Chapter 74

Digital Twin:
A Unified Definition, Issues, Challenges, and Opportunities

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ABSTRACT

Digital twin is a new concept, creating a buzz among researchers and practitioners in all sectors. It is assumed that this revolution will change the way businesses proceed. The concept is garnered with terms or key concepts and so extensively misrepresented that it is losing its originality. In an effort to overcome this issue, the authors endeavored to define digital twin in a more holistic manner. The authors collected 37 definitions from extant literature to build a unified definition that can capture the true essence of digital twin. Furthermore, the authors discussed the issues, challenges, and opportunities that digital twin will bring across all sectors and at large the society. The authors also suggested some of the future works that can be carried forward.

INTRODUCTION

The twenty-first century is marked as the epitome of the technological revolution, forcing firms and enterprises to enter the next-generation technology landscape. Digital technologies involving Cloud Computing, Big Data, Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, Virtual

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Reality, etc., are continuously changing how companies interact, compete, or create value for their businesses (Attaran & Celik, 2023). While businesses are heading toward the global competition era, the need for introducing advanced digital technologies in their overall functions is becoming crucial. Digital Twin (DT) is one of these technologies, acquiring interest of both academicians and practitioners. DT technology utilizes a virtual depiction along with advanced technologies (e.g., blockchain, edge computing, communication technologies), and machine learning to allow unique applications across industries (Khan et al., 2022). The market size of DT is growing continuously. For instance, Global Market Insights report highlights that the size of the digital twin market was $8 billion in 2022 and is anticipated to increase at a compound annual growth rate (CAGR) of 25% during 2023-32. Another report by Global Data estimated that the DT market is ready to rise from $12.9 billion in 2022 to $153.66 billion during 2022-30.

The notion of Digital Twin is not new but came into spotlight recently due to its wide array of applications in sectors ranging from construction, real estate, agriculture, energy, manufacturing, healthcare, construction, aerospace, marine, transportation, and others (Attaran & Celik, 2023; Enders & Hoßbach, 2019; Fuller et al., 2020; Khan et al., 2022). The intentions of using DT in each sector may differ but the popularity is same across all sectors. In the manufacturing sector, competitors are using DT with distinct objectives. For instance, Parametric Technology Corporation, a software manufacturing company uses DT for improving manufacturing flexibility and affordability, Siemens, a technology company endeavours DT to enhance quality and efficiency, General Electric leverages it for estimating the wellbeing and functioning of the product, and TESLA uses it for synchronising data flow between the real product and virtual twin (Schleich et al., 2017). In oil and gas industry, DT is used for asset integration, asset life cycle management, and asset planning and monitoring (Wanasinghe et al., 2020). In the construction sector, DT is utilised for developing the virtual representation of construction project to prevent any kind of malfunction (F. Jiang et al., 2021). In the healthcare division, it is employed for recognising immature diseases, surgery planning, and to experiment with medications (Attaran & Celik, 2023). The applications of DT are numerous to list down in the paper but the major benefits comprise cutting costs, reducing risk, personalising offerings, improving performance, increasing efficiency, reducing waste, reducing time to market, and improving decision making (Schleich et al., 2017; Tao et al., 2019; Wanasinghe et al., 2020).

DT has become the prime topic of research in the literature and an inimitable attribute for industries, a unique definition to clearly understand the nature and scope of the concept and to expand its application potential is extremely important. The distinct descriptions of DT in the extant literature has emphasized on its attributes, components, allied concepts, dimensions, and applications (Attaran & Celik, 2023; Enders & Hoßbach, 2019; Fuller et al., 2020; Rasheed et al., 2020; Tao et al., 2019). However, a unified definition fully capturing the crux of the concept is still missing. Therefore, a consolidated definition to strengthen the concept and to embark further research is necessary (Liu et al., 2023). This work is an effort to observe the multiple explanations of DT from the literature and build a unified definition portraying all aspects and providing a solid ground for future research. The goal of this work underlines the significance of defining the Digital Twin in a more abstract manner and distinguish it from other related conceptions (e.g. simulation, cyber-physical system, additive manufacturing).