Immersive Technology as A Tool for Sustainable Architecture

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Abstract. Immersive technology in architecture has begun to be used in the design process. Immersive technology is a computing technology that blurs the boundaries between the real world and the digital world or the simulated world, so that users can feel an atmosphere similar to the real world. Immersive technology includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). This paper discusses how immersive technology can be used as a tool for analyzing sustainable architecture. Methodology in this paper uses a literature study research method, the data obtained are compiled, analyzed, and concluded, to get conclusions about the use of immersive technology in architecture. From several literature studies conducted, it can be concluded that immersive technology can be used as a tool to improve architectural sustainability.

Keywords: sustainable architecture, immersive technology,

1. Introduction

Sustainable architecture is a consequence of international commitments on sustainable development because architecture is closely related and focuses its attention on the human factor by focusing on the main pillars of the concept of sustainable development, namely the aspects of the built environment with the development of its environment, in addition to the pillars of economic and social development. An architectural concept can be said to be a sustainable architecture if the architectural concept can meet the needs of its users at present, without jeopardizing the ability of future generations to meet their daily needs [1]. Sustainable architecture is a response and expression of our existence and a sense of concern for the world around us.

Most of the building evaluations are carried out after completion. At that point, people will have a negative reaction, coming back to make changes that would be either very expensive or impossible at all. By using immersive technology, before a building is built, people can think and feel about a building later, making it easier for them to make design decisions [2].

Immersive technology is a computing technology that blurs the boundaries between the real world and the digital world or the simulated world so that users can feel an atmosphere similar to the real world. Immersive technologies include Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) [3]. Recent developments in immersive technology allow for the visualization of information that was not built into a full-scale livable environment, providing architects, clients, and other stakeholders with insights previously unavailable. These technological capabilities offer the opportunity to communicate and analyze the quantitative and material aspects of design decisions.
related to sustainability and the built environment in an immersive and understandable way, for both architectural and other broader disciplines.

2. Methodology
The research begins by determining the search keywords, then searching the data through the predefined search engine applications. Based on a brief review (title, abstract, research methodology, instruments, and conclusions) of each article taken. The keywords defined were "immersive technology", "sustainable architecture and virtual reality", "sustainable architecture and augmented reality", "sustainable architecture and mixed reality", and "sustainable architecture and immersive technology". The research period is set to be between 2011 and 2020.

3. Results and Discussion
Akin et al. delivered a paper on the design of a mixed-reality environment that supports the integration of architectural design through simulation and design. The environment is integrated through BIM, which is used in architecture and building energy simulation tools. The environment visualizes model designs, BIM data, and simulation results, and interacts with models at multiple scales. The research conducted on the 9 participants in workshops shows that the mixed reality has the potential to provide insight into the design of someone during the architectural design process. The tools used can provide additional perception to simulate the natural lighting and geometry of the building [4].

Issac et al. delivered a paper platform that was used to provide an interface that presented the city in a 3D and interactive virtual manner with overlain sustainability information. 3D virtual urban areas are created using video game techniques and presented to users for later exploration. This technique is used to assess sustainability that is not accessible to stakeholder groups. The trials that have been carried out have shown that the virtual environment is a useful medium for communicating the interdependence of sustainability indicators and for comparing and contrasting planning scenarios [5].

Jamei et al. presented a paper on the use of virtual reality to answer current challenges in creating, modeling and visualizing smart cities through material modeling and light simulation in a virtual reality environment. This study aims to help urban planners, stakeholders, and the public to better understand the role of planning policies in creating smart cities, especially at the initial design stage [6].

Yilmaz presents a conceptual model that focuses on users of the built environment. Its main concern is to meet the needs of the end-user in terms of design size, concerning to social sustainability. This model aims to increase users' understanding of design, help them determine their activity in a particular new building, and increase their involvement in communicating with designers and conducting design evaluations, especially in terms of spatial configuration, and gathering feedback [7].

Delgado et al. presented a paper on the use of augmented reality and virtual reality in architecture and construction techniques. The exploration workshop was conducted involving 54 experts from industry and academia. The study results show that augmented reality and virtual reality can be used in various ways throughout the development cycle. Virtual reality has been more widely adopted than augmented reality, and stakeholder engagement is the most widely adopted use. Although the adoption rate in construction companies is lower, there is high interest in investing in augmented reality and virtual reality technologies. But studies also show that augmented reality and virtual reality are not ready for full adoption in the construction industry and that there are still research and development gaps [8].
| No | Author | Title | Methodology | Instrument | Results |
|----|--------|-------|-------------|------------|---------|
| 1  | Şahin Akın, Oğuzcan Ergün, Elif Surer, İpek Gursel Dino, Middle East Technical University Ankara, Turkey | An Immersive Design Environment for Performance-Based Architectural Design: A BIM-based Approach [4] | Flowchart of the developed transfer method | Performance simulation tools, BIM tools that capture large amounts of design data necessary for simulation, MR-based tool that makes an interactive visualization building design model | The MR-based tool provides a perception of the model's geometry, as well as the relationship between the results of quantitative simulations on daylighting and building geometry in 3D. |
| 2  | John P. Isaacs, Daniel J. Gilmour, David J. Blackwood Ruth E. Falconer, University of Abertay Dundee, United Kingdom | Immersive and Non-Immersive 3D Virtual City: Decision Support Tool for Urban Sustainability [5] | Combines computer game techniques, modeling of economic, social, and environmental indicators to provide an interface that presents a 3D interactive virtual city with sustainability information overlain | The tool is split into 3 components: Interface, Engine and Games techniques, and is developed using the XNA programming environment utilizing pixel shader language 3 | The virtual environment is a medium that can be used to communicate sustainability indicators |
| 3  | Elmira Jamei, Michael Mortimer, Mehdi Seyedmahmoudian, Ben Horan, Alex Stojcevski, Victoria University, Deakin University, Swinburne University of Technology, Australia; | Investigating the Role of Virtual Reality in Planning for Sustainable Smart Cities [6] | VR (virtual reality) participatory planning system. | Modern game engines and interactive VR hardware | The most important aspect of the smart city concept is data visualization and forecasting. Virtual reality enables researchers to perform real-time analysis of various "what if" scenarios and helps governments, stakeholders, and communities |
4 Meltem Yılmaz, Fine Arts Faculty Hacettepe University Ankara Turkey

Virtual Reality as A Tool for Participatory Architectural Design [7]

Improve users’ understating on the design, help them specify their activities in the given new building and increase their involvement in the communication with designers and conduct an evaluation of the design, mainly in terms of spatial configuration, and collect their feedback.

2D CAD, BIM Application, Game Engine, VR system

Understanding the user needs and responding to them appropriately will create a path for more sustainable environments which are built via optimizations of virtual visualizations and evaluations and providing a higher degree of user satisfaction.

5 Juan Manuel Davila Delgado, Lukumon Oyedele, Peter Demian, Thomas Beach. University of West of England Bristol, Cardiff University, Loughborough University, UK

A research agenda for augmented and virtual reality in architecture, engineering and construction [8]

A combination of qualitative and quantitative data collection and analysis methods were used.

Qualitative Analysis: FGDs, Data Compilation, Data Segmentation. Quantitative Analysis: Targeting Participants, Survey, Literature Survey.

Augmented reality and virtual reality can be used in various ways throughout the entire life cycle of a built asset. Studies also show that augmented reality and virtual reality are not ready for full adoption in the construction industry. There are still research and development gaps.
4. Results and Discussion

Based on the results of the literature review, it can be said that immersive technology allows researchers to carry out real-time analysis of sustainable architectural indicators and compare them with scenarios at the next design stage. The virtual environment is a medium that has the benefit of communicating the interdependence of indicators of sustainability. Understanding user needs through immersive technology can provide a fast response to users, thereby creating a pathway for a more sustainable environment built through visualization optimization and virtual evaluation. However, several studies also show that immersive technology is not fully ready for adoption in the construction industry, and still requires further research and development.

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