We are IntechOpen, the world's leading publisher of Open Access books
Built by scientists, for scientists

6,700
Open access books available

182,000
International authors and editors

195M
Downloads

154
Countries delivered to

Our authors are among the
TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™
Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Chapter

Introductory Chapter: Digital Twin Technology

Orhan Korhan

1. Introduction

Simulation has been used as a modeling tool to build an infrastructure for monitoring the properties of the actual system by moving data from a physical system already existing in the real world to a virtual environment. Because it can make the evolution of manufacturing processes traceable, it offers benefits in terms of time, cost, and risk management. In order to organize the required preparations, the simulation's goal is to forecast probability in the virtual environment. By simulating every aspect of the physical system in the digital world, a successful simulation is feasible [1].

The idea of digital twins has evolved as a transformational paradigm that spans the divide between the physical and digital worlds in the constantly changing technological context. A virtual representation of a physical system, process, or item is referred to as a "Digital Twin," and it is made by gathering and fusing real-time data from numerous sources. This virtual version of the real counterpart acts as a potent tool for tracking, examining, and reproducing that counterpart's actions. Digital twins allow improved comprehension, predictive insights, and well-informed decision-making across a variety of sectors by offering a mirror copy of the real-world entity [2].

They include not only the geometric features of the physical object but also its functional and behavioral traits. The Digital Twin delivers a dynamic reflection of its physical counterpart by utilizing real-time data gathered from sensors, simulations, and historical records. Therefore, data analysts and IT specialists may mimic them before producing actual gadgets. They thereby impact the development of technologies like the internet of things (IoT), artificial intelligence (AI), and data analytics in addition to being employed in manufacturing [1, 3].

Real data regarding an actual thing or system is the input for a digital twin. Based on these inputs, it then provides simulations or predictions of how the real item or system would behave. It is a computer software that can simulate in its most basic form. A digital twin is first programmed, frequently by professionals in data science or applied mathematics. These professionals start by looking at the simulated versions of genuine objects or systems. The digital twin, a mathematical model that simulates the real world, may then be created using this data [4].

2. Evolution of digital twins

The concept of digital twins has its origins in NASA's use of computer models to simulate and manage space missions in the 1960s. Digital twins, on the other hand, only became well-known recently because of developments in sensor technology, data

IntechOpen

analytics, and cloud computing. The contemporary idea of digital twins was created as a result of the convergence of various technologies, which made it possible to gather, integrate, and analyze data in real time [5].

The term "digital twin" refers to a virtual duplicate or digital representation of a real object, such as a system, process, or product. Due to its potential to fundamentally alter how we build, monitor, and optimize real-world systems, this idea has attracted a great deal of interest from a wide range of businesses. In order to realize the goal of Industry 4.0, which calls for smart factories, intelligent infrastructure, and effective supply chains, a critical enabler has been identified as the digital twin idea [6].

3. The components of a digital twin

A complete digital twin comprises the following elements:

- Physical Entity: The real physical system, item, or process that the digital twin represents is referred to here. It could be a piece of equipment used in manufacturing, a structure, a vehicle, or even the complete infrastructure of a city [1, 2].

- Virtual Representation: Digital representation of the physical entity is included in the virtual model. Geometry, material characteristics, behavioral algorithms, and other pertinent characteristics are all included [6].

- Sensors and Data Sources: These are built into the physical object to gather current information about its performance, surroundings, and operating circumstances. The virtual model is regularly updated by these data sources, maintaining synchronization [4].

- Data Integration and Analytics: Using cutting-edge analytics methods like machine learning and artificial intelligence, the gathered data is combined and processed. Understanding the behavior, patterns, and potential problems of the physical thing is made possible by this study [7].

- Tools for Visualization and Simulation: Users may engage with the digital twin using a variety of visualization and simulation tools, which offer a dynamic depiction of the state and behavior of the real item [3].

- Connectivity and IoT: The digital twin depends on a smooth data transfer between the actual object and its virtual equivalent. This connectedness is made possible via the Internet of Things (IoT), which makes it possible for data to be sent, received, and evaluated [6].

4. Applications of digital twins

Applications for digital twins may be found in many different industries:

- Manufacturing: Digital twins are used to improve manufacturing processes, track the health of the equipment, and anticipate maintenance requirements, leading to greater productivity and less downtime [8, 9].

DOI: http://dx.doi.org/10.5772/intechopen.113345

- Healthcare: By mimicking physiological processes and forecasting illness progression, digital twins in medicine help in the tailored treatment of patients [7].

- Urban Planning: Cities may use digital twins to predict traffic patterns, energy use, and infrastructure growth, assisting in environmentally friendly urban planning [4, 6].

- Aerospace: Digital twins of aircraft and spacecraft allow for real-time performance analysis, proactive maintenance, and enhanced safety [9].

- Energy: Digital twins improve the integration of renewable energy sources, estimate energy consumption, and optimize the operation of power plants [8, 9].

5. Advantages, challenges, and future directions

The potential of the Digital Twin idea to transform businesses and fundamentally alter how we interact with the real world becomes increasingly clear as it gets popularity. They have enormous promise, but there are a number of issues that need to be resolved.

The difficulties of building realistic virtual models, interoperability across diverse systems, and data security and privacy issues are a few of the difficulties that academics and practitioners are actively attempting to solve [10].

The idea of digital twins is anticipated to develop further as technology advances, including developments in augmented reality, virtual reality, and AI-driven analytics [8, 9, 10].

6. Conclusion

Digital twin technology has caused a paradigm change in how we view, engage with, and utilize the physical environment. The origins, elements, uses, and difficulties of the idea of "digital twins" are discussed in this chapter as an introduction. The technological details, case examples, and the developing landscape of digital twin technologies will be covered in greater detail in later chapters.

Author details

Orhan Korhan
Department of Industrial Engineering, Eastern Mediterranean University, Famagusta, North Cyprus, Turkey

*Address all correspondence to: orhan.korhan@emu.edu.tr

IntechOpen

© 2023 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. CC BY

References

[1] Korhan O, Fallaha M, Murat Çınar Z, Zeeshan Q. The Impact of Industry 4.0 on Ergonomics. London, UK: IntechOpen; 2023. DOI: 10.5772/intechopen.108864

[2] Crespi N, Drobot AT, Minerva R. The digital twin: What and why? In: The Digital Twin. Cham: Springer International Publishing; 2023. pp. 3-20

[3] Soori M, Arezoo B, Dastres R. Digital twin for smart manufacturing, a review. Sustainable Manufacturing and Service Economics. 2023;**2**:100017. DOI: 10.1016/j.smse.2023.100017

[4] Lu Y, Xu X. A review of digital twin for smart manufacturing: Trends, challenges and opportunities. The International Journal of Advanced Manufacturing Technology. 2020;**108**(7-8):2267-2279

[5] Glaessgen EH, Stargel DS. The Digital Twin Paradigm for Future NASA and US Air Force Vehicles. Honolulu, Hawaii, USA: AIAA; 2012. pp. 2012-4343

[6] Grieves M. Digital twins: Virtually everything about almost anything. The Bridge. 2002;**32**(1):4-11

[7] Tao F, Cheng J, Qi Q, Zhang M, Zhang H, Sui F. Digital twin-driven product design, manufacturing and service with big data. The International Journal of Advanced Manufacturing Technology. 2018;**94**(9-12):3563-3576

[8] Tao F, Cheng Y, Zhang L, Nee AY, Srinivasan R. Digital twins and cyber-physical systems toward smart manufacturing and industry 4.0: Correlation and comparison. Journal of Manufacturing Science and Engineering. 2018;**140**(6):061004

[9] Fischer M, Shtub A. Digital twins and cyber-physical systems in smart manufacturing and industry 4.0: A comprehensive review. Journal of Manufacturing Systems. 2020;**57**:158-172

[10] Wang Z, Wan J, Zhang D, Li D, Zhang C. Towards smart factory for industry 4.0: A self-organized multi-agent system with big data based feedback and coordination. Computer Networks. 2016;**101**:158-168