Virtual Reality as New Part of The Methodology for Designing Future Cities

Mona Mohamed Saleh

Abstract- Architecture is the art of transforming imagination into reality. This starts from drawing engineering plans to 3D drawings to executing the building and turning it into reality. With the advent of modern technology, it has become easy to bridge the gap between fantasy and reality (idea and building). Since the architect's profession is the art of persuading clients. So, the emergence of virtual reality technology will create confidence for the architect. And a great transfer in the way engineers work. Where virtual reality has become a new and powerful way of expression. It allows us to explore cities before they are built. And provide virtual models that appear close to real reality and evaluate building design processes before implementing them.

Which leads to providing a realistic environment and an accurate vision of future cities. Virtual reality technology helps avoid any wrong decisions before the implementation of cities begins. Thus, the result will be greater control in the future and a better visualization of future cities, especially smart cities that depend on information and communication technology to increase the quality of life. The research paper aims at how to apply virtual reality technology as part of the methodology for designing future cities, especially smart cities. And measuring the ability of virtual reality to reduce the sensory perception gap between the design idea and the reality after implementation. And raising the design and creative skills of the new cities.

Keywords- Virtual reality- Technology- New vision- Applications- future cities.

I. Introduction

Technology has evolved a lot over the past years, and this has contributed to the advancement of many aspects of industry. This also affected architecture, which benefited greatly from technological development. The architectural design process has changed since the tools changed and the advent of modern technologies. The traditional method of communicating the ideas of architectural designers was manual drawings, then it developed into three-dimensional computer graphics. Computer technology led to the liberation of architects from manual drawings. Show the design idea clearly. With the technological progress and the emergence of virtual reality technology, the architect was able to create interaction between the human and the computer and sensory integration between them.

Where it becomes easy for a person to imagine himself inside the cities and experience any part of the building and live in it in virtual reality. And the person will see himself as a part of this world and immerse himself in it, which made stimulation of the senses more than just 3D graphics on the computer. Virtual reality is another version of a reality that does not exist. Virtual reality can be described as a three-dimensional environment using a computer. Thus, it helps designers to work in a clearer and more accurate manner. In view of the challenges that architectural designers face in designing cities, the use of virtual reality technology during the city design process has become the ideal solution for creating smart future cities that are free from design problems and addressing them before starting to implement cities. Where this technology helps visualize future cities in a larger and more accurate way in terms of environmental impacts, transportation operations, city management, building design and site coordination, which allows the architectural designer to face all challenges and build developed cities.

II. RESEARCH PROBLEM:

Architectural designers face enormous challenges when designing cities. From environmental impacts and absorbing the oversized population, well as the process of transportation and managing cities in a smart way. The design of cities is greatly influenced by the development and advancement of digital technology. Virtual reality is a new tool to face these challenges.

III. Research objective

The aim of the research is to apply virtual reality technology when designing new cities to benefit from this wonderful technology. And with the aim of a greater imagination of what will happen in the future and realizing the problems of cities before they are built and the solutions to those problems, as well as presenting their capabilities and modifying them. Thus, raising the level of designing future cities using virtual reality technology.

IV. Definition of Virtual Reality (VR)

The term virtual reality originates from two words (reality) and (virtual), which suggests that it is (near-reality), that is, it is another version of reality, but it does not really exist. And this has become possible through technology so that people can perceive a real person with the human eye and the person becomes part of a virtual environment with the possibility of manipulating it. This proves that technology is constantly evolving. People use this technology to stimulate people's senses more. This technology also contributed to the flight simulation. The term virtual reality was born in the twenty-first century [1].
V. VIRTUAL REALITY IN ARCHITECTURE

And the uses of virtual reality have become in many fields. With the integration of this technology with the field of architecture, architects will be able to build stronger buildings by building virtual reality models first. He presented its design, then evaluated its capabilities and performance, and judged it before its construction. This enables the architects to see the result and how the buildings will look before construction. Virtual reality becomes a new tool for engineers in the design process, creating a prototype and achieving better results. In addition, virtual reality is used as a tool for developing cities. And how to operate and simulate. With the development of this technology, however, the task is not easy for architects.

Where it requires the engineer to enter all data and information accurately and completely and convert a two-dimensional model into a three-dimensional model and an accurate visualization of the environment. Which makes the task not easy. This technology is still in its infancy, which means that it can be further developed and improved [2].

VI. THE BENEFITS OF VIRTUAL REALITY IN ARCHITECTURE

Virtual reality is applied to the entire construction process and can be present at all stages. From design to implementation, presentation, and maintenance of the work.

6-1 The Design:

At the design level, augmented reality allows us to design in real time on the ground and make the necessary measurements and adjustments to achieve a better final build, or to consider all the details of mountain science that may affect us. Execution: Virtual reality makes it possible to visualize what a work should look like in detail before executing it. This allows developers to more directly and clearly visualize how it will complete and use virtual reality to see if everything is progressing correctly.

6-2 Commercial

A major issue is the consensus of the design and working with the client, what VR allows is that the client will be able to visualize clearly and in their real environment what the work will look like in detail, so that they can convey whether their idea is being implemented correctly.

6-3 Maintenance

Building maintenance is as important as its concept to be effective for many years. Virtual reality helps us focus on important points and make decisions quickly and without errors [3].

6-4 Offers a memorable client experience.

Virtual reality offers a unique experience to the customer as it allows immersion in a design experience that he will not forget. He will be able to walk around the future buildings and will give them a better understanding of the projects before they are built.

6-5 Provides a better understanding of space.

Architectural presentations are presented to clients at a 360-degree angle for the project, providing them with a great deal of technical knowledge. It provides them with information that may not be easy to understand through two-dimensional graphics. Thus, an easier discussion of the architectural details, the exchange of notes, and the development of desired modifications. This is to avoid any unwanted surprises during construction.

6-6 Stay ahead of the competition.

In architecture, it is preferable to adopt new technology to always be distinguished and a strong competitor, as you can offer something that others cannot offer. Where virtual reality listens to you by turning imagination into reality, and the customer experience is distinctive, giving you a competitive advantage [4].

VII. Tools used in virtual reality technology

This virtual environment is displayed by using specialized equipment. Use of headsets and physical props such as controllers and sensors [5]. The scene is rendered by allowing him to look around, move around, and interact with this artificial environment. It is a unique experience that easily conveys the user's sense of place and artificial environment [6].
C-Large display screens (Displays Angle-Wide)
D-Motion Sensors (Trackers Body and Head).

VIII. Virtual reality programs in engineering offices

- Unity 3
- Sketch Fab 2016
- Unreal engine 5 2023
- Quest3d 2008[20].

IX. SKILLS NEEDED TO SUCCEED AS AN ARCHITECT IN THE VIRTUAL REALITY:

What comes to our mind when we hear the word (virtual reality engineer)? He is someone who can design virtual reality, not ordinary reality. He exploits his technological skills and design skills to simulate user experiences. And how objects and buildings interact with each other in the virtual world. The virtual reality designer designs buildings, characters, and virtual models based on the needs of users, as well as based on engineering technology principles, as well as on the amount of data and information to embody a two- and three-dimensional environment using a computer [7].

9-1 TECHNICAL EXPERTISE

The architect must be very familiar with the technologies that run the 3D modeling programs. The ability to design and manipulate virtual environments and 3D buildings. The 3D modeling software allows the architect to create landscapes and virtual objects. Without that skill, the architect would not be able to create a dynamic, visually stunning environment.

9-2 CREATIVE VISION:

The architect must have a strong and creative vision to be able to realize this vision. Designing attractive cities that capture the imagination of users and provide all their needs. With the ability to manage the city in a smart way.

9-3 DESIGN SKILLS:

It is the ability of the architect to design sustainable cities and his ability to come up with a strategy for managing that city. And create a system of modern technologies. Through which the efficiency of buildings is controlled. And his ability to design a virtual city like the normal city. In which both the population and the bodies perform their activities indirectly through the technologies made available by digital media.

X. Solve Every Problem With VR Technology

With the advent of smart cities, we will rethink the way future cities are designed. To make it safer, healthier, and more efficient. Where some designers are a little afraid of future cities, where the architectural designer must maintain the sustainability of the city and the continuity of things, whether it is traffic or energy efficiency and provision. Instead of focusing on creating a temporary environment, we seek sustainability in the new cities. And creating an integrated city system that can predict human behavior in and around the design [8].

Fig. 2. Studying city solutions in virtual reality.

XI. THE POSSIBILITY OF VIRTUAL REALITY IN VISUALIZING CITIES:

Virtual reality technology will play a major role. In safely managing the next phase of urban development, feasible, more sustainable, and cost-efficient. Also, virtual reality can face challenges Urbanization, including climate change and the movement of people and goods across the border. Which will help transform cities into smart areas.

This technology enables us to visualize the future for cities better. Since the cities of our region are still growing and expanding, we will be able to use virtual reality technology to plan in ways that were not previously available. Thanks to the simulation, the implementation process will be specific. Effective and accurate, we will be able to expand the horizons of design and imagination through the visualization of projects using this technology. And eventually implement it in the fastest time, less cost, and more quality [9].

The world of virtual reality helps to understand the consequences of design schemes from multiple perspectives. Planners can assess the impacts of new developments on cities in terms of transportation patterns and environmental consequences. And infrastructure. Access to landmarks easily. Planners can also evaluate the social, cultural, and behavioral response, which facilitates good evaluation of plans in designing new cities. Data visualization through virtual reality provides sufficient information about the cities that will be built. It put forward the fears, desires, and empirical knowledge of societies.

Thus, the development of policies in future planning. These considerations can avoid negative consequences in cities.

Visualization in virtual reality is a dynamic perception and not an interactive perception at all. The designer must be able to interact with the design by modifying and deleting the designs and by evaluating the design from different aspects and modifying the design data if necessary. We also have some data that can be clarified by VR technology:

II-1 Virtual reality and simulation:
Simulation is a design technique that attempts to create a virtual space for the proposed design. We can benefit from this technique about the structural structure of the building, its thermal path, movement paths around the building, and so on.

### 11-1-1 Thermal analysis

Air flow and temperature can be visualized through a 3D model. The movement around the buildings can be examined to determine the air speed and temperature and measure them to determine the standards that must be adhered to.

![Fig 3. An image showing an analysis of the intensity of light during daylight hours for a building using a program design builder.](image)

### 11-1-2 The structural path of the building

The places of tension and pressure on the parts of the building can be observed by adding a color gradient to a specific pressure or tension value. To reach knowledge of the behaviors of the different forces of the structural structure of the building. These values can be compared with the standards that must be adhered to about the coefficient of stability and safety of the building.

![Fig 4. An image showing the use of the SAP2000 program to build and analyze one of the structural structures in the building.](image)

### 11-1-3 Human behaviors

It is possible to notice the path that people will walk around the building. User data, the time it takes people to get from one place to another, and places of crowding and gatherings are used to set appropriate standards for people’s behavior around buildings.

![Fig 5. A picture showing the use of a program design builders to analyze and clarify pedestrian movement inside buildings.](image)

### 11-2 The possibility of virtual reality in data management:

The data-centric smart city concept consists of a set of data sources. And computing techniques to identify and evaluate various urban characteristics and to update. Better future urban developments. Virtual reality helps in many aspects of spatial information management and development urbanization such as urbanization management, land use planning, infrastructure spatial data, and finally geographic information systems that are created on the Internet.

### 11-3 Places of virtual reality in the perception of transportation of the city

Traffic and efficient transportation are important topics in sustainable cities, and there are different ways to collect traffic and transportation data such as smart cards mainly used in smart public transportation, car trackers, smart camera systems to control traffic, and smart pedestrian sensors to achieve these goals. that Virtual reality helps provide real-time data on traffic, pedestrian conditions, and parking. And the various transportation systems available to reduce traffic problems and major accidents. Virtual reality can also help visualize future smart lanes that increase the efficiency of transportation systems [10].

### XII. THE ROLE OF VIRTUAL REALITY IN DESIGN FOR THE FUTURE CITIES:

Virtual reality is a computer-generated simulation in which a person can interact with an artificial space. Interacting with a 3D environment, virtual reality brings sights, sounds, and sensations through glasses, headsets, sensors, and controllers [11].

In designing cities, virtual reality allowed designers to imagine spaces and buildings before implementing them. To evaluate advantages and disadvantages and conduct...
simulation tests. Such as (weather - social contact - air flow - wasted energy) [12].

Therefore, we will know how each building behaves, how much energy it wastes, and the amount of pollution emanating from each building. Accordingly, it is treated in the available ways. This will make building models from virtual reality more environmentally friendly, and thus produce sustainable cities [13].

AI can be used to improve the performance of designers in architectural and structural engineering. The design process in a virtual environment may be complex, but to overcome this problem, another methodology can be used. It is a design methodology that focuses on the user and his needs and how to achieve comfort with sustainability and ease of use.

And the user's behavior and feelings towards the building and collecting notes and identifying them and modifying the design accordingly.

The world of virtual reality helps to understand the consequences of design schemes from multiple perspectives. Planners can assess the impacts of new developments on cities in terms of transportation patterns, environmental consequences, infrastructure, and other facilities. Planners can also assess the social, cultural, and behavioral response, which facilitates a good evaluation of plans in the design of cities.

Data visualization through virtual reality provides sufficient information about the cities that will be implemented and raises the concerns, desires, and empirical knowledge of the communities. Thus, the development of policies in future planning and these considerations can avoid negative consequences in cities.

The basic benefits of using virtual reality in Designing smarter cities includes: the ability to evaluate ideas Design at the right time and within a three-dimensional space. during the design and planning phase, Effective communication between various stakeholders, academics, and professionals, and provide a large amount of time by taking the guesswork out of Design, and the integration of all aspects in the design, thus achieving a sustainable city design with flexibility and less amount of time; Encourage participatory planning. The main challenge in the application of virtual reality in planning Urban is the cost.

Fig 6. A picture showing how to coexist with a virtual city.

XII. DESIGN METHODOLOGY USING VIRTUAL REALITY TO HELP DESIGNERS DEFINE DESIGN PATTERNS:
1- The design pattern is determined based on the behavior of the occupants and the orientation towards a design that directs users to more efficient behavior in the use of energy.
2- The behavior of the occupants can be monitored through virtual reality and evaluate the behavior, thus setting a new style for the design.
3- Virtual reality can be used to analyze the energy requirements of the building and the engineer can plan to improve the energy system of the building. Determine the best devices to be used in buildings to save energy.

And improving the solar energy system for the entire city in terms of testing the direction of the building during the different hours of the day to obtain the best orientation for the buildings [14].

XIV. EXAMPLE OF A VR CITIES:
In this part we will show an example of a hypothetical city with the aim of identifying the most important roles of virtual world applications in architectural design.

14-1 Zaha Hadid Architects designs virtual Liberland Metaverse city.

The British studio of architect Zaha Hadid created an urban electronic city named after (Liberland Metaverse Virtual City). It is an exact copy of the Republic of Liberland, where Zaha Hadid develops the entire city through virtual reality technology.

Where people can access any place in the new Liberland via virtual reality technology, and people can visit buildings designed by architects, including the square, exhibition center and town hall.

The architects of Zaha Hadid's office designed all the buildings in a graceful, zigzag style with rounded corners. And the city hall contains a runway, a ladder wrapped around it from the inside, and the Liberland flag can be seen hanging on the wall.

People can also buy plots of land in the virtual city and if they do so they will have a share in the real Liberland. Virtual
reality allows engineers to create and develop cities like real cities as well, or to create new cities that have not been designed before[15].

Fig 7. ZHA is developing a city in the metaverse called Liberland.

XV. COMPANIES SUPPORTING VIRTUAL REALITY IN EGYPT:

The country is currently tending to use modern technologies and technology in all its needs. In addition to the state's tendency to establish smart cities that are planned so that previous mistakes are not repeated in the old cities. Whether from poor planning, design, or the impact of buildings on the surrounding environment and energy saving. Poor planning, design, and lack of future vision for projects before implementation resulted in crowded cities and negatively affecting the environment.

Virtual reality technology entered Egypt in 2009 with two companies: Talaat Mostafa Group (TMG) and Nasr City Company (MHND). And they used this technology to show their projects and give the user a unique experience.

15-1 The city of Celia

Is in the new administrative capital. On an area of 500 acres, and before its implementation, the real estate developer, Talaat Mostafa, created a virtual city that matches the design drawings of the city. This is for presentation to clients, as well as for studying the design and discovering problems before starting to build.

Fig (9) studio is used so that students can evaluate their design on the environment.

15-2 A virtual reality studio in the American University

In 2022, when the COP27 climate conference was held, the American University announced the use of a virtual reality studio model to assess the impact of students' architectural designs on the environment. This is a studio that combines green architecture with virtual reality. This studio is used so that students can evaluate their design on the environment. And to ensure that their designs do not negatively affect the future user. This is by presenting problems and addressing them, whether by reducing the emission of co2, by adding trees or installing solar panels. Thus, achieving sustainability[16].

Fig 8. The use of virtual reality technology when marketing the city of Celia in 2020
Egypt announced the implementation of the first Egyptian virtual city, which is the city of (Meta Tut), to combine the greatness of history and the creativity of the future. The idea of the city depends on people moving to the world of ancient Egyptian civilization through simulation, and the name of the city (Meta Tut) was chosen in relation to the era of King Tutankhamun. What if Wahad Tut came to our time to complete his dream of building modern Egypt? [17] The city was designed in the ancient Egyptian style, but in a modern way, without pyramids or temples or tombs. Residents practice all areas of life within that virtual city. The entire city was designed by a team of 100% Egyptian engineers, and this is a good start for designing future cities using virtual reality technology.

Siemens company also opens the first center for smart city model technologies in Egypt. The center offers an experience that combines the real and virtual worlds and moves from the theory of the smart city to the reality of smart technology. The center reviews the latest technological solutions and applications to establish infrastructure, buildings and industries in smart cities that are sustainable and efficient. The Smart Cities Experience Center is located at Siemens’ headquarters in Cairo. Visitors can realize the benefits of transforming our current communities and cities into smart cities, and they can also view the latest technological solutions for smart infrastructure for cities and buildings, including low and medium voltage electricity supply lines, energy management methods, smart solutions for energy distribution, and SCADA systems for managing water facilities Natural gas and electricity [18].
These smart infrastructures and the huge amount of real and geo-localized data generated by the tools we use will drive the use of augmented reality in the government sector.

Augmented reality can only achieve the desired value and result in the government sector when it is based on real data, whether this data is made available through open government data initiatives that are beginning to spread in large numbers, sensor-based networks, and infrastructures, or through the collection of massive amounts of data.

By integrating smart infrastructure, big data, and open data, government sector entities at all levels can begin to shape smart cities and smart solutions. Also, imagine a world where individuals and companies can “see” planned government business projects and interact with them via augmented reality devices, such as highways, water and energy utilities, public parks, transportation lines, new stations, and more.

XVII. ADVANTAGES OF USING VIRTUAL REALITY TO DESIGN SMARTER CITIES:

1. The ability to evaluate design ideas in a three-dimensional space in the planning and design stages.
2. Effective interaction between various engineering disciplines and users
3. It saves a lot of time.
4. Integration of all features in the design, thus achieving the design of sustainable cities (19)

XVIII. CONCLUSION:

The use of virtual reality in the design and planning of projects is one of the main and interesting uses in the field of architecture. Virtual reality merges virtual information with the real world, allowing engineers and designers to view 3D models and technical details of projects in an enhanced and realistic way. Virtual reality applications are used to display proposed buildings and structures in a detailed and realistic way, and they can be moved and interacted with in different ways. With virtual reality, engineers and design teams can analyze and evaluate spaces and technical details more accurately and realistically. Engineering and technical information is displayed prominently and easily accessible, helping to make accurate and appropriate decisions in the early stages of design and planning. In addition, clients can use virtual reality applications to explore and review proposed projects before actual construction begins. This interaction with the 3D models allows them to see the potential outcome realistically and in detail, so they can clarify the vision and identify any modifications or improvements before the construction process begins.

Thanks to virtual reality, the communication and collaboration of design teams and work in the construction industry is enhanced. This integration allows them to exchange information seamlessly and efficiently, and to jointly clarify designs and technical details. Engineers and designers can move and alter 3D models in real-time, directing teams to execute tasks precisely according to set standards. This enhances interaction and coordination between work teams, and thus reduces errors and discrepancies in the design and implementation processes. In short, the use of virtual reality in designing and planning projects is a revolutionary transformation in the construction industry. Contributes to improving design quality, improving interaction and communication between work teams, and facilitating early decision-making. The ability to display 3D models realistically and in detail enhances understanding and brings better compatibility between engineers and customers. Thanks to this innovative technology, project design is optimized, and potential risks and errors are reduced, which ultimately leads to more accurate results and efficient implementation of construction projects. Egypt has begun to use this technology, but it is still in its infancy and in limited places. Despite that, we hope that the state will pay attention to using this technology and allow it to be used in all fields and engineering companies because of its merit in improving future cities and producing more sustainable and smart cities. “What ifs” and helps governments and stakeholders of communities to be aware of the wonderful environmental impacts of their decisions.

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