


Special Issue on Digital Twins in Industry

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1. Introduction

Digital twin (DT) is an emerging and fast-growing technology which provides a promising way to connect and integrate physical and virtual spaces seamlessly. In brief, a DT is a digital representation of a physical object or system. It has bi-directional communication capability with the physical twin through sensors and networks. DT is an evolution and integration of the various information–communication technologies (ICT) that have proliferated the IT scene for the last two decades. It integrates internet of things (IoT), big data, cloud and edge storage, artificial intelligence of things (AIoT), augmented reality (AR), etc. to form a comprehensive communication network for controlling, monitoring, diagnosis and health inspection of equipment and facilities, traffic and transportation systems, buildings, etc.

DT has attracted much interest and enthusiasm from the academia as well as the industry. While academia has worked on algorithms and frameworks, industry will be the final implementer as they can see the immediate benefits offered by DT technology. This Special Issue focuses on the industrial applications of DT technology, and it provides insights for practitioners on how DTs can be successfully planned and implemented, as well as the desirable outcomes achieved.

2. Digital Twin Technology and Applications

This Special Issue contains 11 chapters covering a broad range of applications, in-depth reviews and integration of DT with other technologies such as AR and Industry 4.0.

In the chapter by Wärmefjord et al., they discussed the barriers in the industry that must be overcome before the use of DT for variation management and geometry assurance can be fully utilized. An extensive interview with engineers from eight different companies was conducted. They concluded that 3D models must be kept fully updated in order to maintain a robust digital thread [1].

The chapter by Sepasgozar advocated DT and web-based gaming technologies for online education; not quite an industry application of DT as such, as it is more for educators. Nevertheless, this is useful in view of COVID-19 as much of the face-to-face instruction has become virtual and online [2].

The chapter by Jacoby and Usländer emphasized the importance of interoperability by addressing the need to consolidate the various standards of DT and IoT. A classification scheme was created and applied to the standards, in order to adopt serialization formats and network protocols. This is an important issue as this could lead to smooth and robust operations of DT and the ability to overcome barriers of Industry 4.0 [3].

An industrial application of DT was presented by Bambura et al. who implemented DT for engine block manufacturing processes. They constructed a DT consisting of three layers: physical, virtual and information-processing. Raw data were collected using programmable logic control (PLC) sensors. They concluded that even when only partial results were presented, DT seems to be a prospective real-time optimization tool for the industry [4].



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Another industrial application by Sierla et al. proposed a semi-automatic methodology for generating a DT of a brownfield plant, in the area of construction and urban development. As outlined in the paper, many procedures are required to construct a DT. The case study showed that only few manual edits were needed for the automatically generated simulation model [5].

In the chapter by Greco et al., they used a DT to set up models for monitoring the performance of manual work activities with near real-time feedback to support the decision-making process for improving working conditions. This is an interesting presentation of a human-centric DT for improving ergonomics and working conditions [6].

Autiosalo et al. presented an integrated DT for an overhead crane, providing a service for machine designers and maintainers in their daily tasks. They showed that a good-quality Application Programming Interface (API) is a significant enabler for the development of DT, and advised traditional industrial companies to start building their own API portfolios [7].

In another industrial application, Pang et al. developed a DT and Digital Thread framework for an "Industry 4.0" shipyard. A new framework which combines the DT and Digital Thread was proposed for better management and to ensure continuity and traceability of information. The twin/thread framework encompasses specifications that include organizational architectural layout, security, user access, databases and hardware and software requirements [8].

The chapter by Pareja-Corcho et al. reported the development of simulation tools for gerotor pumps. The paper is not a direct application of the DT but is a virtual prototype which can be considered in the context of a DT tool. Future work is necessary to further integrate the physical pump with the software tool [9].

Agnusdei et al. presented an interesting chapter querying if DT technology supports safety management. The study analysed existing fields of applications of DTs for supporting safety management processes, and provided a comprehensive bibliometric review to identify future trends between the DT approach and safety issues [10].

Carvalho and da Silva reported a rarely addressed area of DT-based systems in sustainability requirements. They conducted a meta-systematic literature review and concluded that DTs across the product life cycle or the DT life cycle are not sufficiently studied. In addition, they mentioned in their research that it was not possible to find a paper discussing DTs with regards to environmental sustainability [11].

3. Summary

With the myriad of academic and industrial reports on DT development, this Special Issue could only represent a small fragment of the entire DT application scenario; not to forget the highly sophisticated commercial software which has been developed in recent years, which is capable of handling large-scale and complex industrial systems.

DT is a promising technology and its impact is yet to be fully realized.

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