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APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN URBAN DESIGN

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ABSTRACT

Urban AI represents a cutting-edge shift in urban design. This technology facilitates swift decision-making and the achievement of optimal solutions in urban design, leading to significant time and resource savings on routine tasks in urban design processes. This, in turn, empowers urban designers to concentrate on more strategic and high-impact aspects of their work. Moreover, as the volume of data generated daily in urban planning and design continues to rise, AI becomes an indispensable tool for analyzing and processing this information for creating intricate urban models and plans. This paper aims to equip researchers, practitioners, and investors in urban AI with a comprehensive knowledge base, keeping them engaged with continuous developments. Also, the research paper provides a broad understanding of artificial intelligence background. Specifically, the research paper presented an inventory and monitoring of the sub-fields of artificial intelligence, and identification of the most effective ones in urban design, to identify the most important applications of artificial intelligence in urban design and clarify its effective role and functions. Notably, the research reached some important results that artificial intelligence excels in all stages of the design process except for the development stage, which humans still control. By comparing traditional and digital design through a matrix linking the stages of workflow and the effective role of both human experience and artificial intelligence. Ultimately, we assert that this in-depth research is crucial for grasping the effective utilization of AI, as a tool, in the urban design process.

KEYWORDS: Urban AI, Artificial intelligence, urban design processes, decision-making.

تطبيقات الذكاء الإصطناعي في التصميم العمراني

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الملخص

يُعَدُّ الذكاء الاصطناعي قائد الثورةً الصناعية الرابعة، والذي أحدث تغييرات جذرية في مجالات عديدة بما في ذلك التصميم العمراني. ومع زيادة حجم البيانات المُستخدمة في التخطيط والتصميم العمراني، أصبح الذكاء الاصطناعي أداة قوية لتحليل البيانات، وإنشاء نماذج تصميمات عمرانية أكثر مرونة واستدامة. كما تدعم المتخصصين في اتخاذ القرارات وإحداث نقلة نوعية من التصميم العمراني التقليدي إلى التصميم الرقمي ذي أفكار إبداعية وحلول أكثر فعالية، كما يعمل على توفير الوقت والموارد

البشرية لعمليات التصميم العمراني التقليدية. وتقدم الورقة البحثية قاعدة معرفية شاملة عن خلفية للذكاء الاصطناعي، ومفهوم الذكاء الاصطناعي الحضري، وفوائده في التصميم العمراني. كما قدمت الورقة البحثية حصر ورصد مجالات الذكاء الاصطناعي الفرعية، والتعرف على أكثرهم فعالية في التصميم العمراني، للوقوف على أهم تطبيقات الذكاء الاصطناعي في التصميم العمراني وتوضيح دورها ووظائفها الفعالة في التصميم العمراني. كما استعرضت الورقة البحثية أهم التحديات الخاصة بتفعيل الذكاء الاصطناعي في التصميم العمراني، والتي قد تمثل عائقاً في تحقيق الفوائد المثلى من الذكاء الاصطناعي كأداة تصميمية. كما توصل البحث إلى بعض النتائج الهامة أن الذكاء الاصطناعي يتفوق في جميع مراحل عملية التصميم عدا مرحلة التطوير التي مازال الإنسان المتحكم بها، وذلك بالمقارنة بين التصميم التقليدي والتصميم الرقمي من خلال مصفوفة ربط مراحل العمل والدور الفعال لكل من الخبرة البشرية والذكاء الاصطناعي.

الكلمات المفتاحية: الذكاء الاصطناعي الحضري، الذكاء الإصطناعي، عملية التصميم العمراني، صُنع القرار.

1. INTRODUCTION

The concept of artificial intelligence (AI) and its overlap has spread in various fields as a magic shortcut tool to facilitate and simplify decision-making, forecasting, obtaining analysis, understanding, and providing a four-dimensional perception of solutions. With urban populations expanding, revisiting city planning becomes imperative for sustainability. Urban planners and designers are amidst a technological revolution [1]. The widespread adoption of artificial Intelligence as a versatile tool across diverse fields for simplifying decision–making, forecasting, analysis, and comprehension has made it an invaluable asset. In the realm of urban design, where complicated processes demand significant human effort, the application of AI techniques becomes crucial. The evolution of artificial intelligence traces back to the mid-20th century, stemming from advancements in digital computing [2].

The current challenges revolve around the availability of substantial data for training the artificial intelligence algorithms coupled with a lack of awareness regarding its utilization and apprehension towards technological advancements---a phenomenon highlighted by Gertman as the ‘implementation gap’. The daily escalation in the influx of data underscores the pressing need to organize and analyze it, which in turn recognizes the intrinsic value of artificial intelligence and its subfields, encompassing machine learning, artificial neural networks, pattern recognition, etc. Plays a pivotal role in deciphering data, and proposing new creative solutions employed in various urban planning tasks [3].

Every day with the increase and emergence of new data that needs to be tabbed and analyzed, it is important to recognize the value of using artificial intelligence and implementing its applications including machine learning, artificial neural networks, analyzing and processing this data, making predictions, understanding urban patterns and dynamics, building perception, and contributing to decision-making and vision for the future better and faster [4].

2. Artificial intelligence background

2.1. The emergence of the idea

Its beginnings were in the early 1950s when a group of scientists came up with the method What's new in producing an intelligent machine based on recent discoveries? In the 1950s, Alan Turing, a prominent British scientist, introduced the concept of (AI) in articles on machines and intelligence. Publish an open research paper entitled “Intelligence, Machines and Computing” did the following: He conducted a test to classify the Machine as whether it was smart or not smart. By

passing this test, which consists of questions asked to a machine, the machine answers like a human. These questions were considered by “judgment”, which represents proportionality Between a machine and a person, knowing that this was only a preliminary idea [5].

2.2. History of Artificial Intelligence

Despite initial tests and developments in the 1950s and 1960s, significant progress was achieved in the 1970s with advancements in computing technologies, leading to the emergence of neural networks and machine learning. Subsequent years, particularly in 2011, 2015, and 2016, witnessed notable developments such as deep learning, computer vision, and natural language processing. AI has become widely accessible, transforming various fields including medicine, engineering, education, business, production, and industry [6].

2.3. Artificial Intelligence Definitions

Definitions of AI vary across different domains, reflecting its diverse applications. This technological revolution has made AI a prevailing trend, influencing various aspects of contemporary society. In the subsequent discussion, we synthesize general AI definitions and specifically explore their characterization in the context of planning and the urban design process. Professor McCarthy, in 1955, initially defined AI as the science and engineering dedicated to creating and teaching programmed machines to be intelligent [7]. Subsequently, the definition evolved to encompass formulating a theory for generating intelligence and manufacturing intelligent machines in 1980 [8]. This period also saw AI defined as the construction of a computational model for machine operations [9]. By 1981, clarified as a domain within computer science focused on innovating intelligent computer systems, aligning their essence with human intelligence in areas such as understanding, learning, thinking, analyzing, and problem-solving. In 1984, the field progressed, and it was characterized as the examination of concepts that enhance computers' intelligence [10]. The following year, in 1985, it was defined as the exploration of mental capabilities using computational models, subject to testing and analysis [11]. By 1991, it had transformed into the study of enabling computers to mimic human abilities and surpass them [12]. At the end of the last century, in 1998, intelligence was exposed by machine software [13].

Due to the ongoing evolution and modernization inherent in any science, artificial intelligence underwent significant development in the early 21st century. In 2008, it was redefined as a specialized branch in computer systems and software, tasked with enhancing tasks and improving system and machine behavior [14]. Definition was completed in 2010, as a branch of computational science concerned with developing systems and programs that exhibit behavior that is considered intelligence similar to human intelligence. AI is based on a variety of technologies and methods to perform tasks that require intelligence, interaction with the environment, and informed decision-making [15]. By 2023, the definition evolved to performing human tasks with increased accuracy and speed, and its ability to learn from human experiences over time and carry out decision-making and planning tasks [16]. Analytical methods consisting of input, analysis, and output according to the analysis performed by the artificial intelligence **Fig 1**.

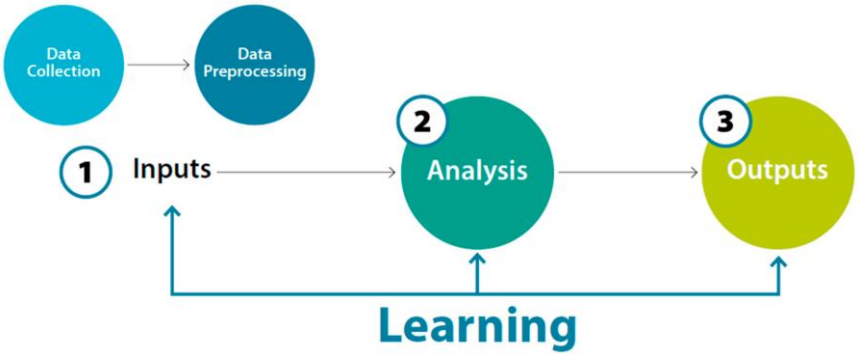

Fig.1. The basic analytical process for AI [16].

To sum up, scientists and researchers have provided varying definitions of artificial intelligence over time, reflecting the changes in technology. Throughout its development, AI has been characterized as a diverse set of applications, tools, and techniques enabling computer systems to perform at or even exceed human capabilities in learning, thinking, problem-solving, environmental interaction, and decision-making. While definitions differ, there is a consensus that AI empowers machines by endowing them with intelligent systems that emulate human thought processes. **Table 1** provides an overview of general definitions of artificial intelligence. In essence, It leverages modern technology to generate greater benefits for humanity, aligning with human criteria and standards. AI operates in various domains, including data analysis, solution extraction, forecasting, problem-solving, and decision-making.

Table 1. General AI definitions.

Authors	**Year**	**AI Definition**
McCarthy	1955	The science is dedicated to teaching programmed machines to be intelligent [6].
Nilsson	1980	Formulating a theory for manufacturing intelligent machines [7].
Bundy	1980	The construction of a computational model for machine operations [8].
Barr& Feigenbaum	1981	Computer science is focused on innovating intelligent computer systems [9].
Winston	1984	Examination of concepts that enhance computers' intelligence [10].
Charni ack & Ma Dermott	1985	Exploration of mental capabilities using computational models, subject to testing and analysis [11].
Rich &Knight	1991	The study of enabling computers to mimic human abilities [12].
`Poole, Mac Worth & Goebel	1998	The intelligence is exposed by the machine's software [13].
Luger & Stubblefield	2008	Specialized branch in computer systems and software, tasked with enhancing tasks and improving system and machine behavior [14].
Russell& Norving	2010	Branch of computational science concerned with developing systems and programs that exhibit behavior similar to human intelligence [15].
Th. Sanchez	2023	Analytical methods consist of input, analysis, and output [16].

2.4. Urban AI

Over the past twenty-five years, planners have effectively incorporated computers to aid in analysis and decision-making. Recent years have witnessed significant changes, particularly with the development of artificial intelligence technology. This has led to the widespread application of AI tools to enhance planners' decision-making capabilities, making problem-solving more efficient. Mastering AI as a planning tool holds the potential to benefit planners, especially those with limited experience with current systems [17]. In the 1960s, AI was primarily a scientific endeavor and wasn't extensively used by planners. The slow utilization of information technology for planning compared to other industries highlights the urgent need for modern tools in the field of urban planning and design to accelerate processes and enhance efficiency and skill [18]. With significant advancements in AI, the shift is towards collaborating with machines instead of opposing them. New organizational structures are needed to harness AI for urban planning, leveraging its capabilities in processing large volumes of data and accelerating analysis [19]. AI is introduced as an advanced technique for addressing complex and dynamic urban issues, offering optimal ways to analyze and adapt to urban growth [20]. Artificial intelligence will play a pivotal role in the upcoming advances in urban planning and design; thus, planners must master it as a skill to be aware of advanced urban technology [21].

To sum up, scientists in the field of planning diverged in their definitions of artificial intelligence based on the discoveries of their time, taking various paths. Despite these differences, there was a consensus that artificial intelligence would enhance and expedite the urban design process. They also agreed that planners should now acquire mastery in this technological skill, staying in touch with the latest developments to ensure the field of planning remains aligned with global advancements and doesn't lag. Urban AI empowers planners with efficient tools, techniques, and programs, facilitating swift and high-quality urban planning and design. And so, The definition of urban AI is to transform the process from routine to quick and simple, enabling data analysis, solution extraction, prediction, problem-solving, and decision-making.

2.4.1. Benefits of AI in urban design

Urban AI is considered beneficial for urban planners and designers through facilitating the creation of responsive environments that are effective for the good of the population. It streamlines traffic and facility management, and significantly expedites the urban design process, offering insights and value for decision-making among designers and policymakers, serving as an effective tool for large-scale data processing, analysis, and learning. This foresight extends to predicting future urban trends, development patterns, population growth, and changing transportation needs. In doing so, it empowers urban planners and designers to proactively align with the city's development. AI, with its advanced data processing and analysis capabilities, facilitates the understanding of city dynamics including traffic patterns, infrastructure, and environmental factors which are traditionally challenging to analyze [22].

3. Artificial Intelligence Tools and Techniques

In this section, we attempt to provide an inventory of the components of artificial intelligence that are employed in various fields. Current components serve as efficient tools, aiding

various fields, from daily tasks to medical advancements like early skin cancer detection. While these components prove useful in many domains, some fall short in the urban design process. There are six primary subfields of AI: machine learning, artificial neural networks, deep learning, cognitive computing, natural language processing, and computer vision [23], as shown in **Fig.2**. Within the six primary subfields, four are notably applied in urban planning and design including machine learning, artificial neural networks, computer vision, and natural language processing [4].

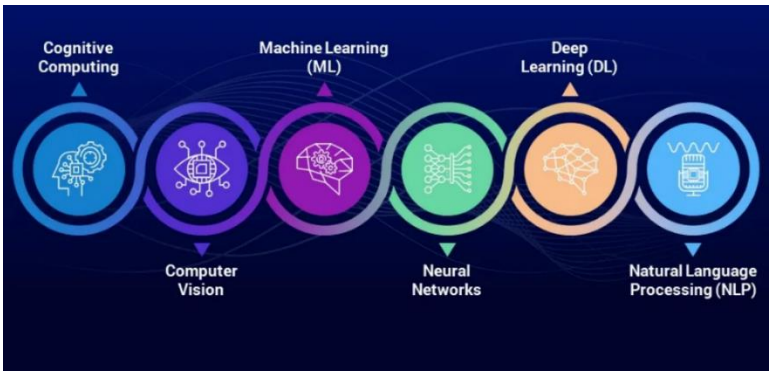

Fig.2. The common subfields of AI [23].

3.1. Machine learning (ML)

Machine learning is a sub-field of artificial intelligence, which is one of the most interactive areas of advanced technology. It is based on machine learning from data, pattern recognition, and decision-making. It possesses the ability to analyze images and speech, learn from errors, and enhance performance [24].

In the realm of urban planning and design, machine learning finds multifaceted utility in functions such as design facilitation, analysis, and prediction. Within transportation design, it manifests in innovations like self-driving cars and drones. Moreover, it offers the capacity to scrutinize maps and graphs essential for the urban planning process. Additionally, it excels at processing, analyzing, and interpreting vast datasets, thereby generating actionable insights for city planners, urban designers, and governmental authorities. Moreover, it helps predict solutions for future scenarios based on its data input. Machine learning (ML) can perform routine tasks in the design process, such as analyzing demographic, economic, and social data, environmental factors, infrastructure studies, and public services. This contributes to decision-making on housing policies that serve to benefit the population, which promotes decision-making within the framework of maintaining the principle of quality of life and living more efficiently and sustainably. Fig. 3 illustrates how ML works in urban planning. Urban forms are urban data sources, machine learning models, and indicators of planning forms. The first axis, the elements of the urban form, represents inputs. The first upper axis represents inputs for the ML model to process and learn from. The second axis, urban form indicators, provides simulation models for input indicators. Importantly, this gives experience to the urban design process because of the ability to come up with these indicators and solutions. The third axis is urban data acquisition from satellite, hybrid, and sensor data sources. For machine learning to train and learn, sufficient data must be available for it to feed itself. The fourth axis, machine learning models, processes inputs from big data. In the following, we discuss some of the practical machine-learning applications in urban design [25].

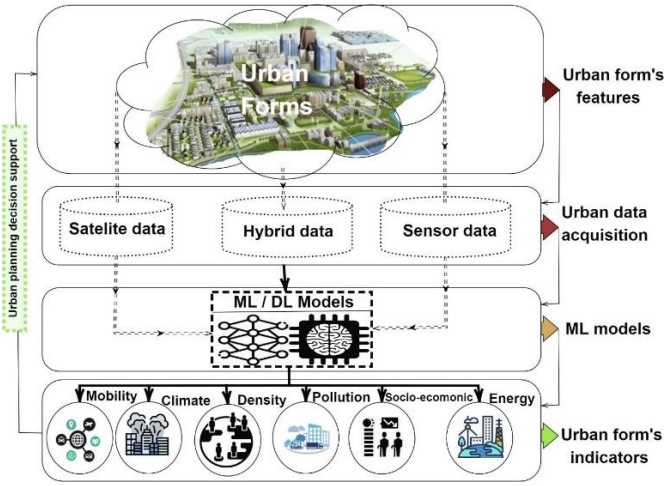

Fig. 3. Illustration of the potential role of ML for urban forms applications [25].

3.1.1. Delve

Delve is a tool developed by Sidewalk Labs that helps users save time and money on property development. Delve is a complete design solution that has been successfully implemented in various cities around the world, including Tokyo, London, Vancouver, Singapore, and suburban India. Machine learning uses the fourth axes of urban forms, urban form indicators, urban data acquisition, and ML models to get new designs in a few seconds. Delve then generates hundreds of viable designs based on the user's input within a few minutes. A machine learning algorithm is utilized to determine land parcels, public areas, and height restrictions while taking into consideration the financial budget, design program requirements, and quality of life. **Fig. 4** shows one of the scenarios selected from several suggestions according to the proposed budget and design program for the case study in the city of Japan. This feature has saved customers significant time and money. Delve is useful for projects of various scales, from a single block to 300 acres, and at different stages of the planning process. Providing critical insights early on and enabling users to create more livable places, neighborhoods, and cities [26].

Fig.4. A Japanese real estate Design scenario by Delve [26].

3.2. Neural Networks (NNs)

Neural networks are a branch of artificial intelligence that works more advanced and more accurately than machine learning. It creates productive models with higher accuracy and faster computational speed, besides its ability to learn and deduce the features of the engineering design it encounters. Also, it creates architectural forms and analyzes those forms to give more quality to the design. As a superior tool for machine learning, a neural network is used for prediction and analysis in the urban design process. The neural network can be used to predict the soundscapes of new designs, allowing designers to make better decisions regarding the construction of geometric shapes, train tracks, and roads from a landscape perspective. The neural network takes into account the effect of various factors, such as high-frequency streets, underground train tracks, and trees, on sound pressure levels. By modifying construction sites or other design elements, designers can leverage the neural network to create more relevant audio clips for their projects [27]. In the following, we discuss some of the practical neural network applications in urban design.

3.2.1. City Engine

City Engine, by Esri, is a is a 3D procedural content creation tool for urban design and visualization. The City GAN algorithm, a part of neural networks, is a game-changer in urban design as it can generate highly realistic 3D models for the design process. Neural networks can be employed in City Engine to analyze spatial data, generate realistic 3D, and simulate urban growth patterns. **Fig.5.** shows Realistic 3D design and changes in the urban pattern, while allowing the testing of numerous solutions to be shared with stakeholders to support the decision-making process. Neural networks in City Engine work using artificial neurons to process and analyze input data. Networks are trained using large spatial data sets, such as patterns, infrastructure studies, and socioeconomic studies. The neural network learns from this massive amount of data and can then create realistic 3D urban environments based on what it has analyzed within the input data. Neural networks are also used in City Engine to predict future urban growth and show the impact of different development scenarios [28].

Fig.5. 3D design by City Engine [28].

3.3. Computer vision (CV)

Computer vision is an essential component of artificial intelligence. It is a system that enables computers to interpret and understand the visual world using various functions within artificial intelligence. Computer vision can process and analyze large amounts of visual data. Additionally, computer vision systems can help urban designers make informed decisions. In urban design, surveillance cameras equipped with computer vision algorithms can detect potential security threats in public spaces. By analyzing visual data, we enable efficient and smart management of infrastructure. Computer vision is used for environmental analysis by analyzing aerial imagery or street views for green spaces [29].

3.3.1. VisoSuite.ai

Visosuite.ai is an AI-powered platform that provides a wide range of services and solutions. AI technologies have been integrated into the urban design process to enable analysis and prediction. In Visosuite.ai, computer vision is used for driving the urban design process. The technology facilitates advanced functionalities like visual data analysis and predictive solutions. Visosuite.ai is a platform that helps organizations automate repetitive tasks, simplify workflows, and improve operational efficiency. **Fig.6.** illustrates A user-friendly interface for streamlining several parts of analysis, data visualization, and reporting. To help designers easily understand their data, designers grasp indications, visual data, and data analysis reports. Visosuite.ai assists in decision-making by providing intelligent recommendations based on data analysis and solution scenarios. A practical example of how Visosuite.ai can be used in urban planning is its application in traffic management and optimization. Through incorporating real-time data from various sources such as traffic sensors, weather services, and public transportation systems. Using data-driven insights, Visosuite.ai optimizes traffic management and public transportation systems to improve the quality of life in urban planning [30].

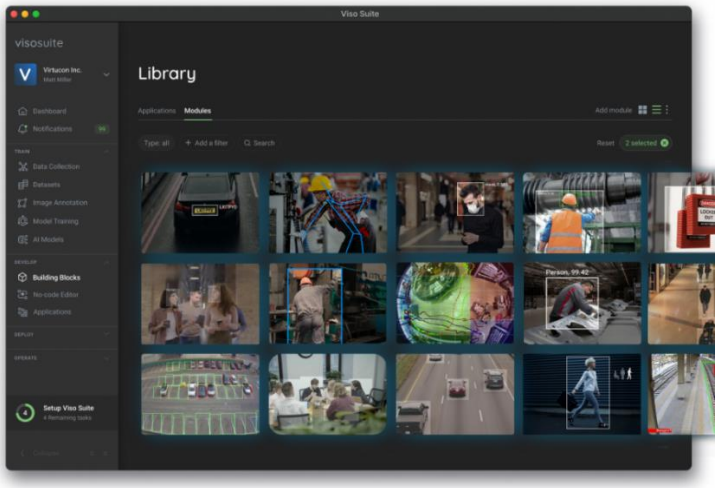

Fig.6. The interface of the VisoSuite.ai platform [30].

3.4. Natural language processing (NLP)

NLP is one of the six most important sub-fields of artificial intelligence and one of the four influencers in the field of urban planning and design. It is also considered a simulation that allows computers to understand the natural language of humans. It can be found in personal assistants such as Alexa and chatbots to help consumers. In the context of urban design, it can be utilized for a wide range of applications, including analyzing urban planning documents, understanding user feedback, and optimizing city services [30].

How Does NLP Work in Urban Design? Natural Language Processing (NLP) can help urban planners analyze vast amounts of textual data from multiple sources. including planning documents, public consultations, and social media. Through understanding the requirements and preferences of users. Consequently, they can create buildings and spaces that better cater to their needs. Also Improving decision-making processes leads to greater efficiency and better service delivery. **Fig.7** illustrates NLP's pivotal role in smart city applications to significantly impact urban design. By making the urban design process more efficient, we can analyze textual data better, understand user preferences, and improve communication between citizens and city officials. NLP delivers advanced functionalities for processing and analyzing complex data. NLP it can join many smart city components, such as infrastructure and building, technology and energy, transport, and community [32].

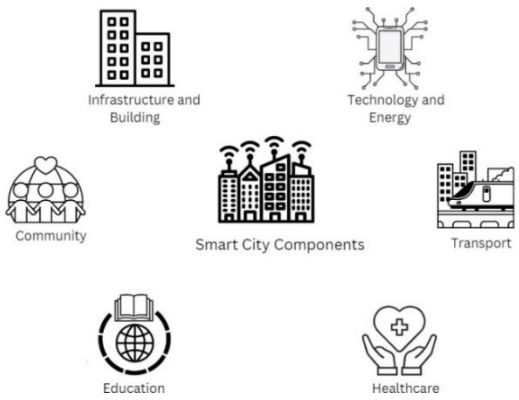

Fig.7. The Role of (NLP) in Smart City Applications [32].

3.4.1. Qua-Kit

Qua-Kit is a web platform for editing urban design and addressing simple urban architecture. The Qua-Kit tool provides urban designers with a user-friendly interface to explore and analyze their data shown in **Fig.8** Qua-Kit provides a comprehensive set of tools to simplify the urban design process, with the incorporation of GIS, simulation, modeling, data analysis, and collaboration functionality. Utilization unfolds in two key stages. Initially, it facilitates design by tackling specific problems, generating scenarios, and extracting corresponding designs. Subsequently, it transitions into a comparative exercise, presenting twenty pairs of resultant solution scenarios. NLP processes and comprehends the entered standards, while other algorithms and sub-domains of artificial intelligence contribute to envisioning future solutions. Qua-Kit offers a range of functions that cater to different aspects of urban design. Which include: land use

planning, transportation planning, urban form analysis, environmental analysis, and visualization and presentation. The Qua-Kit assists in creating urban spaces that are more sustainable, functional, and aesthetically pleasing [33].

Fig.8. The interface of the Qua-Kit tool [33].

Table 2. Subfields of AI and functions in urban design.

AI subfield	**Apps in urban design**	**Functions**
Machine Learnings	Delve	ML models use fourth axes to get new designs in a few seconds. Delve then generates hundreds of viable designs based on the user's input within a few minutes [26].
Neural Networks	City Engine	Neural networks can be employed in City Engine, to analyze spatial data, generate realistic 3D, and simulate urban growth patterns [28].
computer vision	Visosuite.ai	Visosuite.ai helps organizations automate repetitive tasks, simplify workflows, and improve operational efficiency. Visosuite.ai assists in decision-making by providing intelligent recommendations based on data analysis and solution scenarios [30].
Natural language processing	Qua-Kit	NLP processes and comprehends the entered standards, while other algorithms and sub-domains of artificial intelligence contribute to envisioning future solutions [33].

Table 2 deals with the four most important current sub-areas in the field of urban planning and design using artificial intelligence. It sheds light on artificial intelligence in terms of its sub-fields, tools, and technologies. In explaining the definition of the branches of artificial intelligence, how it works, and how it can be used in the field of urban design and the field of planning. In general, the impact of the application of artificial intelligence and its taming as a tool for urban planning and design has found many platforms, programs, and applications.

4. The practical interaction of artificial intelligence and Urban design

The urban design process changes with the change of planning via a mixed effort between humans and artificial intelligence. However, a drawback of artificial intelligence lies in the large amount of data that needs to be fed into its algorithms to achieve the desired outcome. This is considered a challenge for planners to overcome to achieve the intended output.

4.1. Artificial Intelligence Challenges

This research study needs to pay attention and reveal the obstacles to the application of artificial intelligence and what makes it limited and ineffective, as it is expected to be utilized as a quick tool for urban planning. Dr. Thomas explains that there are three main challenges: the need for new skills, changing data needs, and transparency and explainability [21]. Despite the advancements offered by artificial intelligence in urban planning, several obstacles have emerged. The primary challenge stems from a limited understanding of the available software and applications. Their rapid evolution poses difficulties in staying consistently updated, compounded by financial and time constraints. To provide time and additional money to work on creating a basic state of learning and understanding about this modern field. As for the data, there are limitations and inaccuracies that cause weakness in the work of artificial intelligence. The gap between learning about AI and practice is a major concern. Please keep in mind that many investors are fearful of investing in this modern technology [34]. This leads us to take into account all these obstacles and the extent of the gap that grows whenever the field of urban planning and design lags behind modern technology. I believe that the solution lies in creating an approach and a database that is familiar with these modern technologies and working to learn and master them as a tool in urban design.

4.2. Comparing Traditional and Digitalized Urban Design

After becoming familiar with artificial intelligence, its tools, and its techniques, it was necessary to mention the significant impact that artificial intelligence has had on the urban design process. **Fig. 9** illustrates the incorporation of artificial intelligence into the urban design process and its dominance across various stages, including briefing, sketching, fabrication construction, and management. Also allows AI for more efficient and innovative workflows. However, this requires designers and planners to acquire AI skills or collaborate with computer scientists who have the necessary skills. In the subsequent discussion, we delve into the comparison between the traditional and digitalized urban design phases [35].

Fig.9. Traditional and digitalized urban design workflow comparing [35].

In the initial phase of brainstorming, the urban designer initiates the process by gathering concepts associated with the upcoming project to broaden its scope. Tools like NLP are employed to analyze client preferences, facilitating the transfer of ideas to ML for further processing. This enables the collection of inputs crucial for the urban design process, where AI excels in accuracy, speed, efficiency, and contextual understanding.

Moving to the second phase, traditional design methods often yield a limited number of ideas, requiring significant time investment from designers. In contrast, AI leverages advanced technical tools to swiftly generate an infinite array of sketches, uncovering novel concepts overlooked by humans. Here, AI excels in speed, efficiency, and interpretation.

The development stage marks a transitional phase, where human expertise refines and enhances the design, adhering to project requirements and standards. AI operates in tandem with human guidance during this phase, indicating that human involvement remains foundational to the urban design process. Entering the design phase, conventional methods rely on existing software to create designs and explore solution scenarios, which can be time-consuming and costly. AI, however, enables rapid creation, editing, and iteration of designs, resulting in streamlined processes. Here, AI showcases proficiency in accuracy, speed, efficiency, flexibility, and visualization.

Finally, in the post-implementation phase, traditional workflows involve project handover and dedicated teams for follow-up. Conversely, AI offers digital twins linked to electronic clouds for seamless project monitoring and adaptation to future changes, underscoring its crucial role in project oversight and adaptation.

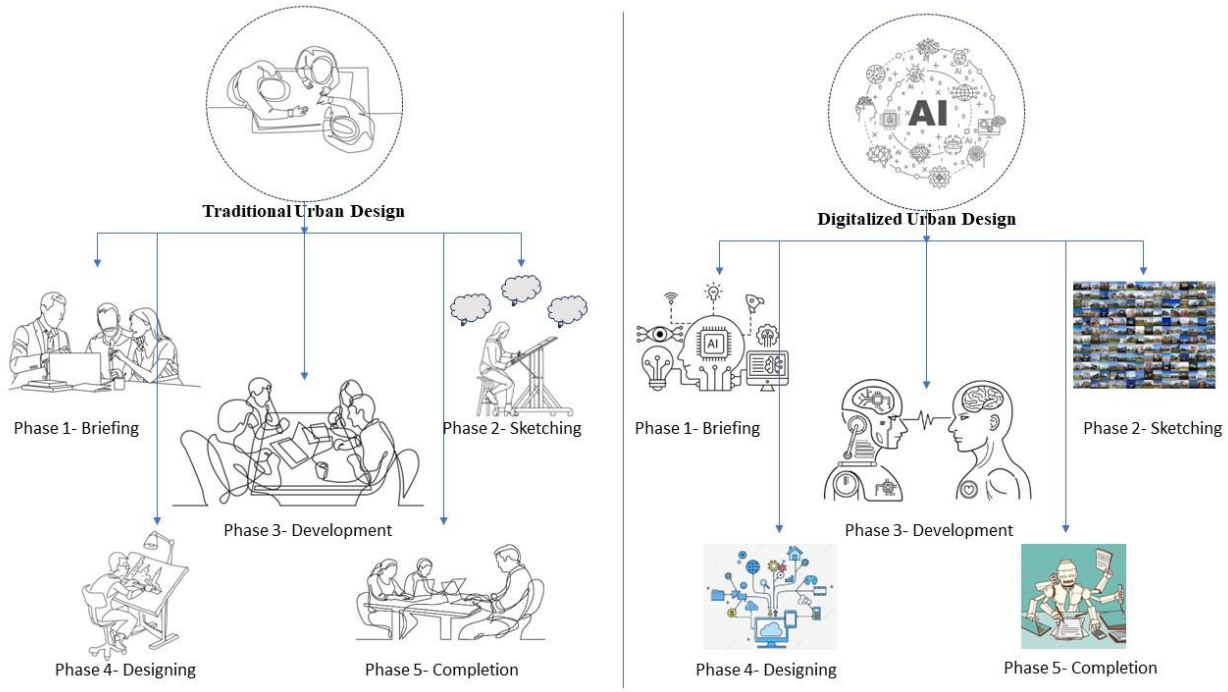

Fig.10. Urban design phases Traditional and digitalized.

In conclusion, the preceding analysis underscores the pivotal role of artificial intelligence as a tool in urban design. However, its effectiveness hinges on the infusion of human experience as data during the development stage. In essence, we are ushering in a new era marked by precision, swiftness, efficiency, and adaptability. Urban design now embraces a transformative tool in the age of big data: urban artificial intelligence.

Table 3. Comparing the effective role of both human expertise and AI during design phases.

Phases	**Traditional urban design by Human expertise**	**Digitalized Urban Design by AI**
1- Briefing		AI proficient here in terms of accuracy, speed, efficiency, and emotional and contextual understanding
2- Sketching		AI is proficient here in terms of speed, efficiency, and Interpretation.
3- Development	Human expertise plays a crucial role as it ensures adherence to rates and standards. Additionally, it directs and leads the entire design process.	
4- Designing		AI is proficient here in terms of accuracy, speed, efficiency, flexibility, and visualization.
5- Completion		AI plays a crucial role in project monitoring and adapting to future changes.

Conclusions

In the conclusion, the paper emphasizes the impending dominance of artificial intelligence (AI) and the necessity for city planners to collaborate with AI specialists. The research's objective is to establish a framework for urban designers regarding urban AI. The following key points were elucidated:

- A matrix delineating general AI and urban AI concepts was crafted to provide an urban designer's perspective on both.
- By synthesizing contemporary scientific insights, the researchers devised a matrix illustrating AI applications as urban design tools. This elucidates AI's effective contributions, facilitating a more expedient, proficient, and high-quality urban design process.
- The research delved into a comprehensive comparison between traditional and digitalized urban design processes. AI has demonstrated its efficacy as a design tool across four stages. However, the paramount developmental stage relies on human involvement.

These findings establish a foundational knowledge base, aiding urban designers in comprehending and engaging with AI across various dimensions. Moreover, the research sets the stage for subsequent investigations in this domain, elucidating AI's role in urban design and its potential to enhance urban efficiency and quality.

References

[1] Batty. (2022). 'The emergence and evolution of urban AI'. AI, Soc, Google Scholar -38, 1045-1048.
[2] Sanchez. (2023). 'Planning on the Verge of AI, or AI on the Verge of Planning'. Urban Sci, MDPI ,7(3) ,70.
[3] Geert Man. (2017). 'Beyond the implementation gap'. Science Direct- 104, 70-76.
[4] Sanchez. (2022). 'Planning with Artificial Intelligence'. APA.
[5] Mariusz Flasiński. (2016). 'History of Artificial Intelligence'. Spring link.
[6] Alex Wright. (2023). 'About artificial intelligence'. Bim.
[7] McCarthy, L. Minsky, Rochester, E. Shannon. (1955). A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence. AI Magazine.
[8] Nilson NJ. (1980). Principles of Artificial Intelligence, Book, Stanford.edu.
[9] Bundy. (1980). Book Artificial Intelligence. An Introductory Course University of Edinburgh -Research Explorer.
[10] Barr, Feigenbaum. (1981). The Handbook of Artificial Intelligence – Cambridge university press.
[11] Winston, Patrick Henery. (1984). Artificial Intelligence, Book. Addison Wesely, Archive.org.
[12] Charniak, Eugene & McDermott, Drew. (1985). Introduction to artificial intelligence, Book. Addison Wesely
[13] Rich, Elaine, Knight, Kevin. (1991). Artificial intelligence, Book. McGraw Hill.
[14] Poole, David & Mackworth, Alan & Goebel, Randy. (1998). Computational Intelligence: A Logical Approach. Oxford University Press.

[15] George F. Luger and William A. Stubblefield. (1989). Artificial Intelligence -Structures And Strategies for Complex Problem Solving, Book. Archive.org.
[16] Russell, Stuart & Norvig, Peter. (2010). Artificial Intelligence: A Modern Approach. 3rd Edition, Prentice-Hall, Texas A&M University.
[17] T.W. Sanchez, H. Shumway, T. Gordner & Th. Lim. (2023). The prospects of artificial intelligence in urban planning. APA.
[18] Richard Langendorf. (2007). Computers and Decision Making. Research gate.
[19] Daniel, C & Pettit, C. (2021). Digital disruption and planning - use of data and digital technology by professional planners, and perceptions of change to planning work. Australian Planner, Taylor & Francis Online.
[20] Brynjolfsson, Erik & McAfee, Andrew. (2011). Race against the machine: how the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy. Academia.edu.
[21] Kamal Jain & Payal. (2011). A Review Study on Urban Planning & Artificial Intelligence, IJSCE. Research gate.
[22] Sanchez. (2023). 'Planning on the Verge of AI, or AI on the Verge of Planning'. Urban Sci, MDPI,7(3),70.
[23] Sank, SS, Hep Mahendra. (2023). Artificial Intelligence and Urban Design, Technologies, Implementation, and Impacts, E-Book. Scribd.
[24] Siebel Thomas. M. (2019). Digital Transformation; Survive and Thrive in an Era of Mass Extinction. Perlego.
[25] Davies, Marion. (2023). The Major Subfields of Artificial Intelligence. Konsyse.
[26] Linda Tucci,2023. What is machine learning and how does it work? TechTarget.
[27] Jeffrery Heimgartner, 2022. Sidewalk brings ML to urban planning. Engineering.com.
[28] Siedler, Philipp. (2019). Predicting city soundscape using a Neural Network. Philipps AI Hub.
[29] Tutorials ArcGIS City Engine Resources. (2023). Arcgis, com.
[30] Gaudenz Boesch. (2024). The Most Valuable Computer Vision Smart City Applications Guide.Viso.ai.
[31] Tyagi, Nemika & Bhushan, Bharat. (2023). Demystifying the Role of Natural Language Processing (NLP) in Smart City Applications: Background, Motivation, Recent Advances, and Future Research Directions. Pudmed.
[32] Primer, (2022). How AI & NLP can create a smarter, safer, and more resilient city. Primer AI.
[33] Herthogs, Pieter, & He, Peijun & Tomarchio, Ludovica & Hasler, Stéphanie. (2019) The interface of Qua-Kit. Research gate.
[34] Walaa S.E. Ismaeel. (2022). Challenges for applying artificial intelligence in the field of urban design and planning; case of Egypt. APA.
[35] Sank, SS, Hep Mahendra. (2023). Artificial Intelligence and Urban Design, - Technologies, Implementation, and Impacts, E-Book, Chapter 1 pages 45-43. Scribd.