Digital Twin Applications

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Industrial Digital Twin (IDT) systems integrate physical and virtual data throughout a product life cycle.

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1. Introduction

The DT of a physical system of the natural world can simulate the life cycles of the system and reflect the synchronized action of the virtual and physical twin, coupling the virtual and real-world [1][2]. Thus, the product life cycle is an action in the physical world represented by a combination of the system's process, data, and components. DT can reproduce the state of the physical entities through physical models. DTs can update data in real-time so that virtual models can improve continuously through data updates from physical assets.

Systems have considerable agility, autonomy, and efficiency improvements [3]. They have characteristics such as an interconnected network, regularly exchanging data, and interlinking communication between all the system's objects. However, researchers have the so-called legacy systems that, among their definitions, researchers can say that it is an old application or system that may be based on outdated technologies, but is fundamental to day-to-day operations.

Considering the various applications by using the DT, researchers have a promising scenario for further research into DT architecture, Industry 4.0 applications and concepts, legacy system upgrades, intelligent systems, and others. These technologies help improve performance and solve problems in the modern world.

2. DT-Driven Management

DT-driven management, in some cases, can predict potential problems and support integration between process and operation. There are management activities that include defining an organization's strategy and coordinating the role and duties of its employees to accomplish its demands through the application of available resources (financial, technological, and human).

The digital twin supports features such as the decision-making process, configuration, reconfiguration, planning, commissioning, and condition monitoring. Therefore, DTs can function as a real-time management system.

The development of science and technology necessitates the development of novel quality management methods. Innovative approaches are emerging along with existing processes and quality management systems [4][5].

There are distinct types of management DT, and the concept of an intelligent inspection management system has emerged. This type of system uses modern technical characteristics, such as integrating the Production Management System (PMS) [6], Geographic Information system (GIS) [7], Radio-Frequency Identification technology (RFID), and Personal Digital Assistant (PDA) [8], use in-process and maintenance. The goal is to improve the efficiency of the inspection work to control and analyze the process through data provided by various sensors and devices to support the correct measurement of variables and display this information on the monitoring platform [9].

3. Trends and Challenges of the Digital Twin

In general, the models proposed in the DT framework are built by observing the physical system, that is, by investigating and understanding the entire system. Modern needs may include the biggest problem of precise indoor localization and the proper representation of virtual reality, giving the user an actual sensation of what is happening on the shop floor.

The faithful representations of the DT that can predict unmodeled and emergent events challenge the DT models. Emergence occurs when unshaped or unpredictable behavior arises in the production process. When such a situation occurs, the system can measure this information and solve it through countermeasures such as prediction and detection of abnormalities in the system. This problem represents an interesting behavior because a change in an undesired event is already or not described in the model and combines concepts of AI, machine learning, and DT networks aiming to adapt the system to the new situation.

The main idea is to reproduce/simulate such conditions on the premise that they occur. However, in cases where unwanted behavior does occur, the system must manage these changes. These changes are parameter variations that the system cannot always take because they are too many, not foreseen, or lack processing power, thus causing an obstacle or problem that can be highlighted in this context.

The emergence problem mentioned earlier is related to system complexity. The way to deal with this can be by obtaining a more significant amount of data in the model-building phase or possibly “front-running” a simulation in real-time. Thus, it is possible to deal with such a situation before it occurs and produce a more straightforward solution that depends only on the designer, unlike the computational effort demanded by the solution that integrates AI and machine learning applications to solve this problem. However, this solution is specific and not generalized and promotes a greater dependency on the designer’s knowledge to adapt and improve the solution.

To mitigate complexity, the simulation could be a window into the future of system states that might occur and run the system with real-time data feed [4]. Such a suggestion would make it possible to predict with a certain degree of anticipation due to the simulation of the system’s behavior being just before the reproduction of the entire system. Thus, it would have a window into the future with various application possibilities.

In this sense, another possibility is applying retrofitting techniques to improve the legacy systems in Industry 4.0 technologies. These applications are the most cost-effective way, providing advantages such as reduced production costs, efficiency, and reliability. Thus, the main idea is to update a legacy system process to achieve specific demands of the Industry 4.0 concept.

In this situation, the strategy should identify similarities related to technology and resources in the retrofitting process to facilitate and create a basic overall model to increase the number of old systems that may migrate to the Industry 4.0 concept. The retrofitting also allows the inclusion of more advanced management models and real-time monitoring of each asset in the process.

4. Conclusions

The proposed structure in five layers aims to describe and specify a basic design and detail the functionality of physical objects, related technologies, and the integration interlayer process. Then, the challenges related to the retrofitting process of the legacy system were discussed, i.e., updating the process in the context of Industry 4.0 and improving characteristics such as increasing productivity, reducing costs, and updating the devices of the process.

A retrofitting process is an essential approach in the industry, and it is possible to define steps to achieve the desired update. First, it is necessary to analyze the equipment or process and the environment, describe the procedure of control and monitor the variable and new data flow, and finally, use technologies such as IoT, cloud computing, DT, and CPS to update the legacy system.

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