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# Design and implementation for AI sustainable smart city healthcare

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**ABSTRACT**

The combination of Internet of Things (IoT) with artificial intelligence (AI) offers a potential way to solve real-time IoT application problems. AI improves large data processing by providing unmatched speed and accuracy. Yet there are significant obstacles to overcome in order to advance large data analysis with AI, including those related to training data, privacy, data security, and centralised architecture. Smart cities refer to metropolitan regions that use diverse technologies, sensors, and actuators to gather and analyse data, resulting in significant insights and amenities for inhabitants. In order to ensure the best possible use of resources, information technology plays a crucial role in managing the social, commercial, and physical infrastructures of smart cities. Smart homes, smart cars, smart industries, and smart transportation are just a few examples of IoT devices found in smart cities that may interact and use smart solutions to efficiently and successfully optimize several domains. Using AI to improve healthcare services in smart cities while putting sustainability first means using AI to support sustainable healthcare. By integrating healthcare systems, this integration seeks to improve inhabitants' well-being while reducing its negative effects on the environment. IoT has major obstacles such data security, centralization, data analytics, connectivity, and hardware constraints despite its many benefits.



## INTRODUCTION

AI plays a crucial role in bestowing intelligence upon machines, rendering them smart and adept. Essentially, it refers to the intelligence exhibited by machines and software programs. AI's influence permeates various aspects of contemporary life, including social interactions and economic activities of individuals. Within the context of smart cities, an array of smart sensors, actuators, and devices routinely collect and generate copious amounts of data, subsequently utilizing wireless communication for data transfer [2]. AI steps in to process this immense volume of data with remarkable accuracy and efficiency, simultaneously learning from it. This learning aspect enables the derivation of valuable insights, contributing to the sustainability and resourcefulness of smart cities [1]. By leveraging AI, we can curtail unsustainable growth and work towards achieving growth that is sustainable across various domains

including economics, education, healthcare infrastructure, and climate control a shared aspiration on a global scale.

## OBJECTIVE OF THE STUDY

The principal objective of this study is to work towards sustainable development and the attainment of sustainable healthcare goals. AI holds immense potential in predicting infrastructure failures, usage patterns, resource demand ratios, and other critical factors relevant to this pursuit. However, integrating AI into smart cities poses a formidable challenge [5]. The predominant issue lies in the fact that the majority of AI resources and capabilities are confined to a select few companies, each with its own AI ecosystem [3]. To surmount this obstacle, it is imperative to transform AI into a service and utility that is accessible to all. Our overarching goal is to foster sustainable development on a global scale. The world is eagerly seeking solutions, and meeting these expectations presents a considerable challenge. The collective efforts worldwide are dedicated to sustainability, and our study stands to significantly benefit smart, sustainable cities through the effective utilization of AI [7].

## Literature review

**Wang, X., Li, X., & Leung, V. C. M. (2015) [1]** present a comprehensive overview of artificial intelligence (AI) techniques applied to emerging heterogeneous networks (HetNets). The authors explore state-of-the-art methods in network optimization, resource management, and dynamic spectrum allocation, emphasizing the critical role of AI in handling network complexity and diversity. They highlight the opportunities AI provides for improving network efficiency and user experience, while also addressing the challenges associated with real-time data processing, algorithm scalability, and system adaptability. This work serves as a foundational reference for researchers exploring AI integration in next-generation communication networks.

**M. M., & Bishop, M. (2014) [2]** focus on computational creativity, distinguishing between weak and strong forms of machine creativity. The study investigates how AI systems can emulate human-like creative processes in problem-solving, design, and artistic domains. By analyzing different models of creativity, the authors provide insights into the limitations and potential of AI-driven creative systems. This contribution is significant for understanding how AI can move beyond analytical tasks to more innovative, generative applications.

**Obulesu, O., Mahendra, M., & Thrilok Reddy, M. (2018) [3]** offer a survey of machine learning (ML) techniques and tools, highlighting their applications across various

domains. The paper categorizes ML algorithms, including supervised, unsupervised, and reinforcement learning, and discusses practical implementation tools and platforms. The authors provide comparative insights into the strengths and limitations of these techniques, making the study a valuable resource for practitioners seeking to select appropriate ML strategies for specific problems.

**Alam, M., & Khan, I. R. (2022) [4]** explore the application of AI in smart cities, detailing how AI-driven systems enhance urban management, transportation, energy efficiency, and public safety. The authors discuss the integration of AI with IoT, big data analytics, and cloud computing to create intelligent urban environments. Challenges such as data privacy, interoperability, and scalability are also addressed, emphasizing the need for robust frameworks to fully leverage AI capabilities in urban infrastructure.

**Kar, A., Subash, A., & Rao, V. U. (2020) [5]** investigate the role of reactive AI in precision medicine, demonstrating how AI can analyze large-scale healthcare data to provide personalized treatment recommendations. The study underscores the significance of big data in developing AI models that respond dynamically to patient-specific information. The authors also discuss the ethical and technical challenges associated with implementing AI in clinical settings, including data security, model transparency, and integration with existing medical workflows.

**Scassellati, B. (2002) [6]** explores the concept of "theory of mind" in humanoid robots, focusing on the robot's ability to model and predict the beliefs, intentions, and actions of human agents. The study emphasizes how incorporating cognitive models in robotics can enhance human-robot interaction, enabling robots to respond more effectively in social and collaborative environments. This foundational work lays the groundwork for research in socially aware and adaptive robotic systems.

**Schmidt, M., Berg, E., Friedlander, M., & Murphy, K. (2009) [7]** present a limited-memory projected quasi-Newton algorithm designed for optimizing costly functions with simple constraints. Their approach addresses computational efficiency and memory limitations, making it suitable for large-scale optimization problems in machine learning and statistical modeling. The authors provide theoretical analysis and empirical results demonstrating the algorithm's effectiveness, contributing to the development of practical optimization methods for complex AI tasks.

**Gorbenko, A., Popov, V., & Sheka, A. (2012) [8]** investigate robot self-awareness

by exploring internal states and their implications for autonomous behavior. The paper examines mechanisms through which robots can monitor and evaluate their internal processes, leading to improved decision-making and adaptive control. This study highlights the importance of self-reflection capabilities in robotic systems, particularly for tasks requiring autonomy and situational awareness.

**Digalaki, E. (2019) [9]** analyzes the impact of artificial intelligence on the banking sector, detailing how AI technologies are transforming financial services. The report outlines applications in fraud detection, customer service, credit scoring, and risk management. It also discusses challenges such as data privacy, regulatory compliance, and system integration, providing a clear view of AI's practical benefits and constraints in modern banking operations.

**Insights, C. (2022) [10]** provides a comprehensive overview of AI trends, investments, and adoption across industries. The report identifies emerging technologies, market shifts, and key players driving AI innovation. It serves as an authoritative source for understanding the global AI landscape, highlighting opportunities for research, commercial deployment, and strategic planning in AI-driven sectors.

**O'Leary, D. E. (1995) [11]** explores the early integration of artificial intelligence (AI) in accounting, finance, and management. The study highlights how AI systems can assist in data analysis, decision support, and predictive modeling to improve organizational efficiency and financial accuracy. By examining rule-based expert systems and early machine learning applications, the work provides a historical perspective on the evolution of AI in business contexts and lays a foundation for later research on AI-driven financial systems.

**Wu, F., Yen, Z., Yunhe, H., & Ni, Y. (2004) [12]** investigate applications of AI techniques in power generation planning and investment. The authors discuss how AI algorithms, including neural networks and optimization methods, can enhance decision-making for long-term energy planning, capacity expansion, and cost management. Their study emphasizes the role of AI in handling complex, nonlinear systems with multiple constraints, offering a methodological contribution to energy system planning.

**Bartoletti, I. (2019) [13]** examines the ethical and privacy challenges associated with AI in healthcare. The author highlights concerns related to data security, patient consent, algorithmic bias, and transparency. The study stresses the need for robust governance frameworks and ethical

guidelines to ensure that AI applications in healthcare are safe, equitable, and trustworthy, reflecting a growing awareness of social implications in AI deployment.

**World Health Organization (WHO) (2021) [14]** released its first global report on AI in health, outlining six guiding principles for the design and use of AI technologies. The report emphasizes ethical, transparent, and patient-centered AI systems that prioritize safety, equity, and accountability. It provides a comprehensive framework for policymakers, developers, and healthcare providers to ensure responsible implementation of AI in medical contexts, marking a milestone in global AI governance in health.

**Grand View Research (GVR) (2022) [15]** provides an industry-focused report on the AI in media and entertainment market, projecting it to reach $99.48 billion by 2030. The report details key trends, including AI-driven content creation, recommendation systems, personalization, and production automation. It underscores the economic potential of AI technologies in creative industries and highlights market dynamics, adoption challenges, and investment opportunities for stakeholders.

## RESEARCH METHODOLOGY

Employing artificial intelligence and a host of converging technologies in a systematic manner can be instrumental in achieving the Sustainable Development Goals (SDGs). A plausible future approach could involve offering AI as a paid service, either based on the volume of data processed, hourly usage, or project-based models [8]. It is imperative for universities and educational institutions to expedite AI courses and dedicate efforts to cultivate a proficient workforce and AI systems. Looking ahead, AI should transition into a utility accessible to everyone, akin to the normalization of cloud computing anticipated in the coming 8-10 years.

The correct implementation of AI is poised to wield substantial influence over the development and enhancement of smart cities. AI will progressively learn how residents interact with their cities, analysing data and generating predictions based on past interactions. Furthermore, integrating IoT and Block chain technologies will fortify the concept of smart cities, and the synergy of these converging technologies holds immense promise in achieving Sustainable Development Goals [9].

## ARTIFICIAL INTELLIGENCE

AI involves emulating human understanding and intelligence in machines. These machines are programmed to think and act like humans, aiming to replicate human actions. AI machines, in essence, possess the capability to learn from experiences and engage in

problem-solving, akin to human cognition [10]. A fundamental attribute of AI is its capacity to assimilate knowledge from past experiences and make decisions based on input, optimizing the likelihood of achieving a desired objective. Machine Learning (ML) operates as a subset of AI. Within ML, computer programs possess the ability to autonomously learn and adapt with newly provided data without requiring human intervention [11]. Deep learning, a subset of ML, facilitates automatic learning by utilizing vast amounts of structured and unstructured data, encompassing audio, video, images, text, and more [12].

**Understanding Artificial Intelligence**

When we hear the term AI, we automatically start to think about robots. This is because many novels and movies tell us stories about robots and other human like machines wreaking havoc on humans and the planet earth. But that is not the truth at this moment.

The basic principle of AI is that the intelligence of humans can be recreated and be used by the machines to execute a set of tasks or even mimic the human behavior, be it the very complex tasks or even the simplest ones [13]. The goal of AI includes mimicking the human cognitive activities. Humans have reached the levels where machines are mimicking human activities such as learning, reasoning, and perception, with a very high success rate [1]. Researchers and scientists believe that sooner or later they will be developing a system that will surpass the human capacity to learn or reason out any subject. But it is still an achievement to achieve since all cognitive activities are linked with the value judgments that are unique to experiences of the humans.

Benchmarks defined previously regarding AI are being surpassed everyday due to the advancement in technology [15]. For instance, text recognition systems or machines calculating basic functions are no longer considered to be an AI system, they are now days thought of as an inherent computer function.AI is evolving continuously and is being used in almost every industry.

**Applications of Artificial Intelligence**

AI has endless applications today. The technology is being applied to all sectors of life and industries. AI is also being extensively used in healthcare industry for various different tasks such as calculating drug dosages, giving personalized treatments to patients, and aiding in surgeries and operation theaters [16]. AI is being used in gaming; they play games such as chess which require the use of mind and skills. Self-driving cars also use AI. In the above two examples, the next steps are changed and altered due to the current as well as previous

state. Each action has an impact on the end result [17]. Winning the game is the end result in chess, while in self-driving cars; the AI must take into considerations all the external data and factors and make progress likewise to prevent a collision and other miss happenings [3].

AI is also being used in financial industries. It is helping the banks in detecting and flagging unusual card usage as well as deposits of huge amounts at a time. AI is being used in smart cities and making the life easier for the citizens [18]. It will be discussed in great detail in upcoming sections.

**Types of Artificial Intelligence on the basis of complexity**

AI can broadly be categorized into two main types: weak AI and strong AI [4].

Weak AI is designed in such a way that it carries out a single work. For example, video games like chess, shooter games etc., personal assistants such as Amazon A lexa, Apple siri, Google assistant etc. We ask these assistants our questions and they provide us with the answers. You tube's and Netflix's recommendation engine tell us what movie we should watch, Chat bots and search engine are other examples.

Strong AI are the systems that perform tasks that are considered to be human-like. These systems are more completed and complex [19]. They are capable of handling tasks on their own in which human intervention is needed otherwise. Self-driving cars and puzzle solving and exhibition of common sense are a few examples.

**Types of AI on the basis of development**

Artificial intelligence can be categorized into four types.

- **Reactive AI:** This category of AI utilizes algorithms to optimize the output based on a specific set of inputs. For instance, AI used in chess playing is a prime example [5].
- **Limited memory:** AI systems of this type have the capability to adapt to their past experiences and update themselves based on new observations or data.The memory is often limited hence called limited memory [20]. Autonomous vehicle system is an example [6].
- **Theory-of-mind:** Theory-of-mind AI refers to the development of artificial intelligence systems that possess the ability to understand and model the mental states of humans and potentially other AI agents. This concept involves creating AI systems that can attribute beliefs, intentions, emotions, and desires to themselves and others, allowing them to

comprehend and predict human behavior based on inferred mental states [7].

- **Self-aware AI:** Self-aware AI refers to the concept of artificial intelligence systems that possess a level of consciousness and self-awareness similar to human beings. Self-aware AI is still largely theoretical; contemplating its implications highlights the intersection of technology, philosophy, and ethics [21]. While the journey toward self-aware AI is complex and uncertain, its exploration pushes the boundaries of our understanding of both AI and human consciousness [8].

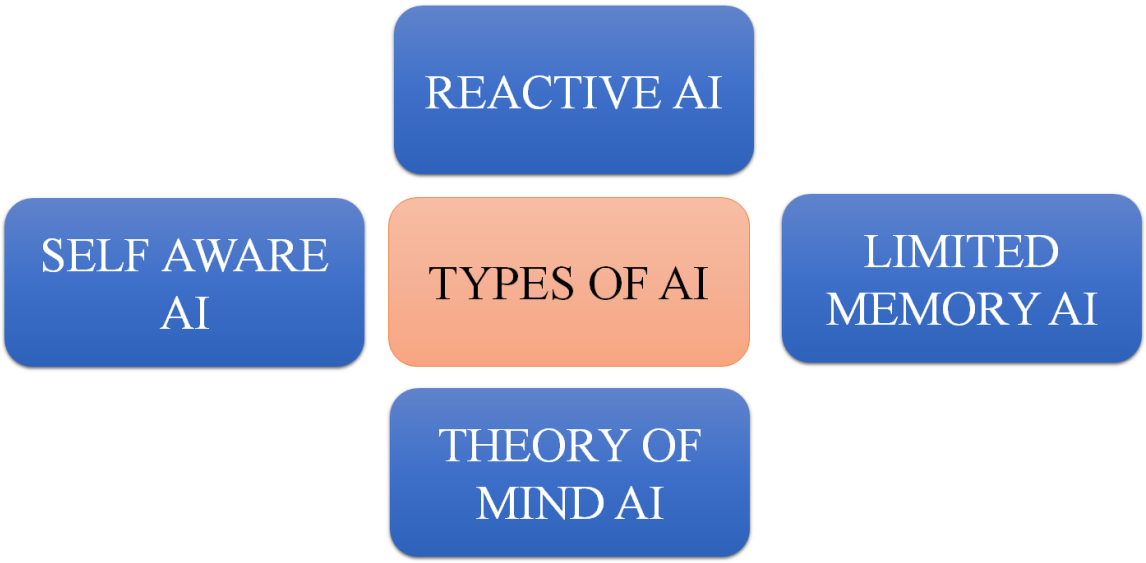


**Figure 1: Types of AI**

**Why Is Artificial Intelligence Important?**

AI offers a range of critical benefits and services to the users that make it a very useful tool for almost every organization or industry. It is being used from developing vaccine to automating processes like fraud and money laundering.

As per report by CB insights, the private market of AI saw a record-breaking increase in 2021. The global funding were up by 108% compared to that of 2020.In which 18% was in the healthcare industry alone [9]. Figure 2 depicts the same. Due to the speedy adoption in various industries, AI is making waves all around the world.

According to the Business Insider Intelligence's 2022 report more than 50% of banking and related companies have already started to use AI for risk management [22], revenue generation and customer service. AI

can lead up to $400 billions in savings if employed properly [10].

In 2021, World Health Organization (WHO) reported that integration of AI in healthcare is a difficult task but not impossible. It comes with its challenges as well as benefits and the technology “holds great promise”. AI could help in providing personalized healthcare to the patients and accurate and perfect diagnosis [11].

AI has also touched and benefited the entertainment industry. according to an estimate done by Grand View research, the global media and entertainment industry using AI was $10.87 in 2021 is estimated to touch $99.48 by 2030 [12]. AI is being used in detecting plagiarism in the media content and developing high-end graphics using AI and computers.

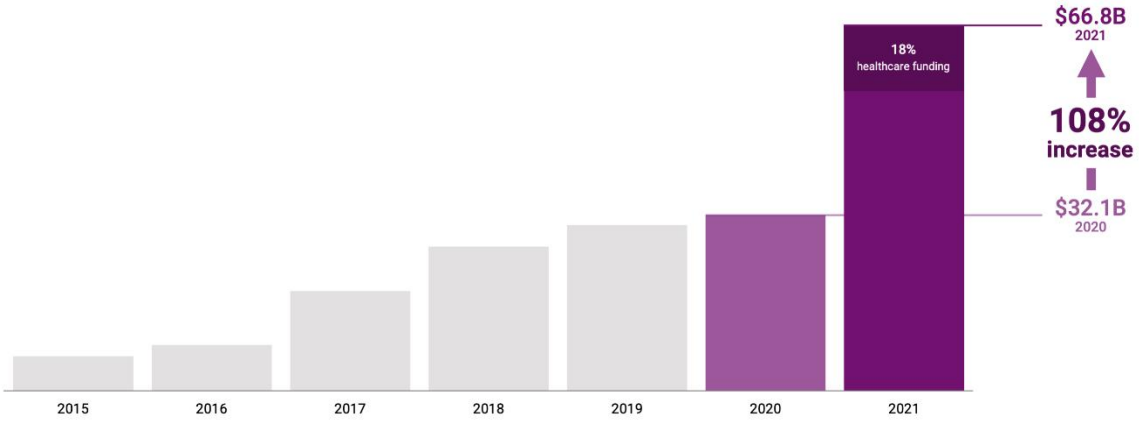


**Figure 2: AI funding up by 108% in 2021.**

**How is AI Used Today?**

Today, AI is being used in almost every industry across a wide range of services and applications, with different intensity of sophistication. Recommendation systems are the most used and implemented AI systems. Chat bots flashing on various websites are the next most used AI system. AI is also utilized in smart speakers such as Amazon Alexa, Google Assistant, and Apple Siri. Predictive systems are also being implemented to make predictions on weather and financial forecasting. This section has highlighted some of the primary applications of AI [13][14][15][16].Figure 3 illustrates the various uses of AI [24].

**Personalized Shopping:** When a user visits a shopping website and searches for an item, the recommendation engines help in better engaging with the users and improving their shopping experiences. The recommendations are made on the basis of previous searches,

interests and preferences. This helps in improving and maintaining good terms with the customers.

**AI-powered Assistants:** Chat bots are also included in AI powered assistants. These assistants, currently, solve 40% of customer queries without any intervention of humans. The percentage is likely to increase in the near future.

**Fraud Prevention:** Financial fraud and fake ratings and reviews are the most serious issues which can be tracked and solved by the use of AI. Fraud can be prevented by checking and studying the usage patterns of the card and the card holder. AI can help in the same. A large number of new as well as the old users prefer to go through the reviews and ratings of a product or services before purchasing them. Fake reviews and ratings can have great impacts on the users. AI can help identify and eliminate fake reviews.

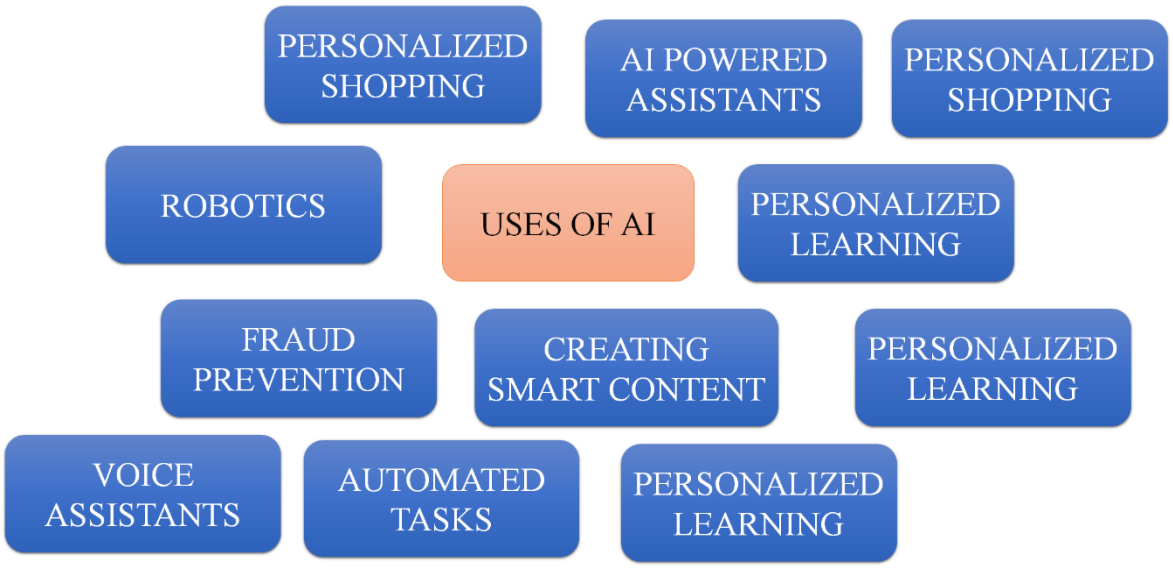


**Figure 3: Uses of AI**

**Artificial Intelligence Pros and Cons**

While AI is considered to be a life changing technology, it comes with its shares of downsides [18].

Few of the advantages of AI are

- Reduction in errors caused by humans
- Takes risk instead of humans
- Available 24X7
- Helping in repetitive jobs
- Virtual assistants
- Faster decision
- New inventions

Some of the disadvantages of AI are

- High cost of creation
- Making humans lazy
- Unemployment
- No emotions
- Lacking out of the box thinking

## AI IN SMART CITIES HEALTHCARE

Smart cities are now a reality with smart healthcare as one of its important pillar. We have a number of smart cities around the world. But these cities still need development in one or the other sectors. Currently smart cities deploy Internet of things (IoT) [19], Internet of Drones (IoD) [20], Cloud computing[21], Edge computing [22], smart healthcare and other technologies.AI, if implemented correctlyplays a crucial role in the development and upgrading of smart cities and its healthcare.

AI will start to learn how people use their cities. It will start analyzing the data and give predictions on the basis of previous experiences.

### How can AI be used in smart cities healthcare

The massive amount of big data being generated in cities every day is making AI very different to the AI of the past. Huge amount of data is the main driver for AI. When this big data is paired with efficient and robust algorithms, the capabilities of AI increase exponentially. The use of AI in healthcare is becoming interesting as the developers are integrating and creating systems that are capable of learning from the past experiences [23]. For example, in a smart healthcare system where demand of energy tends to spike under certain circumstances, AI can learn where the spike is usually occurring and under what conditions and circumstances [26]. Engineers and scientists can then make better use of the power grid. Other examples could be, by learning, AI can provide services to disabled and elderly people who might not be able to go for grocery shopping.

#### *Natural language processing*

AI's application in healthcare extends to natural language processing (NLP), a field focused on teaching machines to comprehend and interpret human language. NLP can significantly enhance communication between patients and healthcare providers and facilitate the analysis of vast quantities of medical text data. A notable instance of NLP in healthcare is the deployment of virtual assistants or chat bots that engage with patients in natural language, gathering and analysing their symptoms and medical history. These virtual assistants play a crucial role in helping patients recognize potential health issues and provide guidance on appropriate next steps, such as scheduling appointments with healthcare professionals [25]. Furthermore, NLP can be leveraged to

scrutinize electronic health records (EHRs) and medical literature, revealing patterns and trends in patient outcomes, drug efficacy, and disease prevalence. This empowers healthcare professionals to make well-informed decisions about patient care and devise superior treatment strategies. Another vital application of NLP in healthcare is within clinical decision support systems (CDSS), designed to aid healthcare professionals in clinical decision-making by analysing patient data and offering recommendations based on the latest medical research. NLP's role is to analyse patient records and furnish CDSS with supplementary information, enhancing their precision and relevance. In conclusion, NLP holds immense promise in refining communication and data analysis in healthcare, leading to improved patient outcomes and a more streamlined healthcare delivery. As it continues to advance and integrate into healthcare systems, NLP is poised to play an increasingly pivotal role in the future of healthcare.

**Big data**

AI finds extensive utility in healthcare, particularly in the analysis of big data. The proliferation of electronic health records (EHRs), wear ables, and digital health technologies has led to a wealth of healthcare data that can be harnessed to enhance patient outcomes and refine healthcare provision.

One prominent application of AI is the analysis of big healthcare data to uncover patterns and generate valuable insights, ultimately enhancing patient care. Machine learning algorithms, for instance, can scrutinize patient data to detect patterns indicating the potential onset of specific diseases, enabling timely intervention before conditions exacerbate.

Furthermore, big data analytics play a pivotal role in optimizing healthcare operations, resulting in cost reductions and heightened efficiency in healthcare delivery. Predictive analytics, as an example, can foresee demand for particular procedures or services, enabling healthcare providers to allocate resources more judiciously.

An additional noteworthy application of big data analytics in healthcare is within drug discovery. AI is leveraged to analyse vast datasets concerning molecular structure and function, aiding in the identification of potential drug candidates and predicting their efficacy.

In summary, the analysis of big data in healthcare holds transformative potential for how we approach patient care and healthcare delivery. AI-powered analytics empower healthcare providers to comprehensively

grasp patient needs, enhance outcomes, and streamline healthcare operations to achieve superior efficiency and effectiveness.

## CONCLUSION

This paper delves into an exploration of the diverse implications of AI within the realms of smart city environments and healthcare. It encompasses an examination of challenges and drawbacks, proposing effective strategies to mitigate and eliminate these hurdles. The insights generated from this study are poised to stimulate novel ideas and propel researchers to new heights, aligning with the aspirations of sustainable development goals. A notable focus of this research lies in the domain of smart healthcare.

By incorporating AI into smart city healthcare, we can foster an array of advantages for society, foremost among them being the creation of an eco-friendly environment conducive to sustainable development. The amalgamation of smart cities with AI promotes energy efficiency, environmental sustainability, streamlined traffic, effective waste management, and intelligent lighting and appliances. These advancements play a pivotal role in pollution reduction, thereby contributing to a cleaner environment and conserving energy.

The future of healthcare appears exceedingly promising owing to the rapid progress in sensor technology, AI, and machine learning. These advancements offer fresh opportunities for patients, hospitals, physicians, and medical device manufacturers, paving the way for leveraging the potential of the Internet of Things. While challenges and substantial changes await, the literature consistently underscores the application of smart technologies in smart cities, particularly in the healthcare domain. AI and blockchain stand out as pivotal drivers, enhancing the overall user experience in smart cities. Despite potential drawbacks associated with AI and machine learning in the context of smart cities, they hold significant potential to revolutionize our approach to smart healthcare and smart cities alike.

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