JIT Journal of Innovation and Technology
e-ISSN: 2721-8562; p-ISSN: 2721-8570
Vol. 2, No. 2, October 2021. Page: 60 – 63

Digital Twin Technology in Internet of Things (IoT)

Anitha Vemulapalli[1], Geeta Mahadeo Ambildhuke[1], and N Anuradha[1]

[1] *Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Hyderabad – 500075, India*

*Corresponding Author: anitha@klh.edu.in

Article history
Received: 07.10.2021
Revised: 21.11.2021
Accepted: 31.12.2021

DOI:10.31629/jit.v2i2.3507

Abstract
Developments in virtual technology and data acquisition technology put way to digital twin technology. Digital twin is a virtual entity that is linked to a real-world entity. Both the link and the virtual representation can be realized in several different ways. Digital Technology plays a very much key role in different areas like in production management, manufacturing, health care, smart cities and so on. Digital Twin Technology is mainly developed to improve manufacturing processes. With the development of new-generation information and digitalization technologies, more data can be collected, and it is time to find a way for the deep application of all these data. As a result, the concept of digital twin has aroused much concern and is developing rapidly. Digital twins facilitate to monitor, understand, and optimize the functions of all physical entities and for humans and also provide continuous feedback to improve quality of life and well-being. Digital Twin is best described as the effortless integration of data between a physical and virtual machine in either direction. This paper provides an overview of the Digital Twin technology used in different work spaces and also how it will be effective in the Internet of Things network.

Keywords: digital shadow, digital twin technology, simulation technology

1. Introduction

As the research and development in Digital Twin technology is increasing, there are many issues that should be considered. Digital twin is considered as an object which have some virtual information [1,2]. It is also considered as a technology for representing the simulation method. Other technologies like a cyber physical and digital shadow systems are relevant to the digital twin technology. There is a need to study the relationship between these concepts. Digital twin technology is applied in designing the product, operating the product and in maintaining the product. It is rarely used in the production and testing stages.

The implementation of Internet of Things (IoT) to the various fields of engineering, like manufacturing, healthcare, smart vehicles and environments and other application. Those applications led to the accumulation of large amounts of data required thus need a data analysis system to be done for the prediction and maintenance of the fault detection in the systems [3-5]. Digital twin technology, by acting as a connection between the physical and virtual devices can handle the problem encountered. This paper aims to discuss the issues of digital twins' technology and their applications in different areas of engineering. The benefit on the implementation of IoT to the industrial and engineering uses will also highlighted.

DOI:10.31629/jit.v2i2.3507

2. Materials and Methods

2.1 Terminology

Digital twin technology is misinterpreted in different concept. While working in Digital twin technology, we will come across the terms like digital model, digital shadow and digital twin which have their own special meaning, that presented elsewhere [6]. They are including as follow:

a) Digital model. A digital model is a digital version of an existing or a planned object. There will be no exchange of information between the physical object and the model. Building plans, product designs etc. will come under this type.

b) Digital shadow. It is a digital representation of an object that has data flow in one direction which is from physical device to digital model. This is a uni-directional, which is from physical to digital device.

c) Digital twin. If the data flows between an existing physical object and a digital object and vice-versa then we refer to it as Digital Twin. Any change made to the physical object automatically gets reflected in the digital object and the reverse is also true.

2.2 Digital Applications

There are a number of potential applications that we can view in the digital twin technology which may include different domains, sectors and which may refer to a particular task. Digital twin is growing across different academia and due to the advancements in the IoT and artificial intelligence application, as informed elsewhere [7-10]. The different applications are primarily implemented of Digital twin technology now, such as:

i) Smart cities. The dramatic effect of Digital Twins is drastically increasing year by year in the smart city environment due to the rapid developments in the field of Internet of Things (IoT). It may gather more data from the IoT sensors embedded into the main services which may lead to the research developments in artificial intelligence algorithms. Advancements in the smart city is including its ability to utilize the digital twin technology. Using the data collected it can be analyzed the data and testbed experiments on the virtual object which may have impact on the physical device after implementation [11,12].

ii) Manufacturing industry. The other application of digital twin is in the manufacturing. Here products can be tracked and monitored which helps us in saving time and money. The digital twin gives real time status about the performance of the machine along with the production line. It also helps in increasing the connectivity between the devices, improves the reliability and increases performance.

iii) Automotive Industry. In this field, the ability to have a digital twin of an engine or car part can be valuable in terms of using the twin for simulation and data analytics. Artificial Intelligence improves the efficiency of testing as it can perform data analytic on the vehicle data to predict the future performance

iv) Construction. This is another industry where digital twin comes to much use. It helps in predicting the accuracy, strength of the building constructions. Creating the blue prints of the models and applying different AI algorithms enables us to estimate the life time of the constructions.

v) Healthcare. This is one of the most important areas where digital twin technology comes to great use. The IoT devices used in this area are cheap and easy to implement leading to greater connectivity. This technology can be used to stimulate the effect of some drugs. It also helps in performing the surgical procedures.

3. Result

3.1 Implementation challenges

Among the numerous challenges encountered with the use of digital technology, to be discussed here is founded on the internet of things (IoT) and industrial internet of things (IIOT), as for examples:

i) Data privacy, security and trust. Due to the huge growth in the use of IoT devices in home, industries and smart cities, there is a gradual increase in the collection of data. This data collected should be secured and maintain the trust of the organization. If this data is not protected, it may lead to drastic changes. It will create problems if the data is not secured and privacy is not maintained. For any organization, this data is very sensitive. This needs to be protected with proper security mechanisms or by using proper trust mechanisms that may attack other devices globally, as in the case of distributed denial-of-service

DOI:10.31629/jit.v2i2.3507

(DDoS) [13].

ii) Connectivity. As there is an increase in the connectivity of IoT devices, more challenges are encountered in the connectivity. These challenges may be due to software errors, deployment problems or power problems. Properly implementing AI algorithms in IoT devices may reduce this challenge.

iii) Expectations. This is another challenge which is encountered when we have high expectations on the digital twin technology implementing in the IoT. Due to this, if the digital tin technology does not fit to standard requirements, it may greatly affect our work.

iv) Correctness of the data This is another challenge that we encounter when the quality of data collected is not good. The data used in digital twin should be good quality data which is free from noise and with uninterrupted data flow.

3.2 Key Technologies for Digital Twin

Key Technologies of digital twins can divide into in three perspectives. They are data related technologies, high-fidelity modeling technologies and model-based simulation technologies.

a) Data related technologies. In digital twin, data is the most important part. Different elements and sensors in Radio Frequency Identification (RFID) tags and readers. Those elements are chosen and integrated to collect total information from the digital twin. The data that digital twin needs is of large volumes having vast varieties which may be difficult and costly to transmit to digital twin through cloud server. The data related technologies which include data collection, data mapping, data processing, data transmission is different for different applications. Standard data interfaces are required to transform this data to digital twin.

b) High-fidelity modeling technology. Models of digital twin comprise semantic data models and physical models. Semantic data models are trained by known inputs and outputs, using artificial intelligence methods. Physical models require comprehensive understanding of its' physical properties and their mutual interaction. Thus, multi-physics modeling is essential for high-fidelity modeling of digital twin. Digital twin modeling can usually use physics-based modeling, black-box modeling or grey-box which are feasible.

c) Model based simulation technologies: Simulation is an important feature of digital twin. It enables virtual model to interact with physical model. To have interaction in both directions, a high-level model based on an automation system. The attributes necessary to exchange data were inserted in an IoT middleware and other systems can access these attributes. Digital twin simulation uses a real-time data that are collected and recorded from physical space via IoT [14].

Conclusion

The Application framework of Digital twin technology for the product life cycle management is discussed. Virtual modeling and construction flow of Digital Twin Technology are explained. To have the full potential of digital twins, it requires a convergence of the modern technologies such as AI, IoT and IIOT. The implementation of digital twins in IoT devices has more impact when implemented in reality after it is being tested with virtual data. Further research is required to have more communication interface between the real and digital twins. Digital twin technology in IoT devices should be accurate such that the users have trust on its working and implements it on the real objects. Technologies implemented should be standardized for its' uses and the sustainability.

References

[1] Grieves, Michael. "Digital twin: manufacturing excellence through virtual factory replication." White paper 1 (2014): 1-7.

[2] Haupert, Jens, Xenia Klinge, and Anselm Blocher. "Cps-based manufacturing with semantic object memories and service orchestration for industrie 4.0 applications." Industrial internet of things. Springer, Cham, 2017. 203-229.

[3] Bilberg, A. and Malik, A.A., 2019. Digital twin driven human–robot collaborative assembly. CIRP Annals, 68(1), pp.499-502.

[4] Mandolla, C., Petruzzelli, A.M., Percoco, G. and Urbinati, A., 2019. Building a digital twin for additive manufacturing through the exploitation of blockchain: A case analysis of the aircraft industry. Computers in Industry, 109, pp.134-152.

[5] Mohammadi, Neda, and John Taylor. "Knowledge discovery in smart city digital twins." In Proceedings of the 53rd Hawaii International Conference on System Sciences. 2020.

[6] Fuller, A., Fan, Z., Day, C. and Barlow, C., 2020. Digital twin: Enabling technologies, challenges and open research. IEEE access, 8, pp.108952-108971.

[7] David, J., Lobov, A. and Lanz, M., 2018, July. Leveraging digital twins for assisted learning of flexible manufacturing systems. In 2018 IEEE 16th International Conference on Industrial Informatics (INDIN) (pp. 529-535)

[8] Debroy, T., Zhang, W., Turner, J. and Babu, S.S., 2017. Building digital twins of 3D printing machines. Scripta Materialia, 135, pp.119-124

[9] Jo, S.K., Park, D.H., Park, H. and Kim, S.H., 2018, October. Smart livestock farms using digital twin: Feasibility study. In 2018 International Conference on Information and Communication Technology Convergence (ICTC) (pp. 1461-1463).

[10] Knapp, G. L., Tuhin Mukherjee, J. S. Zuback, H. L. Wei, T. A. Palmer, Amitava De, and T. J. A. M. DebRoy. "Building blocks for a digital twin of additive manufacturing." Acta Materialia 135 (2017): 390-399.

[11] Soe RM. FINEST Twins: platform for cross-border smart city solutions. InProceedings of the 18th Annual International Conference on Digital Government Research 2017 Jun 7 (pp. 352-357).

[12] Chen X, Kang E, Shiraishi S, Preciado VM, Jiang Z. Digital behavioral twins for safe connected cars. InProceedings of the 21th ACM/IEEE International Conference on Model Driven Engineering Languages and Systems 2018 Oct 14 (pp. 144-153).

[13] Vishwakarma, Ruchi, and Ankit Kumar Jain. "A survey of DDoS attacking techniques and defence mechanisms in the IoT network." Telecommunication systems 73, no. 1 (2020): 3-25.

[14] Sierla, Seppo, Ville Kyrki, Pekka Aarnio, and Valeriy Vyatkin. "Automatic assembly planning based on digital product descriptions." Computers in Industry 97 (2018): 34-46.