Chapter 1
A Critical Overview of Digital Twins

Princess Adjei
University of Northampton, Northampton, UK

Reza Montasari
The University of Huddersfield, Huddersfield, UK

ABSTRACT

In recent years, organisations have invested heavily in the digitisation of their processes to maximise productivity. A digital twin is one of the most recent emerging technologies that is to disrupt business models and to leverage competitive advantage; applications can be found in many industries including, but not limited to healthcare, manufacturing and supply chains, and engineering. This article provides a critical perspective to the benefits of digital twins, their applications as well as the challenges encountered following their use. Cybersecurity risks as one of these key challenges will be further discussed within the article.

INTRODUCTION

A digital twin (DT) is a virtual representation of the elements and dynamics of devices that affect the design, build and operations of how products pull together using real world data (Farsi, et al., 2020). Although the term 'Digital Twin' was devised recently, the concept is not new. A variety of digital twin versions have been used in a wide range of industries for many years to avoid or mitigate risks and increase the optimisation of key decisions, as well as operational efficiency but the term 'digital twin' was just not in use (Aitken, n.d.).

According to Panetta (2016), numerous systems will have an element of DT in the next two years and will use data on its features to operate and respond to its environment. The combination of data, intelligence and the behaviour of physical systems offer an interface that promote efficient monitoring of operations to make valuable predictions (Kaur, et al., 2020). Industry 4.0, Internet of Things (IoT), Artificial Intelligence (AI) are the key enablers of DT and characteristics are highlighted below.

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INDUSTRY 4.0, IoT AND AI

Digital twins have become a core component of Industry 4.0; they enable firms to effectively understand their data, optimise complex processes and facilitate operational optimisation (Aitken, n.d.). MacDougal (2014) defines Industry 4.0 as the technological evolution from embedded systems to cyber-physical systems. These cyber-physical systems (CPS) merge digital and real-time workflows and are key components of Industry 4.0 (Farsi, et al., 2018). Production technologies and smart production processes have embedded systems and sensors that encourage optimum performance of the systems; leading to the transformation of industries like production value chains as well as business models (Mohamed, 2018).

IoT sensors are attached to assets to provide firms access to huge amounts of data; this data forms the basis of DT (Atlam & Wills, 2020). IoT allows connectivity of machines and devices capable of interacting with each other (Hosseinian-Far, et al., 2017). Digital Twins consist of connected products, using IoT and a digital thread which provides connectivity through the system's lifecycle; it also gathers data from the physical twin to update the models in the Digital Twin (Farsi, et al., 2020).

IoT encourages supervision of products in real time and facilitates communication between the CPS and users. By utilising the 4v's i.e.; Volume, Veracity, Velocity and Value of the data captured, Internet of Services (IoS) which provides services through the Internet is effectively achieved (Hosseinian-far, et al., 2017). Digital twins were initially introduced with increasing volume of data affecting the IoT. Merging DT with IoT provides the needed data to gain understanding of the behaviour and performance of the physical twin in the operational environment (Kaur, et al., 2020). Gartner (2014) forecasted IoT to reach 26 billion units by 2020, up from 0.9 billion in 2009. The benefits of the IoT can be expanded through its integration with multiple DTs, each monitored from a central location that manages maintenance schedules and cycles (Mohammadi & Taylor, 2017).

Artificial Intelligence (AI) is defined as a program which in an unpredictable world attempts to respond like or better than a human (Dobrev, 2014); yet there are different forms and categorisations of artificial intelligence (Hosseinian-Far, et al., 2011). AI facilitates the creation of new models and technological systems through intelligent manufacturing (Kaur, et al., 2020). Amazon owes its growth to Machine Learning (ML); a subset of AI and defines AI as a field in computer science for solving cognitive problems associated with human intelligence and the recognition of patterns (Amazon, 2019). The global brand has also reiterated the importance of ML in the growth of its business through the improvement of customer experience and the optimisation of its quality and logistic speed (Amazon, 2019). It is noteworthy to say that machine learning and data mining now has many applications in different industries (Farsi, et al., 2018). DT forms the living model of physical systems and adapts to operational changes; it relies on real time data from IoT sensors and with the help of ML/ AI, it forecasts the performance of the physical counterparts (Kaur, et al., 2020). General Electrics (GE) has been successful in using AI and ML to crunch and analyse big data, which triggered the evolution of Digital Twins and the Internet of Things (GE Power, 2016). DT integrate with AI, software analytics and ML data to create simulations that change as their physical twins change (Kaur, et al., 2020).

OVERVIEW OF DIGITAL TWINS

In the early 70's studies were conducted by medical researchers in the evaluation of the performance of collimators; which were devices that narrowed parallel beams of waves or radiation to align their motion

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