Digital Twinning as an Approach to Promoting Real Estate Projects: Residential Unit at the Lake West, Sheikh Zayed City, Cairo, Egypt

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Abstract

The digital twin concept, as well as Cyber-physical systems (CPS) and internet of things (IOT)-based techniques, are becoming increasingly relevant themes in future industry 4.0 architecture. They have a high dynamic potential in intelligent production control, well traceability planning and as as part and documentation. According research, Digital Twins (DTs)to artificial intelligence technology technology and (AI)offer considerable advantages in the classification of transportation infrastructure and the management of transportation spatial information networks. The intelligent development of transportation infrastructure is analysed and predicted in functional design, intelligent development, and effective integration with new media, with the goal of providing a reference for future intelligent development and construction of transportation infrastructure in smart cities.

This research focuses on the impact of digital twin technology on architecture and real estate professions. The purpose is to assess how much understanding real estate developers have about digital twin technologies, and to analyse the various tools and functions they bring to the profession. The paper first introduces the notion of digital twin technology and how it first arose, and the significance of it in architecture. Afterwards, the paper offers an analysis of models created with digital twin technologies. Finally, it presents a case study of the Lake West project in which the digital Twin model has been implemented.

The paper concludes that a number of professions, including architecture and real estate, will be impacted by the digital twin, which has come into being as one of the most important emerging technologies. This technology is essential for enhancing the functionality of numerous systems.

Keywords: Digital Twin technologies, physical objects, virtual replicas, virtual architecture, real estate market.

1. Introduction

Smart City technologies such as the Internet of Things (IoT), Cloud Computing, Artificial Intelligence (AI), and Digital Twins (DTs) have become widely used in all aspects of life. The core of the Cyber-Physical System is DTs technology (CPS). It fully utilises data such as physical models, sensor updates, and operation history, integrates the multi-disciplinary, multi-physical, multi-scale, and multi-probability simulation process, completes the mapping in virtual space, and reflects the entire life cycle process of the corresponding physical equipment (Jingyi et al., 2022).

Digitalization has become more prominent in manufacturing operations in recent years. As this trend continues, many firms are confused about how to develop and deliver meaningful values, both operationally and strategically. Digital solutions have the ability to add enormous values to a company. This benefit could not have been realized prior to the development of linked and smart technologies.

The concept of digital twin technology has recently piqued the interest of a wide range of professionals. It revolves around producing a real-time digital image of a physical product or process to help improve its performance.

Due to limitations in digital technological capabilities, as well as high processing, storage, and expense, digital twin technology has remained elusive to large corporations until recently. Such impediments have been much less widespread in recent years. Significantly lower prices, increased power and enhanced capabilities have resulted in exponential advancements that can enable leaders to combine information technology (IT) and operations technology (OT) to construct and operate digital twin technologies (Parrott, 2017).

1.1 Historical Background

The process of reproducing a genuine object, system, or being on a virtual interface is known as digital twinning (Fong, 2016). A fully completed digital duplicate is constructed for future testing, development, and experimentation. It is a digital clone or replica that allows its makers to engage with it via a digital platform rather than testing the original physical "twin" that exists in the real world (Arthur, 2020).

Challenge Advisory sponsored a technological presentation for After Michael Grieves at the University of Michigan in 2003, the concept of digital twinning technology spread worldwide. The digital twin concept gained prominence as a result of this presentation. The lecture focused on the construction of a product lifecycle management center. It incorporated all features of a digital twin, such as actual and virtual space, as well as data and information transfer between the real and the virtual spaces.

While the language has changed over time, the concept of integrating a digital and physical twin into a single entity has not. While the digital twin technology is commonly thought to have been invented in 2002, it has actually been a concept since the 1960s. NASA would use core twinning ideas for space programming at this time. They accomplished this by physically replicating systems on Earth to mirror the systems in space (Vickers et al., 2017).

1.2 The Research Problem

The COVID-19 crisis has had a major influence on the residential real estate market. Due to health concerns and stay-at-home orders, fewer buyers have been shopping for homes and fewer owners were ready to list their properties or allow strangers into their homes during a pandemic. A significant decline in demand for new house sales is usually accompanied by a drop in prices.



Fig.1: Total existing home sales in US. Source: (Haas, 2020).

By the end of 2020, the real estate market had not only recovered, but demand had increased dramatically in many countries around the world. In addition to the pandemic, the Russian-Ukrainian war had caused a severe recession due to the temporary economic decline. The recession has also affected the Egyptian real estate market. The real estate sector had not received the same attention from the government, and the Central Bank of Egypt had not delayed the payment of sector debts or reduced interest payments on loans. The property market in Egypt is still struggling, with a nationwide inflation-adjusted real estate index that fell by a staggering 12.35% from Q3 2022 to Q3 2022, following a 14.09% year-over-year decrease in the prior quarter. Real home price decline was 1.14% in Q3 2022 as compared to the previous quarter. In spite of a sharp rise in inflation, housing prices climbed nominally by a negligible 0.81% from Q3 2022 to Q3. Annual inflation surged to 18.7% in November 2022, which is significantly higher above the central bank's goal range of between 5% and 9% and the highest figure since December 2017 (Polavieja, 2023).

1.3 Research Aims & the Objectives

This aim of this research is to introduce the vital role of the digital twin technologies to the real estate developers and ascertain its impact on the market through the following objectives:

- Define the notion of digital twin technology and explain how it originated.
- Distinguish between digital twin technology, virtual reality, and augmented reality.
- Determine the impact of digital twin technology on architecture and the real estate businesses.
- Examine various instances of models built with the digital twin technology.
- Determine how familiar Egyptian real estate developers are with digital twinning technology.
- Examine one of Egypt's initiatives that uses digital twin technology.

1.4 The Research Methodology

This study employs both qualitative and quantitative methods. The research is divided into two sections. The first section relies on surveying the literature of linked sources by researching several primary and secondary sources dealing with the topic of digital twinning. It also analyses the various projects created with digital twin technology. This will aid in the creation of an overview of this technology.

The second section includes a case study in Egypt. The case study concentrates on one of Egypt's mega-projects, the Lake West project, which has a virtual counterpart created with the digital twin. This case study employs a

questionnaire administered to the real estate developers to assess their knowledge of digital twin technologies.

1.5 Research Questions

The research questions are:

1. What are the various tools and capabilities that can be added to the digital twin model to improve it?

2. How knowledgeable are today's Egyptian real estate developers about digital twin technology and its potential market impact?

2. Digital Twin

The fundamental idea of the Digital Twin model has stayed mostly unchanged since its debut in 2002, despite changes in the terminology over time. It is predicated on the notion that an independent entity could be established from a digital informational construct about a physical system. This digital data would be a "twin" of the data that was contained in the physical system itself and would be connected to that physical system for the duration of the system's existence (Vickers et al., 2017).

2.1 The Origin of Digital Twin

The concept of digital twinning dates back to the early 2000s, when Michael Grieves discussed his PLM (Product Lifecycle Management) presentation at the University of Michigan. In his presentation, he proposed that each system be made up of two systems: an existing physical system and a new virtual system that retained all of the physical system's information. This meant that physical systems were mirroring or twinning virtual systems, and *vice versa*.

2.2 Values of the Digital Twin Model

The fundamental tenet of the Digital Twin model is that information may be used in the place of wasted resources like time, energy, and material. Our society is monetized, so we may charge for labour time, material prices, and energy costs over the course of the project.

The Digital Twin derives its value from the planning, design, construction, commissioning, operation, and disposal phases of the real estate. The Digital Twin has the ability to significantly reduce the number of resources that are wasted throughout the lifecycle of our systems, averting an emergency brought about by the undesirable emergent behaviour with uncontrollable repercussions (Vickers et al., 2017).

2.3 Relation between Digital Twin & Architecture

Architecture has also benefited from the possibilities of digital visualisation for marketing research. Virtual tours, which enable users to be immersed in the simulated spaces through 3D virtual walkthroughs, such as Redfin and Sotheby's, employ virtual reality (VR) technology to create tours that immerse customers in a simulated environment and let them explore a home in three dimensions (Sihi, 2018). Additionally, research with prospective homebuyers in Taiwan shows that VR improves their comprehension of the housing project being built and increases their desire to acquire the home (Juan et al., 2018). However, their study revealed issues with potential homebuyers' VR satisfaction and the limited acceptance of the technology for future housing sales by local real estate developers. According to Juan et al. The loss of satisfaction among potential homebuyers with the use of virtual reality for pre-sales of properties may be attributed to the fact that the process of buying a home includes a significant financial transaction and calls for a person to be highly emotionally involved. Although previous research has shown that VR

applications can improve user experience and visualization of the built environment, at the moment, a new generation of technology is sweeping the world's marketplaces. As a result, organizations who are wise enough to begin embracing the new technologies for testing and development are more likely to survive and improve the efficiency of their products and services (Miskinis, 2018).

Digital twinning can be extremely beneficial in architecture and construction industries. When creating an office building, for example, a digital reproduction of the complete structure will be created at the end of design and construction, along with replicas of all the systems involved with this office, such as its HVAC system. Unlike a digital model or simulation, a digital twin is not static. The digital twin of any building lives, grows, and provides fresh insights from the start of the project to the end of its life cycle. This contributes to a higher ROI (return on investment), energy savings, project maintenance, and performance.

The building's digital twin evolves over time, exactly as its physical counterpart does, as people begin to use it. As a responsive system, the digital twin will change as new information from artificial intelligence is gathered (AI), sensors, and the Internet of Things becomes available (IoT). This indicates that the digital twin can mimic and forecast intelligent decisions depending on the real-world properties of a building (Jones, 2021)

Apart from investing in digital twin technologies to take advantage of it, no further costs will be necessary. This implies that a company can run hundreds of tests with the use of the digital twin and by employing qualified individuals who can efficiently run these tests. After applying the needed tests, the gathered data by digital twinning will help in forecasting any future software conflicts and prevent product failures in advance. This will save the company a lot of unnecessary costs (Miskinis, 2018).

2.4 Difference between VR, AR, and Digital Twin

(1) VR (Virtual Reality)

Virtual reality refers to engaging in digital worlds that are very different from the real world. Some of the most common uses of VR applications are in police training and sports training. The user is completely immersed in the digital environment in virtual reality, with no interaction with the physical surroundings. To use the VR system, the user needs to have access to appropriate platforms as well as compatible VR equipment (VR headset) (Rosli et al., 2010).

(2) Augmented Reality

Augmented reality is characterized as a blending of the physical and digital worlds. The incorporation of some digital components in augmented reality enhances the real-world environments. The user can capture the live view with the camera and then overlay digital features on top of it. The most well-known example of AR is the game Pokemon Go. Users can participate in AR-based applications even without a camera because many applications simply layer digital components on top of live footage to entice the users (Rosli et al., 2010).



Fig. 2: Illustration for the concept of Virtual Reality and Augmented Reality Digital Twin. Source: (Parida et al., 2021) edited by the researcher, 2022.

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A Digital Twin is a collection of virtual information structures that replicate the structure, context, and the behaviour of a single real thing or a group of physical objects. Throughout its life span, the digital twin is constantly modified based on data from its physical twin (Arthur, 2020).



Fig.3: Explanation for the Digital Twin Concept. Source: (Boton, 2020) edited by the researcher, 2022.

3. Analytical Examples

The following analytical examples introduce applications of digital twining for Shanghai East Hospital, digital visual representations for buildmedia, and data read-out for Project SCENe, as these projects feature aspects of digital twin.

Buildmedia's team is well-known for developing visual copies for many global architecture projects. Their mission is to create the most amazing visual experiences the world has ever seen by bringing unbuilt architectural conceptions to life, ranging from flats to master-planned cities (Rosenboom, 2022).



Fig. 4: The interface of the Buildmedia. Source: (Rosenboom, 2022).

3.1 Shanghai East Hospital

An A-grade general hospital with ties to the Tongji University is the Shanghai East Hospital, which is situated in the Lujiazui economic district of Shanghai, East China.

The term "continuous lifecycle integration approach," which refers to a precise timetable that directs the integration of appropriate material gradually and punctually over the complete lifespan was used to describe the key technical innovations used in this case study (Peng, 2020).



Fig. 5: Main steps from real-world hospital to Digital Twin. Source: (Peng, 2020)

The outstanding DT project at East Hospital, which has been functioning for more than a year and is thought to be performing as anticipated.

- (1) A poll revealed a 10% increase in management satisfaction compared to the old clinical facility.
- (2) It was predicted that the entire energy consumption would decrease by around 1% annually.
- (3) DT diagnosis prevented more than 10% of facility issues and requested repairs.

3.2 The Sanctuary – The Mount Pleasant

Buildmedia's most comprehensive offering has been the Sanctuary project. It is also thought to be Australia's fastest-selling property in Perth. Buildmedia's Realspace marketing package exceeded expectations (Rosenboom, 2022).

In this, the customers can easily understand the structure based on the interactive model. Thus, meetings that are scheduled to last half an hour are stretched to one and a half hours, which is a good thing because it signals that the buyers are more interested and educated.

Buildmedia created a realistic, engaging virtual tour for this project that house buyers may walk around and explore using a tablet interface or virtual reality. The tour includes five distinct types of apartments, as well as the lobby, the gym, and the common rooftop. The colour palettes of the interior spaces can be changed by the users. They can then email themselves rendered high-resolution photographs. In addition to the interactive tour, Buildmedia created over 200 architectural renderings and around 20 minutes of 4K film.

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Fig. 6: An illustration for The Sanctuary- Mount Pleasant project. Source: (Rosenboom, 2022).

3.3 Tools Used in Realspace

When launching any of Buildmedia's projects that have been developed digitally by the Realspace system, a collection of tools appears on the screen of each project's main interface. Each of these tools and their applications are detailed in this section.

1	8	Sections Cut
2		Gallery
3	1 40	Architectural Drawings
4	D	Project's Videos
5	Ø	Virtual Camera
6	0	Moving to Different Spaces
7	<u></u>	Human Eye Navigator
8		Materials Editor
9	z	Measuring Tool
10	₩	Different Levels

Table 1: Different tools Realspace	e.
Source: (Rosenboom, 2022).	

(1) Section Cut

The segment tool is intended to allow customers to cut through the building at the desired spot. This tool allows clients to study and evaluate any location they desire.

(2) Gallery

This tool enables project users to navigate through a collection of previously created rendered viewpoints. The user can get a selection of perspective images for the project's various interior rooms and external elevations.

(3) Architectural Drawings

When using this tool, the client has access to all the architectural drawings associated with the unit he is inspecting. The client can go over the many levels of floor plans to have a better understanding of the unit and all of its various sections.

(4) Project's Video

This tool showcases previously created films that were developed, rendered, and made available to the customers in seconds.

(5) Virtual Camera

Clients can use this tool to capture quick rendered images for the locations and perspectives that best suit their needs. Clients can then register their email addresses to receive the rendered viewpoints through email, allowing them to review the units at any time.

(6) Moving to Different Spaces

This feature allows the clients to conveniently access the unit's many sections. When you click on the symbol, the names of the neighbouring regions appear, pushing on them will transport the client into these areas effortlessly.

(7) Human Eye Navigator

The application enables the consumers to browse through the various regions of the units while viewing them through the perspective of a typical human being. This means that the sight level's height will be measured in respect to the average human height.

(8) Material Editor

Clients can select from a variety of materials that have already been created for the majority of the units' objects. This implies that the clients can quickly and remotely decide on the material requirements to be utilized during the interior finishing process. They can select from a variety of colours, patterns, and textures on various surfaces and objects.

(9) Measuring Tools

The client may measure the height, length, and width of any object while remaining in real-time digitally generated units.

(10) Levels

This tool allows the clients to inspect the same unit from several height levels, allowing them to explore the surroundings and view from each level. The consumers can then easily select the floor in which they want to purchase the home.

3.4 Project SCENe, the Trent Basin Project

Understanding the relationship between technological innovation and community participation is a vital component of the Trent Basin development project in Nottingham, UK. The Trent Basin Development Project includes Project SCENe (Sustainable Community Energy Networks). It is a sustainable community energy project supported by Innovate UK and the Energy Research Accelerator (Woods, 2019).



Fig. 7: Project SCENe. Source: (Rodrigues, 2019).

SCENe intends to accelerate the development of community energy systems as a novel way to generate and distribute locally generated heat and power to the households and the businesses. The key advantages of this project are cheaper prices and more efficient use of distributed renewables, which reduce overall carbon dioxide emissions from the energy system. Energy storage technologies increase efficiency and provide services that aid in the maintenance of the power grid. The project includes photovoltaic panels as well as local thermal energy production.

The Trent Basin-Community Information Model (TB-CIM) is an interactive online system that displays historical and real-time energy data for the Trent Basin community. The major purpose of this visualization tool is to engage community members by teaching them about collective energy generation, storage, and consumption. It also attempts to encourage public participation in the community energy system by disseminating project outcomes. This platform displays the energy performance details of the community's individual buildings and utilities. The platform is linked to real-time and gathered energy data, as well as analysis tools that allow users to interact with their energy systems in novel ways.



Fig. 8: The multiple touch wall screen located at Trent Basin community hub. Source: (Rodrigues, 2019).

Residents can gain access to community energy data to help them make better decisions and contribute to the overall optimization of the energy scheme. Residents can utilize the web platform or a communal touch screen to compare the level of consumption of any household to the average community consumption, evaluate the quantity of energy produced and sold by the project, and check other real-time information such as the weather.



Fig. 9: Project SCENe's interface. Source: (Woods, 2019).

Integrated Environmental Solutions (IES) assisted in the building of the 3D digital twin model for the Trent Basin development project's first phase. It is a digital model that allows viewers to observe extraordinary levels of detail in real time. People can track the energy consumption of specific households. By clicking on them, they may also monitor the heat and air movements within the dwellings. More importantly, residents may do the same to save money on their bills (Macdonald, 2019).



Fig. 10: Digital image of the Project SCENe's buildings showing the solar energy being gathered. Source: (Macdonald, 2019).

Sensors strategically positioned throughout the site feed real-time data to the digital duplicate, such as the amount of solar energy collected locally and the amount of stored power. The project includes Europe's largest shared battery, a gigantic urban solar farm, and several energy-efficient residences. The project's digital twin has been created to demonstrate an interface that mirrors the project's evolution, while collaborating with IES to create something interactive as well as visually beautiful. Their key goal is to make it very clear and straightforward for the users to understand how the systems run and function.

4. The Case Study

The case study consists of two sections. The first one introduces a project produced with the visual representation aspect of digital twin technology in order to compare and evaluate it with the examples discussed in the previous section.

The following section presents the findings of a study done to establish how well the Egyptian real estate developers comprehend digital twinning technology.

4.1 Lake West Sheikh Zayed City

One of initiatives of Cairo; the Capital of Egypt is the Lake West Sheikh Zayed. It's a completely new perspective on a luxury gated community. The Lake West townhouses and villas have been thoughtfully constructed with exquisite features in every way. The Lake West Masterplan is designed with elegance in mind at every turn. Nature inspires the project's lines, which are blended with the modern architectural components.

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Fig. 11: The Lake West Project Masterplan. Source: (Selim, 2021).

4.2 Exterior Tools of the Lake West Model

The main model interface has five major categories, all of which are used to improve the client experience. Clients can quickly navigate through these five categories in order to select the units that meet their needs. Home, Gallery, Surroundings, Amenities, and Unit Search are the five categories. The components of each category will be briefly explored below.

4.2.1 Home category

The home category is the first in the Lake West interface. It includes a series of tools that allow users to engage with the model more effectively and get relevant and effective data about the compound and its units. The home category contains seven major tools. The use of each of them are discussed below.

1	-`Ċ´-	Sun Path Controller
2		Quality Controller
3		Resolution Controller
4	ð [:] .	Weather Tool
5	To a	Drone Navigator
6	É	Car Navigator
7		Virtual Camera

Table 2 : Seven major tools for home Category.
Source: The researcher, 2022.

(1) Sun Path Controller

Customers can use this tool to analyse the quantity of sunlight that enters their unit at different times of the day. As a result, customers can decide whether or not the apartment they intend to purchase receives an adequate amount of natural light. The program enables customers to see how their unit appears during the day and night.

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Fig. 12: A figure showing the effect of the sun path controller. Source: (TechnoVision, 2022).

(2) Quality Controller

While traversing the Lake West project, the quality controller allows clients to select the quality they want to use. This selection is based on the power of the device used to launch the project. The levels of quality include low, medium, high, epic, and custom-built.

(3) Resolution Controller

Customers can use this tool to select the quality of the photographs and perspectives that they want to export. They can choose between 640x360, 960x540, 1280x720, and 1920x1080 resolutions.

(4) Weather Tool

This program is linked to the Google Weather application; thus, it provides real-time accurate meteorological parameters for weather data of the day. Clients can use this tool to determine the current temperature in the Lake West project area, the number of clouds in the area, the humidity level, and the wind speed.

(5) Drone Navigator

It is a navigation gadget that is used to fly through the Lake West compound in order to examine it from above. The upper view gives the clients a broader perspective. It also helps the users to browse the entire project faster than the traditional navigation tools. Clients can measure anything they desire, such as the height of a structure or the width of a pathway.



Fig. 13: Showing the drone navigator of the Lake West model. Source: (TechnoVision, 2022).

(6) Car Navigator

This is yet another method for navigating the Lake West model. It has two applications. The first method is to consider the client outside of the car, gazing directly inside the car and its surroundings. The second method is the first-person view, in which the client is supposed to be inside the can and can only observe the surroundings of the car.



Fig. 14: The first and third person views for the car navigator in the Lake West model. Source: (TechnoVision, 2022).

(7) Virtual Camera

The virtual camera tool is used to capture real-time rendered screenshots in real time. Clients can manage the angle of their choice and change the level of perspective to present the details they want before pressing the virtual camera tool. Following that, the rendered perspective will be collected and saved to a specific file on the user's device.

4.2.2 Gallery category

In the gallery category, clients are shown a collection of ready-made and previously created rendered images. These graphics assist the clients in developing an overview of the entire project before they browse it.



Fig.15: The gallery category. Source: (TechnoVision, 2022).

4.2.3 The Surroundings

Customers can explore the external regions surrounding the Lake West project in this category. This category allows them to locate nearby malls, hospitals, schools, and universities, as well as close modes of transportation.

4.2.4 The Amenities

This category informs the users about the services available inside the Lake West project. It depicts the placement of various project facilities such as leisure, fitness, transit, and restaurants. As a result, clients can select an appropriate location for their units depending on the available neighbouring services.



Fig. 16: An illustration for the amenities category. Source: (TechnoVision, 2022).

4.2.5 Unit Search

Clients can use a comprehensive search feature to find the unit that best meets their needs. The unit search function enables the clients to specify the unit's requirements based on a variety of characteristics. They can specify the size of the unit, the price range that works for them, and the type of unit based on the number of rooms they require.

Clients can also select whether they want their units to be in the first or second phase. Clients can also select the orientation of the main facade of the units. Once the clients have specified all of their requirements, the digital platform will filter the results and highlight the units that meet the criteria.

When clients click on the highlighted unit of their choice, a window will appear with all of the unit's details, including a gallery with rendered views and the floor plans of this specific unit. If the client hits the (GO) button, the platform would transmit the entire view into the front door of this apartment, allowing them to explore it.

Customers can verify the availability of apartments via the unit search. It depicts the units that have been sold, those that have been reserved, and those that are still available, and highlights each group with a different hue. As shown in Fig. 18.



Fig. 17: An illustration for the unit search category & its filtrations. Source: (TechnoVision, 2022), edited by the researcher, 2022.

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It also provides some main categories of the digital twin model as described before and mentioned as shown in table 3

Surroundings						
Malls	Hospitals	School	Universities	Transport		
Mall of Arabia	El Nada	New Manor	Nile	Dahshour road		
Galleria 40	Dar El Fouad	Beverly hills	Misr	Road el farag		
Arkan Plaza	Global Care	New Vision	MSA	High speed train		
Capital Business Park	Souad Kafafi	British International	6 of October	Cairo-Alex Desert Road		
Amenities						
Leisure	Fitness	Transportation	Restaurants			
Kids areas	Tennis		Restaurants			
Plaza	Football	More Parking areas				
Clinics	Cycling track	auueu	Sky Lounge			
Unit Search						
Surface	Budget	Туре	Orientations	Availability		
Min: 150 m ²	Max: 10,000K	Phase 1				
		L V T W		Available		
150 to 445	500 to 10,000	Phase 2	N E S W	Reserved		
		V V T A		Sold		
		T-B T-C W				

Table 3: Illustrates the surroundings, amenities, and unit search of the Lake West Project.Source: The researcher, 2022.

4.3 Interior Tools of the Lake West Model

Making extremely realistic interior settings, the degree of clarity and realism provided for the various textures and materials in this is intended to give the consumer the sensation of exploring a real place. A large number of internal tools and features were finished coding and saved for later usage. As soon as the project owner asks them, the tools are ready to use and integrate into any project. Despite the fact that these tools are ready to be used and can be simply integrated into any project, owners should only utilize them when they wish to save time and effort. Some examples for the tools that can be further implemented to the Lake West model are:

(1) Day and Night Mode

Customers can choose whether to navigate about the interior area in day mode, when natural light will permeate the interiors, or night mode, where artificial lighting will provide the majority of the light within the space.



Fig. 18: The day and night mode. Source: (TechnoVision, 2022)

(2) Project Video

Customers can utilize the video tool to check numerous ready rendered films made specifically for the project's interior areas while travelling through the interior spaces. Furniture Editor

With this tool, the clients can adjust the type, form, and materials of the numerous furniture pieces in the interior sections. The tool displays a list of the many pieces in the region; by clicking on the name of the item, various alternatives for each piece are displayed.



Fig. 19: The furniture editor tool. Source: (TechnoVision, 2022).

(3) Material Editor

This application enables clients to build the material that best meets their requirements. Instead, then selecting from a list of pre-made materials, this application allows clients to design their own materials by specifying the exact type, texture, and colour shade for each piece of furniture.

(4) Measuring Tool

The measure tool allows clients to measure the length and width of any surfaces or distances that exist within the model space's internal bounds. The tool assists the customer in developing understanding into the proportion of the interior space and its relationship to the furniture components.

4.4 Conclusion Tools and Functions

The Lake West concept includes a number of exterior tools that enhance and complete the clients' excursions across the project. Since these tools are simple to use and easy to understand, they help clients grasp the Lake West project. Although the interior portions of the Lake West project are supposed to be quite realistic, the interior tools used are relatively limited as shown in Table 4.

Lake	Lake West Tools and Functions				
No	Implemented tools				
1	Sun path	7	Virtual camera		
2	Quality	8	Gallery		
3	Resolution controller	9	Surroundings		
4	Weather tool	10	Amenities		
5	Drone	11	Unit search		
6	Car navigator	12	Provide realistic details in real-time		

Table 4: Conclusion of tools and functions.Source: The researcher, 2022.

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	Tools and Functions to be implemented on demand
1	Day and night mode
2	Project's videos
3	Furniture
4	Material editor
5	Measuring tool
6	Turning appliances on/off

4.5 Assessment of Tools and Functions

The Lake West model incorporates the majority of the tools utilized in the prior digital twin models. Other tools are not currently in use, but if clients want them, they are available. The Lake West model is missing a number of internal tools as shown in the following table 5.

Asse	essment for the lake west r	nodel's tool	ls					
No	Tools							
1	Section			12	Resolution	controller		
2	Gallery			13	Quality con	troller		
3	Architectural drawings			14	Weather to	ol		
4	Project's videos		0	15	Drone			
5	Virtual camera			16	Car navigat	or		
6	Moving to different spaces		0	17	Surrounding	gs		
7	Human eye			18	Amenities			
8	Material editor		0	19	Unit search			
9	Measuring tool D 20 Day and night mode							
10	Levels		0	21	Furniture e	ditor	0	
11	Sun path controller			22	Turning app	oliances on/off	0	
	Functions							
1	Present real-time information I	ike the weathe	er					
2	Measure the energy the project	ct products and	d sell	S			0	
3	Monitor the energy usage and	performance					0	
4	Provide realistic details in real time							
5	Monitor the heat flow							
6	Monitor the air flow							
7	Measure the quantity of solar energy gained							
8	Measure the amount of stored power O							
Imple	emented	Not Impleme	ented			To be implemented on dema	and	

Table 5	: Assess	sment of	tools a	nd funct	ions
5	Source:	The resea	archer,	2022.	

4.6 Project Survey

A survey was conducted and distributed to a range of developers who attended the National EXPO 2021 conference to assess their knowledge of Digital Twin technology in the Egyptian real estate market. The survey included many questions on digital twin technology in general, as well as questions about the Lake West model specifically. The participants were shown a video of the Lake West model and asked to estimate the cost of constructing a similar model with equal tools and features, as well as the file size, time it took Techno Vision to develop the model, and a number of other questions all relevant to the Lake West model.

Following the conclusion of the survey, an interview with Techno Vision's office was scheduled in order to acquire correct information about the Lake West model. After collecting

all of the data from the survey and the interview, the data was examined and compared in order to form a conclusion on the developers' expectations for digital twin technology.

4.6.1 Survey Location and Time

During the National EXPO 2021 meeting, the poll was conducted at the Triumph Hotels. The event was held on November 26th, 2021. 40 of Egypt's most famous development firms attended the meeting. These businesses are all involved in the real estate industry. They were all there to promote their most recent successful endeavours.

4.6.2 Introducing the Survey Sample

This survey included a total of 16 different organizations' employees. The majority of the participants are from ADC Development and work in sales positions.

4.6.3 Survey's Answer Analysis

The survey questions, as well as the responses collected from the survey participants and the accurate answers gained from Techno Vision, are presented in this section.

Table 6: Awareness of Digital – Twin.

Source: The researcher, 2022.

1. Have you heard about "Digital-Twin" before?	
Yes	No
29.2%	70.8%

The percentage of the people who are unaware of digital twinning technology is higher than the percentage of those who are aware of it. This suggests that more studies and seminars should be conducted to explain this technology and differentiate it from VR, as many people confuse the two.

Table 7: Using Digital – Twin for clients.

Source: The researcher, 2022.

2. Do you prefer to present your work to clients via online or offline means, and why?				
Online	Offline			
71.0%	29.0%			

In order to save clients' time and provide more accurate data, 71% of those who responded to the poll prefer to use online means. On the other hand, 29% of the sample prefers to use offline means to better understand the clients' needs and to communicate more facts with them.

 Table 8: Duration taken by Digital – Twin to develop the lake west model.

 Source: The researcher
 2022

Bouree. The researcher, 2022	· ·			
3. How long do you believe "Techno Vision" took to develop the Lake West model?				
Samples' Answers			Techno	
1 to 2 months	2 to 3 months	More than 3 months	Vision's Answer	
54.2%	12.5%	33.3%	1.5 Months	

More than half of the participants correctly anticipated that Techno Vision constructed the digital twin model in one to two months. According to Techno Vision, the digital twin for the Lake West project was produced in exactly 1.5 months. 12.5% thought Techno Vision took 2 to 3 months to complete the model. While 33.3% said it took more than three months.

Table 9:	Number of participants develop the lake west model.
	Source: The researcher, 2022.

4. How many people do you think it took to create the Lake West model?			
Samples' Answers			Techno
2 to 4 poople	5 to 10	11 to15	Vision's
2 to 4 people	people	people	Answer
41.5%	41.5%	17.0%	5 People

41.5% of respondents thought the model was created by two to four people. Another 41.5% estimated that Techno Vision would need five to ten people to finish the Lake West model. While the majority of people believed that more than 15 people worked on the model, Techno Vision said that the Lake West project model was created by only five people.

Table 10: Average of the file size of the lake west model.Source: The researcher, 2022.

Source: The researcher, 2022.			
5. Can you guess the file size of the Lake West model?			
Samples' Answers		Techno	
2 to 3 GB	3 to 5 GB	More than 5GB	Vision's Answer
58.4%	20.8%	20.8%	80 GB

The participants were asked to anticipate the file size of the Lake West Project, which Techno Vision gave to Cairo Capital. The majority of participants, 58.4%, believe that the file size ranges between two and three gigabytes. Surprisingly, Techno Vision revealed that the Lake West model is approximately 80 GB, exceeding all expectations.

Table 11: Model cost estimation.Source: The researcher, 2022.

6. How much do you think it would cost to develop a similar model?			
Samples' Answers			Techno
Less than 1 million	1 to 2 million	More than 2 million	Vision's Answer
54.2%	25.0%	20.8%	400,000 L. E

More over half of those polled believe the Lake West model costs less than a million dollars. 25% of the sample believes the model costs between one and two million dollars, while the remaining 20.8% believes the model costs more than two million dollars. According to Techno Vision, the model costs 400,000 L.E, which corresponds to the majority's response.

Source: The researcher, 2022.			
7. Do you believe that offering digital twinning to clients will be beneficial?			
Very Beneficial	Beneficial	Not Beneficial	
54.2%	45.8%	00.0%	

Table 12: Estimation of Digital – Twin benefits for clients.Source: The researcher, 2022.

When developers were asked if they thought digital twin technology was good or not, 54.2% thought it was very beneficial, while 45.8% thought it was beneficial. None of the developers interviewed were sceptical of the benefits of digital twin technology.

Table 13: The impact of Digital – Twin on company's reputation.

Source: The researcher, 2022.

8. Do you believe that utilizing methods such as digital twinning will promote the company's		
reputation?		
Yes	No	
95.8%	4.2%	

The majority of the participants believe that deploying technologies such as the digital twin will considerably boost the reputations and names of the firms that use them. Only 4.2% of those who surveyed believed that these new technologies would not help firms improve their reputations or value.

Table 14: Percentage of projects need to be developed using Digital – Twin.Source: The researcher, 2022.

9. Do you have a project that you which to develop using the digital twinning technology?			
Yes		No	
58.3%		41.7%	
10. If yes, name the project that you would like to develop using digital twinning technology?			
Loft Plaza	New N	Varges	Vera Tower
11.0%	11.0%		17.0%

When asked whether they had any projects they would like to develop using digital twin technology, 58.3% of the developers answered they had. While the remaining 42.7% lacked acceptable projects. Participants were also invited to suggest initiatives that would benefit from the use of the digital twin. The Vera Tower, Loft Plaza, and New Narges projects are the three most prominent developments.

Table 15: The ability of Digital – Twin to satisfy the client's needs.Source: The researcher, 2022.

11. Do you think that using the digital twinning alone is sufficient to meet the clients' needs		
and illustrate everything for them, or the digital twinning has to be c visualization techniques?	ombined with other	
Yes	No	
50.0%	50.0%	

Half of the participants believe that digital twin technology is sufficient on its own and can meet the needs of the clients without the use of any other measures. The other half, however, believes that digital twin technology is insufficient on its own and must be supplemented with other visualization approaches such as generated viewpoints, movies, and presentations.

Table 16: The awareness about Metaverse.Source: The researcher, 2022.

12. Have you heard about Metaverse?		
Yes	No	
62.5%	37.5%	
13. Do you think that the Lake West model can be used for the future transformation of		
Facebook?		
Yes	No	
100%	0.00%	

The findings of these two questions indicate that some of the participants may have been misled by the phrase "Metaverse," which is frequently referred to as "Facebook's future transformation." The two words refer to the same technology, which appears to be perplexing to some developers, as 37.5% of them answered that they had not heard of the Metaverse; yet, all of those participants stated that the Lake West model can be beneficial to Facebook's future transition.

5. Conclusion

The digital twin has proven to be one of the top future technologies that will influence numerous professions, including architecture and real estate. This technology is crucial in optimizing the performance of many systems. Although there are some current limits that prohibit the digital twin from showing all of its capabilities, scientific innovation in the coming years is predicted to deliver various enhanced solutions that will help overcome the majority of these hurdles.

There are several features and functions that may be added to digital twin models to expand and improve the user experience while exploring the models by making them as realistic as feasible. The Lake West project is an example of a successful Egyptian project that used digital twin technology to construct a model. Because of the diversity of tools and alternatives it provides, this project has had a favourable impact on the Egyptian real estate market. This project's model incorporates numerous tools.

It is expected that the addition of these missing tools will increase the overall value of the project. Many functions are also missing from the Lake West model, such as monitoring the heat and air movements and measuring the quantity of solar energy collected. Adding such functions to the model will significantly increase the total value of the project and increase user satisfaction.

The survey results indicate that the current real estate developers have a poor understanding of the concept of digital twin technology, owing to their prior knowledge of similar technologies such as virtual realities and augmented reality, which are frequently confused with digital twin technology. Despite this, the vast majority of these developers are unfamiliar with digital twin terminology or how it works.

The majority of the participants believe in the importance of using online visualization methods and believe they are of great benefit to the real estate market and promote the reputation of the company when used; however, half of these participants stated that they cannot rely solely on these online methods and must combine them with the traditional offline methods they are used to.

The study reveals that the participants can correctly estimate parts of the Lake West model's statistics, such as the time required to construct the model, its cost, and the number of workers required to complete it. However, because the developers are familiar with the industry and its requirements but are unaware of the digital twin requirements, these estimates are more likely based on speculations rather than true knowledge.

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