A Survey on Smart City Applications

 Using AI

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## ABSTRACT

The world’s population residing in cities is expected to rise to 80% by 2050, from 55% in 2022(Word Economic Forum). According to (United Nations World Population Prospects 2022) world’s population is projected to reach 8 billion on 15 November 2022 and latest projections suggest that the population could grow to 8.5 billion by 2030, 9.5 billion in 2050 and 10.4 billion in 2100. Cities are going to be overcrowded, to tackle this problem and make them more comfortable and to adjust the projected population in the city and giving them a better lifestyle requires proper planning for infrastructure and its implementation. Modern problems like traffic congestion, sewage problems, noise pollution and many more. To overcome these modern problems, we can use modern technologies such as enabling Artificial Intelligence (AI), Machine learning (ML) and Internet of Things (IOT) to bring smart solutions. Smart cities are the solution to all these problems. Smart transportation, education, healthcare, and energy sectors in the smart cities have more significant influence on AI adoption.

**Keywords**—Artificial intelligence (AI); Smart cities; Automation; Sustainability.

## I. INTRODUCTION

A City is defined as a large human settlement where majority of the population residing in that area are basically not indulged in agriculture as their main occupation [1]. City is a permanent and heavily populated region with the modern amenities like airport, roads, bridges, multiplex, malls, trains, metro, public transportation, public parks, water supply and electricity. The world’s population residing in cities is expected to rise to 80% by 2050, from 55% in 2022(Word Economic Forum) . The rate at which urbanization is taking place will surely influence on the environment, management, healthcare, education, energy and security. In order to prevent overcrowding and high pressure on the existing infrastructure, we need to build new infrastructure/add existing infrastructure with the modern technologies such as Artificial Intelligence (AI), Machine Learning (ML) and Internet of Things (IOT). The modern technologies can be implemented in each and every sector like healthcare, education, transportation, security and energy. Various technologies used in modern smart cities help in achieving long-term socio-economic goals and prospects. Scientometric analysis shows that AI has been used in smart cities [2]. Furthermore, it has been used by underdeveloped countries to achieve United Nations Sustainable Development Goals [3]. AI will surely help in giving modern solutions to overcome the problems. AI will cater the purpose to reduce road congestion, more adequate water, reducing noise and pollutions. By 2025, AI will allow over 30% of smart city applications including transportation solutions considerably adding sustainability, social welfare, resilience and vitality to urban life [4].

**II. LITRATURE**

## A. Emerging smart cities

 Smart city is basically defined as a modern urban area that uses information and communication technologies (ICT) to increase operational efficiency, share information with the public [5]. Smart literally implies nothing in ICT but due to its popularity Smart word is used as a synonym for everything nearly intelligent. Basically, people’s definition for the word smart is something which performs its function just on a few commands/touches by individual [6]. Smart cities help its citizens to do things quickly and more efficiently, it helps to reduce time and makes it easier and faster for ordinary citizens. In transportation intelligent monitoring (IMS) system built through sensors can monitor vehicles and can generate penalties on vehicles for violating rules, can calculate traffic volume and regulate traffic signal durations to clear traffic jams. In security IMS is used in intelligent alarm devices which are placed at corresponding positions of the streets, if anyone feels threatened then they can go to the nearest alarm. This system is also used in cabs and other public transports. Coming to architectural aspects, we can use AI for face recognition and voice recognition and to collect data in smart buildings, comfort level of buildings is improved by combining architecture with 5G and 3D modelling to form an intelligent building. In healthcare it is used in diagnosing and storing data of the patient and keeping track of patient’s previous encounter with diseases so as to make it convenient for doctor to diagnose better and treat the patient. Governments can keep the track of the citizens who have paid tax or not and it helps in smoother administration and governance. Smart garbage trucks which can pick the garbage without the help of human and segregating the waste in dry, wet and plastic, thereby reducing a lot of man-work.

## B. Artificial Intelligence (AI)

 **“The science and engineering of making intelligent machines”** [7]. Artificial intelligence [8] term was coined by a computer scientist named john McCarthy in the year 1979. Artificial intelligence (AI) basically is defined as the capability of machines/systems to mimic human intelligence to perform tasks and iteratively improve themselves based on data collected. Total of 37% of organizations have implemented AI in some form and the percentage of Enterprises implementing AI has grown to 270% in past four years (As Per Garton). It is roughly estimated that by 2025 customer interactions will be powered by AI (Servion’s Global Solutions). Recently, it has been estimated that the market value of AI will expand at compound annual growth rate (CAGR) of 39.4% reaching USD 422.37 Billion by 2028, currently AI market was valued at USD 59.67 Billion (2022). North America had a share of 41% in the global AI market during 2021. Markets of AI in Asia–pacific is expected to grow at a higher CAGR in the projected period of 2022 to 2028, the use AI services in healthcare, manufacturing, and automotive sectors by the nations like Japan, China, Australia will fuel this expansion. Smart city initiatives are proposed in many countries. The Smart cities are majorly backed by AI based

Smart applications to help in user friendly interaction and easy the process. China owns the largest number of smart cities in the world approximately 800 smart cities which more than half of smart cities worldwide [9]. China manages its smart cities and public space by using metering devices, embedded sensors, cameras, other monitoring technologies, data mining, processing and AI based techniques. AI technologies implemented in smart cities will improve the quality of life and efficiency.

## III. ADOPTION OF ARTIFICIAL INTELLIGENCE IN SMART CITIES

To Achieve sustainable development goals [10] as well as new urban agenda smart city should blend with AI assuring incorporation of essential aspects such as culture metabolism and governance use of block chain in smart city will signify significantly improved the urban administration when combined with AI, ml, IoT collecting of data and storing [11] using device setup devices and sensors is necessary for better analysis in urban administration a will be used to conduct advance investigations on the data collected with the advancement of AI government are able to predict the air quality and also help to monitor environmental hazards [12]. An overview of adoption of artificial intelligence in smart cities is shown in Figure 1.


**Figure 1: Adoption of AI in Smart City**

## A. AI in Smart energy

 The use of electronic gadgets and other smart appliances by almost everyone has increased the demand of energy requirement. Energy has become crucial for the world in this era, energy is so much important for development and progress as most of the gadgets used are powered by energy. The shifting of hydrocarbons-based fuel vehicles to electric vehicles has increased at a very rapid rate. To cater the energy needs for the ever-increasing population in cities, we need to develop smart energy models by inclusion of AI into traditional energy. Accurate electric load predicting helps in development of fully automated smart energy grids [13]. The assessing of uncertainty in short term electrical demand estimates is done using DL and gradient tree boosting approaches. Algorithms like ANN, SVM, Decision tree and other statistical algorithms are used to train energy consumption prediction model as its AI-Based energy forecasting are very crucial as they help in forecasting the energy requirements in a smart city [14].

## B. AI in smart agriculture

As the population increases, so does the need for food and jobs. Farmers have been unable to meet these goals due to traditional farming practices. With the help of AI, new automated techniques have been invented and applied to agriculture. The Internet of Things has developed into a suitable approach for agriculture automation and decision-making, thanks to the rapid development of wireless sensor networks (WSNs). Furthermore, [15][16][17] have investigated sensor-based AI techniques in smart agriculture. Sensor-based expert systems [17] have been developed to determine the suitability of agricultural land. A combination of sensor networks with ANN and MLP AI algorithms has been used in this assessment. A proposal by [16] has developed an AI-enabled in situ sensing system that allows continuous monitoring and forecasting of plant leaf growth. In the proposed methodology, they used an LSTM recurrent neural network (RNN) as the AI core. To boost general agricultural output, agrobots may be deployed by planting natural seeds in the soil.

## C. AI in smart healthcare

 Many traditional cities are attempting to imitate the notion of smart city healthcare by combining medical resources with AI-integrated technology. A smart city healthcare infrastructure enables e-health, so the two are connected. AI-integrated IoT has had a significant impact on healthcare systems.

[18] have modelled a disease detection system for diabetes and cardiovascular diseases using AI and IoT convergence approaches. The CSOLSTM model was used to detect illness. Healthcare data was used to assess the performance of the CSO-LSTM model. The CSO-LSTM model was tested to detect heart disease and diabetes, achieving accuracies of 96.16% and 97.26%, respectively. They also proposed AI and cloud-based IoT, with CNN analysing medical imagery and making disease predictions.

The authors of [33], Have devised Digital Image Processing technique to identify abnormalities in cells, a comprehensive ML technique reads the features in the cervix cell. KNN and SVM are trained with the features and shape of the segmented cell and compared with unknown cervix cell sample with this technique. The accuracy rate of 86% for SVM and 70% for GLCM was achieved.

## D. AI for security

As the population of the smart city grows, security concerns may become more prevalent.

AI-based systems to predict or detect crime, violence, and other security incidents in smart cities. researchers such as [19] have presented AI-based safety precaution procedures for the early detection of hazards, disasters, and environmental causes.

System based on DRL and ANN to recognize and investigate any illegal behaviour accurately such as Convolutional models for detecting firearms in surveillance footage [20]. and

Black Networks and AI can be used to protect IoT-enabled smart cities against cyberattacks, according to [21]. This structure provides AI-enabled management solutions to be deployed both near the IoT edge and in Big Data collections, leveraging localized data.

E. **AI** **for environment and waste management**

The problem of smart cities solving environmental issues and waste management in particular is an important issue that needs to be addressed. Trash generation has increased as urbanisation, population growth, and economic development have risen across the world, according to World Bank data [22]

[23] have discussed the utilization of AI to address environmental challenges such as pollution control. Surface water quality has been monitored and assessed by artificial intelligence in [24] . Some researchers have utilized AI-based approaches for waste management in smart cities. [25] used a CNN ensemble model based on dual image processing to categorize reverse vending machine rubbish. Gabor wavelet transformation (GWT) [26] was used to categorize solid waste by convoluting images with Gabor wavelet kernels of various sizes and orientations.

ML models have been developed, including the MLP and ML-CNN algorithms.[27] used an MLP to predict hospital solid waste generation. In 2014,[28] developed a model to estimate solid waste generation and reduce the cost of solid trash collection and transportation. A construction and demolition waste forecasting system were developed by [29] to estimate the amount of each component in such waste. [30] developed SVM and WT-SVM for solid waste generation forecasting using wavelet transform and SVM.

F. **AI for Smart Education**

AI applications are common in Smart Education sector, Education plays a vital role in the development of any country. smart education based on AI applications will also play a big role in development of education field in smart cities . History of smart education initiative taken in different countries like Malaysia (1997), Singapore(2006), Finland(2011), Australia with the help of IBM(2012), South Korea(2012) and North America(2014).

The approach of smart devices-based o intelligent technologies is the link to the smart learning.[31] engaged long term in robotics AI education. The Robobo smart cities educational framework was built around 2 primary components: 1) Robobo, it is a smartphone controlled robot 2) real life smart city model.

G. **AI in Smart Homes**

The developments were a bit more complicated; the machine learning and AI technologies made it easier for simple home technological advancements like air conditional controlling and saving energy, using Alexa devices which have made good internet access and can do many works at just a command [32].

This has been eliminating humans from their job and replacing them with new automation technology even at home and industrial level to cause the end of labour this would let us to the new industrial revolution.

H. **AI in Logistics and Mobility**

The rise in the number of automobiles on the road and the growing population causes transportation, traffic, and logistical problems in most big cities. To design and manage a sustainable transportation system, technology could be enormously beneficial. The Personal Rapid Transit system developed by [34] uses AI. Intelligent transportation systems, also known as ITSs, are systems that incorporate control systems, sensors, actuators, and ICTs that generate a lot of data and influence the evolution of future transportation in smart cities. To properly monitor and estimate real-time data on road traffic flow in urban settings that are crucial to the future of smart transportation systems, ML, AI, and DL techniques are important. The future of intelligent public transit will be significantly influenced by AI.

Intelligent transportation systems, also known as ITS, is a blend of control, sensor, and actuator technologies that generates huge quantities of data and significantly influences the future of transportation in a smart city. In order to monitor and estimate real-time data about road traffic flow in an urban setting, which is a critical component of a future of smart transportation systems, ML, AI, and DRL techniques are crucial. A strategy for leveraging AI in intelligent public transit, traffic control, manufacturing, safety management, and logistics has been outlined by [35]. [36] used deep NLP techniques to investigate employee motivation in a logistics company.

AI-based vehicle traffic prediction, driving and routing applications have been A special issue of a journal which has been dedicated to discussions about AI-driven traffic prediction, driving, and routing applications. [37] developed a novel DL-based GSTGCN model that predicts urban traffic speeds. The method relies on three spatial-temporal components and a supplementary component. The model estimates vehicular traffic flows for a given week and time period. A novel generative deep learning architecture was used to create ‘Traffic-Wave’, a time-flow analysis system [38],[39] created an LSTM network-based traffic prediction model. Furthermore, [38] have presented a summary of AI-based traffic technologies that allow for road vehicle automation and intelligent traffic control.

## IV. CONCLUSION

We discussed the adoption of AI in the major domains of smart cities such as healthcare, education, environment, waste management, mobility, smart transportation, agriculture, risk management, and security. It has been concluded that cities can benefit from the use of AI in smart cities by automating operations, reducing human error, making data-driven decisions, improving the environment by implementing new commercial possibilities, and automating efficient urban management. Regulatory challenges, such as service delivery discrimination, privacy issues, legal and ethical considerations, and lack of qualified professionals, have been identified as obstacles. Furthermore, data availability, unemployment rates, cost, and duration of AI initiatives, and a high unemployment rate have all been recognized as risks and barriers to AI implementation in smart cities. According to the study, ANN, RNN/LSTM, CNN/R-CNN, DNN, and SVM/LS-SVM AI algorithms are having a significant impact on the smart city sectors. To attenuate strain on local resources and enhance governance and services, smart cities are being developed using AI technology.  The modern educational system has evolved to include e-learning platforms, which allow people to learn via the internet. Researchers are still conducting numerous studies to manage traffic in cities, including mobility and transportation systems. To protect citizens, AI is now entering the security sector, thanks to the development of many IoT-enabled devices. AI is rapidly developing as intelligence systems for cyber security are made. With the arrival of IoT-based platforms, intelligence systems for cyber security are developing at a rapid pace. In addition to AI, Blockchain, Virtual reality/Augmented reality, IoT, and 3D printing are five key disruptive technologies driving the smart city forward. Smart city initiatives can assist governments and service providers in optimizing data exchanges and information flow.

## V. FUTURE DIRECTION

In the future, we can examine how traditional city layouts are transformed into sustainable smart cities that implement AI and big data. Future study can focus on further disruptive technologies based on AI technologies described in this article, such as gamification, virtual and augmented reality, wearable technology, 3D printing, social robots, and so on.

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