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Thesis topic: Digital Twin
Thesis title: Digital Twin BIM Model for Total Design of Small Buildings

Abstract

Designers have nothing about the digital twin initially in the design process. Because there is nothing to sense or monitor. A digital twin is a digital representation of something physical that constantly updates itself. The digital twin is usually composed of real objects or objects that are near completion of design and production. The digital twin is applied in many disciplines with the developing information technology. However, we see that the digital twin does not affect design thinking by looking at the design process. ' If the digital twin is a mirrored representation, then how can the digital twin be used for feed-forward and feedback that is not yet in the design stage?' is the question that needs to be answered. Thus, digital twin technology has extensive abilities to support the design process from the concept to the final design. Such as for the physical part sensing, monitoring, and actuating; for the data integration of BIM, IoT, data linking, and storing knowledge; and for the virtual part simulation, prediction, optimization, and agency.

Introduction

Problem Statement

The digital twin is a simultaneous mirroring of physical and digital processes (Glaessgen & Stargel, 2012, pp. 7), where designers have nothing early in the design process because there is nothing to perceive or track (Roozenburg & Eekels, 1995, pp. 118). Having nothing is good for design, as there is still a lot of potential behind the process. For good or ideal designs, designers need to have a proper understanding of the process. Every new evolution comes from previous experiences, mistakes, failures, etc. So, there must be adoptions to reach a good or ideal design when applying new technologies such as the digital twin (Norman, 2013, pp. 8). Despite the growing interest in digital twins, little work has been done on applying the digital twin to the design process before realizing the design (Jones et al., 2019, p. 2558). We assume that the progressive states of the digital twin, called foetal, child, and adult digital twin, are the closest thing to the digital twin and the design process (Sacks et al., 2020, p. 16).

Research Objectives

The research aims to draw attention to the digital twin technology and the architectural design process to how digital twin technology can be used in the design process. To do that, we aim to understand the impact of using the digital twin in the design process. Then, we intend to evaluate the relationship of digital twins to decision-making for the project in the design cycle. The ambition is to predict ideal design with digital twins seeing and solving the architectural design issues.

Research Questions

How can digital twin technology be used in the design process?
What is the relation of digital twins to decision-making for the design cycle in case of interaction with built environments?
What are the criteria to create a generic digital twin of a small building?

Literature Review

The digital twin is a contemporary technology but originally based on NASA's work of the 1960s for the Apollo 13 program designing a mirrored system (Rosen et al., 2015). Later, NASA scientists described it as an integrated simulation of the process reflecting the life of its flying twin (Glaessgen & Stargel, 2012). Mirror Worlds described the imagination of a digital world with a digital twin-like idea (Gelernter, 1991). Thus, a tryadic system (physical-virtual-connection) was put forward in 2003 by John Vickers and Michael Grieves as a digital representation of a physical process and the

intelligence that connects them (Grieves, 2014, pp. 1; Grieves & Vickers, 2017, pp. 92). While there is various terminology underlining the digital twin, it is clear that the digital twin is structured as a physical artefact, a virtual artefact, and their interconnections (Korenhof, Blok & Kloppenburg, 2021).

Methodology
Literature review and collecting data sets
Case study: Create digital twins of small buildings for experimentation and collecting data on the environment (Quantitative)
Surveys with the end-user and experts (Qualitative)
Analysis results
Proposals

Primary Potential Sources

A. Current literature
B. Realized part of the structure such as model, prototype, mock-up, or prefabrication
C. Digital twin BIM Model
D. Follow-up Projects and Research
E. Interviews with practice

Research Timeline: 2021 - 2025
2021-2022
Literature review and collected data sets, studies (Ecosystem map)
2022-2023
Create a digital Twin application for experimentation and collecting data of the environment (Quantitative)
2023-2024
Survey of the end-user and experts (Qualitative)
2024-2025
Result, proposals, and end of the study.

Results from the 1st Year 2021-2022 (M: month)
1stM: Digital twin literature review first looked in detail and wrote a report on the related issues, followed by videos and events related to the digital twin.
2ndM: Digital twin literature review, followed by videos and events related to the digital twin.
3rdM: Digital twin literature review, followed by videos and events related to the digital twin, conference abstract studied, worked on the state of the art of digital twin topic.
4thM: Digital twin literature review, followed by videos and events related to the digital twin, conference abstract studied, started to create a checklist for a network mapping or idea mapping, created questions for meeting DT-related reactions.
5thM: Digital twin literature review looked in detail and wrote a report on the related issues, followed by videos, and events related to the digital twin, started to write a full paper related to the design cycle and DT generation, engaged someone from BIM practice, attended Bentley System iTwin platform education online.
6thM: Conference worked on a full paper related to digital twin and design process, started EuroTEQ course related to wooden construction and BIM.
7thM: Digital twin literature review, followed videos and events related to the digital twin, started work on a new abstract.
8thM: Digital twin literature review, followed by videos and events related to the digital twin.
9thM: Digital twin literature review, followed by videos and events related to the digital twin. Started work on a full paper related to hybrid prototyping in the design process with digital twin technologies.

10thM: Digital twin literature review, followed by videos and events related to the digital twin. Submitted the full paper.

Conferences:

Attended: Emir Isik, G. & Achten, H. (2022). Can we use digital twin technology in the design process? A theoretical framework, In ARCHDESIGN ’22 / IX. International Architectural Design Conference Proceedings, Istanbul, Turkey, May, 2022, pp. 45-54.

Submitted Full Paper wait for results: Emir Isik, G. & Achten, H. (2022). Architectural hybrid* (physical-digital) prototyping in design processes with digital twin technologies, In 10th ASCAAD International Conference, Beirut, Lebanon, October, 2022.

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