predictions about future growth and development.

One use case for smart cities in urban planning and design is the use of AI-powered simulation models. These models allow city planners and designers to visualize different scenarios and make informed decisions based on data. For example, AI can be used to simulate the impact of new buildings on traffic flow or the environment. Another use case is the use of AI to optimize transportation systems. Smart cities can use AI to analyze traffic patterns and optimize traffic flow. By using real-time data, AI algorithms can recommend alternate routes, change traffic signals, and manage traffic in a more efficient manner. AI can also be used to design more sustainable and eco-friendly cities. By analyzing data on energy consumption and emissions, AI can help city planners identify areas where improvements can be made.

VI. SMART CITY SENSORS USING AI

TABLE VI. A VIEW ON VARIOUS SENSORS FOR SMART CITIES

Sensor Type	Estimated Cost Range	Description
Traffic Sensors	$500 - $5,000	Used to monitor traffic flow, speed, and congestion
Air Quality Sensors	$50 - $500	Used to monitor air quality and collect data on pollutants such as nitrogen dioxide, ozone, and particulate matter
Energy Sensors	$50 - $500	Used to monitor energy usage in buildings and public spaces
Waste Management Sensors	$200 - $2,000	Used to monitor the volume of waste in bins and containers
Noise Sensors	$50 - $500	Used to monitor noise levels in urban areas
Water Quality Sensors	$100 - $1,000	Used to monitor the quality of drinking water and wastewater
Parking Sensors	$100 - $1,000	Used to monitor the availability of parking spaces in urban areas
Public Safety Sensors	$500 - $5,000	Used to monitor crime rates and other safety-related issues in urban areas
Temperature Sensors	$50 - $500	Used to monitor temperature levels in urban areas
Pedestrian Sensors	$100 - $1,000	Used to monitor pedestrian traffic in urban areas

VII. RESEARCH GAP AND CHALLENGES

In smart cities, various types of assets collaborate and coordinate to provide a wide range of benefits. As a result, finding a solution that is both workable and fulfilling will be difficult.

A. Several sources and destinations

Cities that use smart technology are more like complex networks, with many nodes and many potential recipients. In the past, routing algorithms were mostly used to find the fastest and most direct way from one point in a network to another. However, with advances in technology and growing demands, it has become necessary to consider several sources and destinations. Before designing a routing approach, it is important to consider the issues of information flooding and packet collision. To discover the best possible routes, a table of all available routes is created and updated at different times. This information is then broadcasted to all nodes so that they are aware of the feasible routes.

B. Availability

To meet the demands for data processing in a smart city, fast, reliable, and efficient record yields are necessary. While resources are abundant, they are often underutilized. It's crucial to minimize the time between the arrival of data and its extraction to extract its value. Achieving this kind of millisecond processing requires a system and approach that can deliver cost-efficient results and timely. Effective routing techniques should utilize resources, and all nodes in the network should know their availability. An effective scheduling mechanism must be employed to regulate the sensor nodes' working phases.

C. Location-dependence

In certain scenarios, it may be necessary to keep the location and identity of data senders anonymous, while in others, it is important to have location awareness for all nodes. When it comes to Location Based Dependence, citizens are directed to nearby resources based on their location. This is typically determined through the use of mobile phone networks [89] or GPS. Since there is a close relationship between the location of the sensor node and the collected data, employing a location-based protocol for effective routing management makes perfect sense. One way to do this is by tracking and using location data from the immediate area.

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D. Security

Smart cities are susceptible to spams due to their constantly changing structure, making it important to ensure that contents originate from trustworthy sources. The routing protocol employed should be able to effectively handle various types of attacks, even though no protocol can guarantee complete security from such attacks. As nodes are deployed in a vast environment, security is a crucial concern. Additionally, due to the limited storage capacity of nodes, advanced cryptographic approaches are not feasible, and therefore, a lightweight validation mechanism is recommended.

E. Scalability

The Quality of Service (QoS) should not be affected by the limited storage, bandwidth, and computational capabilities. The creation of scalable routing protocols is complicated by a combination of factors, including the sheer number of nodes and their density. After something has occurred, the nodes should be reset to their initial, best state. A suitable routing approach should be adaptable and flexible to changes in the network configuration. Hierarchical routing protocols that follow a hierarchical structure are more energy efficient.

VIII.CONCLUSION

Artificial intelligence is expected to be widely used to connect billions of devices soon. artificial intelligence (AI) technologies are playing a critical role in advancing the entire smart city strategy to comprehend the concept of a smart city. It is essential to evaluate how new technology and perceptions such as AI will benefit Smart Cities. This research examines the need for and role of AI in advancing Smart Cities. The main goal of this study is to collect existing experiences from around the world to drive more effective AI use in smart cities. This study explored several technologies deployed in AI-based smart cities, as well as effective incentives. As AI's success can open offers wider opportunities for smart cities, the most detailed analysis on AI in smart cities has been presented, with potential applications studied. In the future the utilisation of technological advancements, algorithmic processes, and artificial intelligence, all of which have the capacity to learn and the ability to automate tasks, will be of great assistance in the process of decision-making and problem-solving in smart cities.

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