Digital Twin

Subjects: Transportation Science & Technology

Contributor: Monika Kosacka-Olejnik, Mariusz Kostrzewski, Magdalena Marczewska, Bogna Mrówczyńska, Paweł Pawlewski

A digital twin is a virtual model of a physical object, a process, a machine, or their component that can be converted into an inherently complex mathematical model. The term of digital twin can be understood in correspondence to a digital shadow and a digital model. A digital twin is based on automatic data flow in contrast to the digital shadow which can work based either on manual or automatic data flow. Whereas a digital model can operate with manual data flow solely. It should be underlined here that a digital model and a physical object are not interconnected by any automatic data exchange. Consequently, a digital shadow is defined as a digital version of an object (a process, a machine, or their component; further mentioned as an object) that is characterized by a one-direction impact between a physical and digital object. A change in any state of a physical object is reflected in a digital model of a physical object, while the reverse situation does not occur. In the case of a digital twin, an impact between a physical object and its digital reflection is mutual. Once a change in any state in a physical object occurs, it automatically leads to a change in a digital object. The opposite interconnection occurs as well. A digital twin is characterized by the following features: interoperability (objects, machines, and people need to be able to communicate with each other via the Internet and in particular IoT in order to enable mutual interconnection of a digital twin with a physical object), virtualization (everything physical within a particular object, process or facility must have a virtual equivalent), autonomy (understood through the mutual communication), working in real-time (a digital twin and a corresponding physical object must operate in real-time, aggregate collected data, analyze them and make decisions in accordance with new arrangements). Currently, many machines and products within the manufacturing industry have sufficient prerequisites to use digital twins, for example owing to the connection of production machines to the IT systems.

Alongside means of automation and data exchange in manufacturing technologies including the Internet of Things, cloud computing, cyber-physical systems, big data and analytics, simulation and augmented reality, this technology fits into the concept of innovations within Industry 4.0.

The terms of a digital twin, digital shadow, and digital model were defined based on the following references:

1. Fuller, A.; Fan, Z.; Day, C.; Barlow, C. Digital Twin: Enabling Technologies, Challenges and Open Research. IEEE Access 2020, 8, 108952–108971, doi:10.1109/ACCESS.2020.2998358.

2. Kosacka-Olejnik, M.; Kostrzewski, M.; Marczewska, M.; Mrówczyńska, B.; Pawlewski, P. How Digital Twin Concept Supports Internal Transport Systems?—Literature Review. Energies 2021, 14, 4919. https://doi.org/10.3390/en14164919

3. Muhuri, P.K.; Shukla, A.K.; Abraham, A. Industry 4.0: A Bibliometric Analysis and Detailed Overview. Engineering Applications of Artificial Intelligence 2019, 78, 218–235, doi:10.1016/j.engappai.2018.11.007.

4. Tay, S.I.; Lee, T.C.; Hamid, N.Z.A.; Ahmad, A.N.A. An Overview of Industry 4.0: Definition, Components, and Government Initiatives. Journal of Advanced Research in Dynamical and Control Systems 2018, 10, 1379–1387.

5. Trotta, D.; Garengo, P. Industry 4.0 Key Research Topics: A Bibliometric Review. In Proceedings of the 2018 7th International Conference on Industrial Technology and Management (ICITM); IEEE: Oxford, United Kingdom, March 2018; pp. 113–117.

Keywords: digital twin ; material handling ; internal transport ; intralogistics ; internal logistics ; material flow

---

A digital twin is a virtual model of a physical object, a process, a machine, or their component that can be converted into an inherently complex mathematical model. The term of digital twin can be understood in correspondence to a digital shadow and a digital model. A digital twin is based on automatic data flow in contrast to the digital shadow which can work based either on manual or automatic data flow. Whereas a digital model can operate with manual data flow solely. It should be underlined here that a digital model and a physical object are not interconnected by any automatic data exchange. Consequently, a digital shadow is defined as a digital version of an object (a process, a machine, or their

component; further mentioned as an object) that is characterized by a one-direction impact between a physical and digital object. A change in any state of a physical object is reflected in a digital model of a physical object, while the reverse situation does not occur. In the case of a digital twin, an impact between a physical object and its digital reflection is mutual. Once a change in any state in a physical object occurs, it automatically leads to a change in a digital object. The opposite interconnection occurs as well. A digital twin is characterized by the following features: interoperability (objects, machines, and people need to be able to communicate with each other via the Internet and in particular IoT in order to enable mutual interconnection of a digital twin with a physical object), virtualization (everything physical within a particular object, process or facility must have a virtual equivalent), autonomy (understood through the mutual communication), working in real-time (a digital twin and a corresponding physical object must operate in real-time, aggregate collected data, analyze them and make decisions in accordance with new arrangements). Currently, many machines and products within the manufacturing industry have sufficient prerequisites to use digital twins, for example owing to the connection of production machines to the IT systems.

Alongside means of automation and data exchange in manufacturing technologies including the Internet of Things, cloud computing, cyber-physical systems, big data and analytics, simulation and augmented reality, this technology fits into the concept of innovations within Industry 4.0.

The terms of a digital twin, digital shadow, and digital model were defined based on the following references:

1. Fuller, A.; Fan, Z.; Day, C.; Barlow, C. Digital Twin: Enabling Technologies, Challenges and Open Research. IEEE Access 2020, 8, 108952–108971, doi:10.1109/ACCESS.2020.2998358.

2. Kosacka-Olejnik, M.; Kostrzewski, M.; Marczewska, M.; Mrówczyńska, B.; Pawlewski, P. How Digital Twin Concept Supports Internal Transport Systems?—Literature Review. Energies 2021, 14, 4919. https://doi.org/10.3390/en14164919

3. Muhuri, P.K.; Shukla, A.K.; Abraham, A. Industry 4.0: A Bibliometric Analysis and Detailed Overview. Engineering Applications of Artificial Intelligence 2019, 78, 218–235, doi:10.1016/j.engappai.2018.11.007.

4. Tay, S.I.; Lee, T.C.; Hamid, N.Z.A.; Ahmad, A.N.A. An Overview of Industry 4.0: Definition, Components, and Government Initiatives. Journal of Advanced Research in Dynamical and Control Systems 2018, 10, 1379–1387.

5. Trotta, D.; Garengo, P. Industry 4.0 Key Research Topics: A Bibliometric Review. In Proceedings of the 2018 7th International Conference on Industrial Technology and Management (ICITM); IEEE: Oxford, United Kingdom, March 2018; pp. 113–117.
