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DIGITAL DOUBLES AS A FACTOR OF INCREASING PRODUCT QUALITY AND PRODUCTION EFFICIENCY

A digital double is a virtual copy of machines or a factory, which is created using three-dimensional modeling, physical rules and mathematical equations [1]. In real time, sensor data from a real machine is transmitted to a digital double, constantly increasing the accuracy of the simulation [2]. Using big data analysis,

the digital double can recognize anomalous sensor data and generate warnings of possible failure.

The digital double also has a number of disadvantages: its creation requires considerable time and resources, the participation of enterprise managers, technological engineers and modeling experts in electrical, mechanical and other domains, for the deployment of the digital double all physical drawings must be available so that it is possible create virtual models. Unfortunately, factory blueprints are not always up to date, making it difficult to deploy a digital double and keep it up to date.

In addition, the implementation of a digital double requires very high data transfer and processing speeds, which in turn requires state-of-the-art hardware and software. A digital double should be deployed where digital platforms are unified (as an example, Siemens Digital Enterprise), or there are simple means of transferring and converting data from engineering systems to production and business process management systems, and vice versa.

Today's Digital Twins use neural networks, machine learning, and artificial intelligence to process production data captured by sensors to gain insight into the process without direct testing on the production floor. There is a connection between artificial intelligence and digital doppelgangers, as the latter's vast amounts of data can train AI models to make accurate predictions.

The implementation of Digital Twins and AI in production allows:

- facilitate the collection of production data thanks to IoT sensors (Smart sensors);
- smprove human-computer interaction by using augmented reality, virtual assistants, chat bots, etc;
- get new knowledge, models.

One of the main advantages of using digital twins and artificial intelligence in manufacturing is increased uptime, as future failures can be better predicted and equipment can be kept up and running, and planning and design costs can be reduced. In addition, a digital twin using artificial intelligence can predict when certain equipment will fail, allowing for predictive maintenance planning that, in addition to reducing downtime, can significantly reduce maintenance costs. The integration of digital doubles and AI gives a synergistic effect.

General Electric used AI-enabled Digital Twin technology across sectors to save \$1.5 billion worldwide. A heavy industry plant found a problem with a two-spindle CNC lathe, saving nearly hundred thousands of dollars. Chevron is also using this technology in its plants to reduce supply chain issues and monitor equipment in real time. Large firms such as IBM, Siemens and Microsoft are also developing Digital Twins solutions.

Alternatives to digital doubles can be modern SCADA, enhanced with AI decision-making capabilities, and machine learning (ML) with empirical modeling.

The main problematic links that determine further trends in the development of predicative analytics in Ukraine are the need to process large volumes of unstructured data in real time, for which it is necessary to use the aforementioned Big Data and Artificial Intelligence technologies. The rapid evolution of artificial intelligence provides potential for the development of digital manufacturing. Artificial intelligence replacing labor with faster and more accurate intelligent automation will undoubtedly bring new growth to this industry.

Currently, the world is actively developing models and standards for managing automated production according to the I4.0 concept, but there is a need to take into account the trends of I5.0, the directions of technology development (evaluate the advantages of machine learning compared to Digital Doppelgangers) and digital platforms (expansion of functionality, mergers and acquisitions) , for the implementation of the most relevant and harmonious management models and approaches during digital transformation.

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