AI on Smart City Technologies

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As the global population grows, and urbanization becomes more prevalent, cities often struggle to provide convenient, secure, and sustainable lifestyles due to the lack of necessary smart technologies. Fortunately, the Internet of Things (IoT) has emerged as a solution to this challenge by connecting physical objects using electronics, sensors, software, and communication networks. This has transformed smart city infrastructures, introducing various technologies that enhance sustainability, productivity, and comfort for urban dwellers. By leveraging Artificial Intelligence (AI) to analyze the vast amount of IoT data available, new opportunities are emerging to design and manage futuristic smart cities.

smart city communication technology IoT 5G AI

1. Introduction

Artificial Intelligence (AI) can revolutionize the technology used in smart cities by facilitating instant analysis of vast amounts of data received from various sources, including sensors, cameras, and IoT devices. AI optimizes and streams various city systems and processes, including transportation, energy, public safety, health care, education, and more [1]. No specific number of AI algorithms can be used in a smart city. The choice of algorithms would depend on the smart city's specific use cases and requirements. Several commonly used artificial intelligence (AI) algorithms exist in smart cities [2]. Some of the most important ones are explained in the subsequent sections.

2. AI Algorithms in Smart Cities

Various AI algorithms can be used in smart cities to improve efficiency, sustainability, and quality of life. Some of the primarily used AI algorithms are discussed in the subsequent sections.

2.1. Machine Learning (ML)

The utilization of ML algorithm [3][4] involves mathematical guidelines that facilitate machines to learn from data and enhance their performance in a particular task without being explicitly programmed. This type of AI empowers machines to identify patterns and make predictions using input data. The ML algorithms comprise supervised learning, unsupervised learning, reinforcement learning, and deep learning, each with advantages and disadvantages, and can be applied to diverse domains, including image and speech recognition, as well as predictive analytics [5][6]. ML algorithms can be utilized in smart cities to examine data and create projections based on patterns and trends humans can discern [7]. These algorithms can optimize resource allocation, improve urban planning, and enhance public safety, among other things. These algorithms can also predict traffic flow, analyze energy consumption patterns, and predict crime hotspots. ML can be used for various applications in smart cities, such as traffic management, energy optimization, and waste management.

2.2. Deep Learning (DL)

DL refers to a category of ML that employs artificial neural networks to address intricate problems by acquiring knowledge from data. DL models have multiple layers of interconnected nodes that process specific aspects of the input data and pass it on to the next layer [8][9]. This enables them to acquire a hierarchical understanding of the data, detecting intricate patterns and characteristics. Widely used DL structures comprise convolutional neural networks (CNNs), deep belief networks (DBNs), and recurrent neural networks (RNNs). DL can be applied in smart city scenarios to optimize traffic flow by predicting traffic patterns and tracking vehicles and pedestrians using real-time analysis of traffic camera feeds. It can also predict energy demand, identify energy-efficient building settings, optimize waste collection, and reduce landfill waste using data from sensors and cameras [10][11]. DL can also detect and respond to safety threats using data from surveillance cameras and improve the ability of autonomous vehicles to detect and respond to objects and obstacles [12]. While DL models demand significant data and computational resources, their implementation can enhance the efficiency, sustainability, and safety of smart cities for the inhabitants.

2.3. Natural Language Processing (NLP)

The subfield of AI, known as NLP, focuses on using natural language to facilitate communication and interaction between humans and computers [13][14]. It is a field of computer science that aims to enable computers to comprehend and produce human language, both in spoken and written forms. NLP algorithms are specifically developed to process and analyze vast amounts of natural language data, including texts, speech, and even emojis, with the ability to carry out various tasks such as sentiment analysis, language translation, speech recognition, and text summarization [14]. NLP has multiple applications in smart cities. For instance, it can be used to power chatbots and virtual assistants to handle customer service, analyze social media data and other text-based sources to identify potential safety threats, analyze public opinion on various urban planning initiatives, provide multilingual support, and analyze social media data to identify traffic issues and provide real-time updates to drivers [15][16]. NLP has the potential to make smart cities more efficient, effective, and responsive to the needs of residents by reducing the workload of human customer service representatives, improving the overall customer experience, improving traffic flow, and helping city planners make more informed decisions [17][18].

2.4. Computer Vision (CV)

In AI, CV algorithms encompass a range of mathematical and computational techniques that empower machines to analyze and comprehend visual data obtained from their surroundings [19][20][21]. These algorithms can recognize patterns and features in images, videos, and other visual data and use that information to make decisions and predictions. CV is a crucial area of research in AI and is used in a wide range of applications, including facial recognition, object detection, image segmentation, and autonomous vehicles. Some of the most commonly used CV algorithms include convolutional neural networks (CNNs), widely used for image and video recognition, and object detection algorithms, which can detect and identify objects in images and videos. Other CV algorithms include feature detection algorithms, which can identify specific visual features in an image, and segmentation algorithms, which can separate an image into different regions or objects. CV algorithms have many smart city applications that can help improve traffic management by analyzing camera feeds and giving real-time updates to drivers, detecting public safety threats through analyzing surveillance camera feeds, optimizing waste collection routes and reducing resources spent, monitoring energy consumption in buildings and identifying areas to promote energy efficiency and understand development patterns and land use in urban planning initiatives through satellite imagery analysis. By automating visual data analysis from various sources, CV algorithms can make smart cities more efficient, safe, and sustainable [22][23][24].

2.5. Reinforcement Learning (RL)

RL is a type of ML that involves an agent learning through trial-and-error interactions with its environment to maximize a cumulative reward signal [25]. The agent takes action in the background, and the environment responds with a positive or negative reward signal, and the agent learns from this feedback. The RL algorithm involves three components: the environment, the agent, and the reward function. RL techniques include value-based, policy-based, and actor-critic methods. RL has been applied in various fields, including game playing, robotics, and autonomous systems. In smart cities, RL can optimize traffic and energy management systems [26][27][28][29]. However, RL can be computationally intensive and requires much data to train.

2.6. Genetic Algorithms (GA)

GAs are optimization algorithms that draw inspiration from the principles of natural selection. These algorithms are frequently employed in AI and ML to tackle complex optimization challenges that traditional methods cannot address [30]. In smart city applications, GAs can optimize many systems and processes, such as traffic, energy, waste, and urban planning. For example, GAs can optimize traffic flow by finding the best timing for traffic lights or the most efficient routes for public transportation. They can also be used to optimize energy consumption in buildings by finding the most efficient settings for heating, ventilation, and air conditioning systems. One potential challenge of using GAs in smart city applications is the computational complexity of the optimization problem [31][32][33]. The problem's size and the fitness function's complexity can make finding an optimal solution in a reasonable amount of time challenging. Therefore, it is essential to carefully design the problem formulation and choose appropriate GA parameters to balance the exploration and exploitation of the solution space.

These are just a few examples, and many more AI algorithms can be used in a smart city depending on the specific needs and goals of the city.

3. Potential Influence of AI on Smart Cities

The impact of AI on smart city technologies is transformative. Implementing artificial intelligence (AI) in urban areas can significantly improve people's quality of life and revolutionize critical aspects of a smart city. According to various sources, including [34][35], AI can positively impact seven major domains: smart mobility, smart governance, smart education, smart economy, smart healthcare, smart environment, and smart living. The following sections are going to elaborate on the potential influence of AI in each of these domains.

3.1. Smart Mobility

Smart mobility involves using advanced technologies and innovative transportation solutions to improve transportation systems, making them more efficient, sustainable, and accessible. This includes integrating digital technologies such as AI, IoT, data analytics, and automation to optimize transportation networks and enhance the mobility of people and goods. By incorporating these technologies, transportation systems can become more efficient, safer, and sustainable. AI and smart mobility have a symbiotic relationship where AI enables smart mobility solutions to operate more effectively and efficiently, particularly in areas such as traffic management, autonomous vehicles, and predictive maintenance. Integrating AI and smart mobility is crucial for improving transportation systems and the mobility of people and goods.

H. Yang et al. [36] proposed a DL model to predict high-resolution traffic speed by combining traffic flow dynamics with topological interdependence. S. Wang et al. [37] introduced a method for traffic signal control that utilizes deep RL and high-resolution event-based data. M. Hassan et al. [38] suggested a congestion-free traffic management approach for smart cities that employs a multi-layer Extreme Learning Machine (ELM) within a DL framework. P. Kaur et al. [39] conducted a methodical review of AI techniques for multi-plate multi-vehicle tracking systems. The review assessed various methods and algorithms employed for vehicle detection, tracking, and recognition, encompassing deep learning-based approaches.

G. Bathla et al. [40] presented an overview of the applications, challenges, and opportunities of autonomous vehicles and intelligent automation. The study argued that autonomous vehicles have the potential to revolutionize transportation by enhancing safety, reducing traffic congestion, and improving mobility for all. Y. Ma et al. [41] provided an overview of validation and verification techniques used for the decision-making and planning of autonomous vehicles. G. Bendiab et al. [42] deliberated on the potential security and privacy risks of the advent of autonomous vehicles (AVs) and emphasized the significance of addressing these concerns to realize the full benefits of Avs. L. Hernandez and A. Castillo [43] examined cloud computing applications in intelligent vehicles and highlighted the advantages of cloud computing, including enhanced storage capacity and computational power, real-time data analysis, and remote access to vehicle data.

For predictive maintenance, C. Yun et al. [44] present an extensive analysis of predictive maintenance in the context of smart city planning. They define predictive analytics as using statistical techniques, ML algorithms, and data mining methods to examine historical and real-time data and make projections for future events and trends. S. Kussl and A. Wald [45] review smart mobility and its implications for road infrastructure provision, emphasizing predictive maintenance and its potential effects on road infrastructure provision.

3.2. Smart Governance

Smart governance is a fundamental aspect of smart cities, which aims to transform traditional governance models by leveraging advanced technologies to provide better services and decision-making processes. With the help of digital technologies such as AI, blockchain, IoT, and data analytics, governments can optimize their operations, streamline decision-making, and provide better services to their citizens. Examples include AI-powered chatbots and virtual assistants, which can automate mundane tasks and respond promptly and precisely to citizen queries. Blockchain can enhance government operations' security, transparency, and traceability, including voting systems, identity management, and supply chain management. IoT sensors within smart cities allow for acquiring real-time information on essential urban factors, including traffic patterns, air quality, and waste management. This abundance of data has the potential to assist governments in making informed decisions and enhancing their services to better cater to the requirements of their constituents. In general, intelligent governance is critical in fostering citizen participation, boosting transparency and accountability, and elevating the quality of life within urban areas.

S. A. A. Bokhari and S. Myeong [46] explored the connections between AI, social innovation (SI), and smart decision-making (SDM) in South Korea and Pakistan. They learned about a favorable and robust mediating effect of SI between the association of AI and SDM, indicating that SI plays a crucial role in AI decision-making. G. V. Pereira et al. [47] reviewed and proposed that smart governance can be regarded as the intelligent utilization of ICT for enhancing decision-making and cooperation between various stakeholders, such as citizens and government. ICT tools, such as social media, can potentially augment citizen engagement and facilitate the establishment of novel governance models for smart government. A. Kankanhalli et al. [48] investigated the potential benefits of employing AI and the Internet of Things (IoT) in smart governance to improve decision-making and provide valuable services in various domains, including transportation, energy, healthcare, education, and public safety.

In a study by M. K. Hasan and colleagues (2019) [49], a blockchain-based Internet of Things (IoT) framework was proposed to address issues of price hikes and corruption in Industry 4.0 and blockchain 5.0. The framework utilized a remote database integrated with blockchain technology, allowing government authorities to monitor transactions between industrial companies and purchasers. Another study by C. van Noordt and G. Misuraca (2020) [50] found that while AI is commonly used to enhance public service delivery and internal management, its use in policy decision-making is still limited.

L. Anthopoulos et al. [51] investigated the relationship between Smart Governance (SG) and Smart City (SC) and examined their significance to scholars in public administration, political science, and information science, as both topics are becoming increasingly popular. Ž. Bojović et al. [52] presented a fresh approach to modelling information systems to assist public administration in the transition from e-government to smart government. To overcome this challenge, the authors proposed using an integration layer for existing databases and services and recommended the application of innovative technologies to facilitate better problem-solving, optimal resource utilization, and policy innovation. Meanwhile, Al-Besher and Kumar A (2020) [53] discussed the challenges governments face in providing e-government services to citizens. They argued that the efficiency and effectiveness of such services could be improved by leveraging AI and IoT technologies. Similarly, Ahn and Chen (2019) [54] suggested that training government employees on AI technologies could enhance their understanding and appreciation of the technology, promoting a culture of innovation and supporting meaningful and sustainable digital transformation.

3.3. Smart Education

Smart education involves the integration of advanced technologies and novel teaching approaches to boost the effectiveness of learning and elevate the standard of education. Its primary objective is to leverage technology to enhance educational quality, promote better student performance, and create an interactive and engaging learning experience that is both efficient and effective. In a smart education system, students have access to customized learning content tailored to their individual needs and abilities, and teachers have access to data-driven insights that help them understand how their students are learning and where they may need additional support. Smart education also involves the integration of various technologies and devices, such as interactive whiteboards, tablets, and educational apps, to create a more dynamic and collaborative learning environment.

According to J. Qu et al. [55], incorporating personalized learning as a significant element can drive educational innovation and development. They propose that integrating AI into education can lead to a new education model, resulting in better learning outcomes. AI education is being developed at different rates in different countries, but there is an increasing demand for AI training and the establishment of platforms to support it. A. Bhutoria [56] conducted a literature review on the application of AI in personalized education and identified key themes that suggest structural modifications to the current education system. In a systematic review of literature conducted between 2019 and 2021, covering China, India, and the USA, over 2000 search results were obtained and filtered down to 353 relevant papers using an NLP model. The review revealed that AI has effectively addressed students' learning needs, habits, and abilities by guiding them through optimized learning paths. In addition, K. Zeeshan et al. [57] have presented a comprehensive overview of the potential applications of IoT in education for school management, teachers, and learners. The authors reviewed recent research on IoT applications in education and discussed how the technology could benefit these three groups.

A. Alam [58] investigated how AI can be applied in education, including adaptive learning, smart campus management, intelligent tutoring robots, teacher evaluation, and virtual classrooms. After assessing the influence of AI technology on education, it has been determined that it has a beneficial impact on both the caliber of teaching delivered by educators and learners' academic achievements. Y.-H. Hu et al. [59] investigated the application of Robotic Process Automation (RPA) and predictive analytics in developing an Intelligent Tutoring Robot (ITR) aimed at students engaged in distance learning. The ITR is designed to provide automated responses to students utilizing NLP, knowledge representation, ML, inference, Rapid Domain Adaptation, and large-scale parallel computing. It also continuously learns and enhances its capabilities. A. Ni and A. Cheung [60] analyzed the implementation of intelligent tutoring systems (ITS) for English language learning in secondary schools in China. The study concluded that the model has significant explanatory power and can be utilized in future research on ITSs in K-12 education.

In their work, W. Yang [61] examined the obstacles and factors that must be considered while creating an AI syllabus for young children in early childhood education. According to the proposed model, the fundamental AI concepts that can be introduced to young children include how AI algorithms can be persistently trained to detect patterns, make predictions, and provide recommendations, despite constraints. J. Su and Y. Zhong [62] proposed three proficiencies crucial for AI literacy: AI Skill, AI Knowledge, and AI Attitude. They suggested that employing a social robot as a learning companion and programmable tool can effectively teach young children the principles of AI. L. Chen et al. [63] conducted a comprehensive evaluation and analysis of the impact of AI on education, with a particular focus on its implementation and effects on administration, instruction, and learning. The findings of the study suggested that AI has the potential to enhance the quality of education and improve student outcomes significantly.

3.4. Smart Economy

In a smart city, the concept of a smart economy involves the integration of advanced technologies and data-driven solutions to create a sustainable and innovative economy. This can include the use of AI and big data analytics to optimize business processes, as well as the implementation of smart payment systems and blockchain technology to enhance financial transactions. Moreover, a smart economy in a smart city can also involve the development of new industries and business models centered around innovation and sustainability, such as green energy, circular economy, and the sharing economy. By leveraging advanced technologies and data-driven solutions, businesses can create new products and services that are more efficient, sustainable, and customer-centric, thereby driving economic growth and competitiveness. In addition, a smart economy can also help promote entrepreneurship and job creation by providing access to training and funding programs and supporting the development of innovation ecosystems that foster collaboration and knowledge sharing among businesses and entrepreneurs. Overall, an innovative economy is a critical component of a smart city, as it enables sustainable economic growth, promotes innovation and entrepreneurship, and enhances citizens' overall quality of life.

The notion and functioning of smart factories are introduced and contrasted with conventional factories by R. Benotsmane et al. [64]. The article emphasized smart factories' economic and social operational prerequisites and effects. A. Aliahmadi et al. [65] proposed a theoretical structure for a sustainable supply chain based on Artificial Intelligence of Things (AIoT) and examined its crucial aspects, constituents, and indicators. The framework applies to various industries and practices, and comprehending its dimensions can assist in its implementation. M. Amiri-Zarandi et al. [66] suggested using a platform approach, which considers six fundamental necessities for smooth integration, handling, and utilization of agricultural data: interoperability, scalability, reliability, end-to-end security and privacy, real-time data processing, and standardized regulations and policies. Implementing a smart farming platform that fulfils these requirements can enhance connected smart farms' productivity, profitability, and overall performance. Y. Zhou et al. [67] examined the utilization of IoT and AI technologies in greenhouse agriculture to enhance productivity and resource management. This approach has proven to be beneficial in meeting the requirements of greenhouse agriculture and fostering innovative agricultural product development practices.

D. Valle-Cruz et al. [68] investigate the potential of implementing AI in public budget allocation to enhance economic, political, and social outcomes. The researchers propose an algorithmic approach utilizing the multilayer perceptron and a multi-objective genetic algorithm to examine World Bank Open Data from 1960 to 2019 across 217 countries. The findings indicate that AI techniques can aid in distributing public spending to increase GDP, decrease inflation, and decrease the Gini index. G. Tran Thi Hoang et al. [69] analyze 76 articles to create a comprehensive map for applying various decision-making methods in different decision and implementation phases. The article recommends that AI could enhance multi-stakeholder involvement in decision-making procedures.

In their study, I. M. D. Andrade and C. Tumelero [70] used data content analysis with Atlas.ti software to analyze how AI can improve customer service efficiency and provide insights on the potential benefits of AI in enhancing customer experience and driving innovation in service processes and the economy. Meanwhile, M. Qin et al. [71] offer valuable insights for AI developers and e-commerce platforms aiming to improve online customer service strategies. Finally, to enhance their resilience and adapt to changing circumstances, companies should consider AI and other emerging technologies, as suggested by P. Agarwal et al. [72], who examined the effects of COVID-19 on these industries and discussed how information technology could be used to implement business strategies to transform businesses and incentivize the implementation of these technologies during emergencies and suggested that companies should consider AI and other emerging technologies to enhance their resilience and adapt to changing circumstances in the future.

3.5. Smart Healthcare

Smart healthcare in a smart city encompasses a range of innovative technologies and solutions that aim to improve access to healthcare services, enhance patient outcomes, and increase the efficiency of healthcare delivery. These technologies include the Internet of Things (IoT), Artificial Intelligence (AI), machine learning, wearables, and telemedicine. Smart healthcare enables patients to receive personalized and real-time care, regardless of location. Patients can access healthcare services remotely through telemedicine and wearable devices, enabling healthcare professionals to monitor their health conditions continuously. Smart healthcare also facilitates collecting and analyzing large amounts of patient data, providing valuable insights into patient health trends and treatment efficacy. Moreover, smart healthcare in a smart city also includes using AI-powered chatbots and virtual assistants that can triage patients, provide medical advice, and schedule appointments, reducing the burden on healthcare professionals and improving the efficiency of healthcare services. Smart healthcare solutions offer immense potential to revolutionize healthcare delivery in a smart city, from improving patient outcomes to reducing healthcare costs and increasing access to healthcare services.

P. Manickam et al. [73] explored the potential for the Internet of Medical Things (IoMT) and point-of-care (POC) devices to improve healthcare in advanced areas such as cardiac measurement, cancer diagnosis, and diabetes management. The review also assessed the significance of AI in improving the functionality, detection accuracy, and decision-making capabilities of IoMT devices while identifying potential risks. J. B. Awotunde et al. [74] suggested a framework based on AIoMT to monitor and diagnose patients and evaluate the model's accuracy.

Integrating AI and IoMT in the healthcare industry can alleviate the burden of medical processes and significantly enhance disease diagnosis, prediction, treatment, screening, and medication. The article by Y. Yang et al. [75] discusses potential research directions in medical research and proposes a smart health management valuable model for decision-makers and healthcare workers in hospitals.

Smart health monitoring systems (SHM) are effective for maintaining a healthy lifestyle amidst busy work schedules. With smart and cost-effective sensors developed through Industry 5.0 and 5G, health monitoring services have become faster, cost-effective, and reliable from remote locations [76]. In a systematic review, Z. F. Khan and S. R. Alotaibi [77] discussed the application of AI and big data analytics in improving the m-health system and proposed a model based on AI and big data analytics for m-health. Their model provides insights to users and enables them to plan and use resources effectively. S. Tian et al. [78] emphasized the potential of AI in drug discovery and its ability to accelerate the process, reduce costs, and improve accuracy. The researchers suggest that AI can transform drug discovery by identifying new drug candidates, predicting their efficacy and toxicity, and optimizing the drug development process. In their study, B. Zhou et al. [79] used NLP techniques to analyze various healthcare domains, such as hospital management, clinical practice, public health, personal care, and drug development. They emphasize the significance of NLP in facilitating smart healthcare and its potential to revolutionize how healthcare is delivered and improve patient outcomes. S. Saif et al. [80] explored the role of the IoT and AI in smart healthcare. They review recent developments in the field, including case studies on drug discovery and predicting chronic diseases such as heart disease and kidney-related ailments using ML and DL techniques.

3.6. Smart Environment

The impact of AI on smart environment in a smart city scenario is significant. AI can help optimize energy usage, reduce waste, and enhance sustainability. For example, artificial intelligence algorithms can monitor and manage energy consumption in buildings, automatically adjusting lighting and temperature based on occupancy patterns, which can lead to significant reductions in energy waste and improved energy efficiency. AI can also help in waste management by predicting waste accumulation, identifying the optimal time for waste collection, and reducing transportation costs. AI can also be utilized for environmental monitoring and conservation. It can help track air and water quality, monitor vegetation changes, and predict natural disasters. Integrating AI and IoT devices makes it possible to create a more comprehensive and real-time picture of the environment, which can aid in environmental management and conservation efforts. AI can transform smart environment solutions in a smart city scenario. By leveraging AI, smart cities can become more sustainable, efficient, and resilient while improving citizens' quality of life. Smart environment refers to using advanced technologies and data-driven solutions to improve natural and built environments' sustainability, efficiency, and resilience.

G. Halhoul Merabet et al. [47] comprehensively examined methods utilizing AI to develop control systems. To reduce energy consumption while maintaining comfortable indoor conditions. L. Li et al. [48] discussed the obstacles encountered when applying AI to enhance energy efficiency and comfort, along with proposed paths for future advancements for research in this area. Their research describes developing and applying A versa-tile AI algorithm with multiple goals that can be implemented in real-world environmental control to quickly and precisely improve the Indoor Air Quality (IAQ), thermal comfort, and energy efficiency of buildings. The results showed a high level of accuracy in predicting outcomes, with over 90% accuracy. Additionally, there was a decrease in air pollution, an increase in thermal comfort, and an average energy savings of 31%, 45%, and 35%, respectively. A. I. Dounis [49] explored the possibility of using AI as a means of designing building automation systems and with an emphasis on the importance of optimizing energy usage, ensuring comfort, promoting good health, and enhancing productivity in residential areas. L. Anthopoulos and V. Kazantzi [50] discussed the increasing attention given to energy efficiency, especially in cities, in response to sustainability and climate change challenges. It highlights the impact of emerging technologies such as blockchain and electricity and suggests analyzing how autonomous vehicles, intelligent building systems, AI, and big data impact the energy system in urban areas. It also proposes a unified evaluation model for determining the energy efficiency of AI and big data. S. Rubab et al. [51] presented a comparative study of these techniques and suggested a comprehensive approach to managing COVID-19 waste, taking into account its potential uses and benefits and outlining both short-term and long-term goals for waste management. A. Shreyas Madhav et al. [52] offered the use of a mobile robot that can identify and segregate ordinary electronic wastes from households. The robot uses a convolutional neural network-based identification system to categorize E-wastes with 96% accuracy.

S. Shukla and S. Hait [53] examined how integrating technologies such as IoT, AI, intelligent transportation systems, and cloud computing could be utilized to establish intelligent waste management practices in smart cities within the current waste management systems. Y. Himeur et al. [54] discussed applying data fusion strategies and AI in evaluating and monitoring the environment, utilizing remote sensing (RS) data and satellite imagery. The discussion culminates in suggestions for future directions and recommendations. K. Bakker [55] discussed introducing a new technique for marine governance and environmental monitoring called AI-enabled, mobile marine protected areas (MMPAs). MMPAs use digital devices to gather information from different sources and employ ML algorithms to analyze the data and swiftly adjust to changes in environmental conditions and disruptions. S. J. Soheli et al. [56] discussed the capacity for enhancing crop production by utilizing an adaptive neuro-fuzzy inference system (ANFIS) and the IoT in a smart, automated greenhouse. The system used sensors to gather real-time data on weather factors such as temperature, humidity, sunlight, and soil moisture. Overall, the system is efficient, cost-effective, and has the potential to improve crop production in the greenhouse significantly.

D. Pamucar et al. [57] discussed the potential impact of Metaverse technologies on the transportation system, highlighted the preparations underway for the transition of transportation into the world of Metaverse, and concluded that Metaverse technologies could revolutionize the transportation system. The assessment framework can help decision-makers prioritize the implementation of sustainable transportation alternatives in the Metaverse. I. Ahmed et al. [58] introduced an intelligent and environmentally conscious theoretical model that uses cloud computing, IoT devices, and AI to handle and acquire essential data. The setup furnished digital data analysis and stores findings in decentralized cloud repositories using blockchain technology to support diverse applications. E. K. Nti et al. [59] discussed that the importance of AI could not be overstated when tackling environmental sustainability problems such as energy, water management, bio-diversity, and transportation. AI models, such as decision support and CV, have been used in transportation. However, it is vital to monitor interventions to enhance environmental sustainability continuously.

3.7. Smart Living

Smart living refers to using advanced technologies and data-driven solutions to enhance living standards, ease of use, and the long-term viability of daily living. W. Li et al. [60] examined the development of smart home studies in the last twenty years, driven by technological advancements such as ICTs, AI, and IoT. IoT is prevalent in creating operational smart homes, yet there is an inadequate exploration of its impact on urban environments and societal concerns. Smart homes have the potential to become a significant contributor towards the realization of smart cities. X. Guo et al. [61] reviewed and aimed to comprehend the direction of smart home advancements and merchandise and the correlation between literature and AI-enabled products in smart homes. D. N. Mekuria et al. [62] discussed the difficulties of logical thinking in environments that supported assisted living technology and emphasized the significance of employing hybrid reasoning methods to manage multiple inhabitants' overlapping, simultaneous, and conflicting pursuits and objectives. L. M. Gladence et al. [63] summarize that Smart Living Home automation is a technology that enables remote access and management of different devices and appliances within a household. IoT, AI, and cloud computing technologies can be utilized. This technology offers a more comfortable and convenient lifestyle for the physically impaired or elderly.

K. Zvarikova et al. [64] review literature from various databases, identify 18 main empirical sources, and show that AI chatbot customer service and hyper-realistic personalized interactive experiences can boost customer engagement. Additionally, the study suggests that digital interactive experiences involving virtual goods and assets influenced consumer behavior by utilizing location data. R. Dr. Bharati [65] highlighted the Chat Generative Pre-trained Transformer (ChatGPT), which facilitates the processing of natural language and generation of automated text, and its capacity to transform how humans interact and communicate with machines. W. Wang et al. [66] highlight the potential of using IoT, 5G, and AI technologies to revolutionize the tourism industry and provide personalized recommendations to travelers.

O. Taiwo et al. [67] presented the importance of security in smart homes and gave an intelligent home automation system that monitors environmental conditions, manages household appliances, and detects motion within the house and its surroundings. It highlights the significance of intelligent monitoring and response for the efficiency and safety of smart home automation. K. Ahmad et al. [68] explore the challenges of implementing data-driven AI services in modern smart cities, focusing on these algorithms' security, safety, and interpretability and advising on existing constraints, drawbacks, and future avenues for research in these areas. M. H. Panahi Rizi and S. A. Hosseini Seno [69] recognize existing security and privacy remedies, unresolved research issues and obstacles, and furnish a structured literature map. The study aims to deliver a baseline for future research in the field and condenses the results into a collection of previously diverse and intricate evidence.

K. Jokinen et al. [70] presented the development of a virtual coach designed to assist older adults with everyday activities and help maintain their well-being and healthy lifestyles. The e-VITA EU-Japan Virtual Coach for Smart

Aging project aimed to prototype virtual coaches for smart environments, develop standards for component interoperability, and conduct a study of "proof-of-concept" for assessing user acceptance. N. Bagaria et al. [71] reviewed existing literature on Health 4.0 Using Digital Twins for maintaining personal health and wellness, which involves essential terms, uses, and research gaps. The aim is to give a summary of the possible advantages and difficulties associated with the utilization of Digital Twins in the fields of healthcare and well-being. A. El Saddik et al. [72] also proposed a DTwins ecosystem that is going to accelerate the convergence of IoT, big data, communications mechanisms, security, and multimodal interaction to empower individuals' wellness. It also enhances their quality of life. M. A. Makroum et al. [73] reviewed 89 studies published between 2011 and 2021 and concluded that wearable technology had gained significant attention in the medical field for individuals with long-term health conditions such as diabetes and has the potential to assist in diabetes management, prevent complications, and improve quality of life.

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