Chapter 6
Digital Twins Enabling Technologies, Including Artificial Intelligence, Sensors, Cloud, and Edge Computing

Subramaniam Meenakshi Sundaram
https://orcid.org/0000-0003-2352-0714
GSSS Institute of Engineering and Technology for Women, Mysuru, India

Tejaswini R Murgod
Nitte Meenakshi Institute of Technology, Bengaluru, India

Sowmya M.
GSSS Institute of Engineering and Technology for Women, Mysuru, India

ABSTRACT

With the fast growth of big data, IoT, industrial internet, and intelligent control technology, digital twins are extensively employed as a novel form of technology in many aspects of life. Digital twins have emerged as the ideal connection between the real world of manufacturing and the digital virtual world, as well as an effective technological way of realizing the interaction and cooperation of the real and information worlds. Digital twins rely on knowledge mechanisms, digitization, and other technologies to build digital models. They use IoT and other technologies to convert data and information in the physical world into general data. Its necessity is mainly reflected in the massive data processing and system self-optimization in the digital twin ecosystem, so that the digital twin ecosystem is orderly and intelligent cloud travel, and it is the central brain of the digital twin ecosystem. The rapidly expanding digital twin market indicates that this technology is already in use across many industries and is demanded to rise at an estimated USD 48.2 billion in 2026.

DOI: 10.4018/978-1-6684-5925-6.ch006

INTRODUCTION

The idea of digital twin technology was first voiced in 1991, with the publication of Mirror Worlds, by David Gelernter. However, Dr. Michael Grieves (then on faculty at the University of Michigan) is credited with first applying the concept of digital twins to manufacturing in 2002 and formally announcing the digital twin software concept. Eventually, NASA's John Vickers introduced a new term "digital twin" in 2010. However, the core idea of using a digital twin as a means of studying a physical object can actually be witnessed much earlier. In fact, it can be rightfully said that NASA pioneered the use of digital twin technology during its space exploration missions of the 1960s, when each voyaging spacecraft was exactly replicated in an earthbound version that was used for study and simulation purposes by NASA personnel serving on flight crews.

Advanced computer technologies such as Artificial Intelligence (AI), cloud computing, digital twins, and edge computing and big data have been applied in various fields as digitalization has progressed. A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making. The purpose of a digital twin is to run cost-effective simulations. The digital twin uses IoT sensors, log files and other relevant information to collect real-time data for accurate modeling of assets. These models are then combined with AI-powered analytics tools in a virtual setting. Digital twins can significantly improve enterprises' data-driven decision-making processes. They are linked to their real-world equivalents at the edge and businesses use digital twins to understand the state of the physical asset, respond to changes, improve operations, and add value to the systems. These digital assets can be created even before an asset is built physically. Research the physical object or system that will be mimicked and integrate sensors into physical assets or monitor log files and other sources to collect data. This is further integrated into the virtual model with AI algorithms. Later by applying analytics into these models, data scientists and engineers get relevant insights regarding the physical asset. The digital twins are commonly used in manufacturing which provide lower maintenance costs via predictive maintenance, improved productivity, faster production times, testing prior to manufacturing and improved customer satisfaction.

Although simulations and digital twins both utilize digital models to replicate a system's various processes, a digital twin is actually a virtual environment, which makes it considerably richer for study. The difference between digital twin and simulation is largely a matter of scale: While a simulation typically studies one particular process, a digital twin can itself run any number of useful simulations in order to study multiple processes.

For example, simulations usually do not benefit from having real-time data. But digital twins are designed around a two-way flow of information that first occurs when object sensors provide relevant data to the system processor and then happens again when insights created by the processor are shared back with the original source object. By having better and constantly updated data related to a wide range of areas, combined with the added computing power that accompanies a virtual environment, digital twins are able to study more issues from far more vantage points than standard simulations can with greater ultimate potential to improve products and processes.

Alexopoulo et al. (2020) pointed out that the digital twin's model can be used to accelerate the ML training phase by generating an appropriate training data set and automatically labeling it through a simulation tool chain, thereby reducing user participation in the training process. These synthetic datasets may be expanded and cross-validated using extensive real-world data that does not require considerable use. Fan et al. (2021) investigates and proposes a vision of a disaster city digital twins concept, which