



SE Seminar #9 Report

Digital (Virtual) Twin The Future of Manufacturing

01286391 Seminar in Software Engineering

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Introduction

In this seminar Dr. yunyoung Teng-amnuay, a special speaker, discusses the topic "Digital (Virtual) Twin The Future of Manufacturing"

Digital twin

A digital twin is a virtual representation of a physical entity that utilizes real-time data from embedded sensors to simulate its behavior and monitor operations throughout its entire lifecycle. It can replicate a variety of real-world objects, from individual machinery to extensive systems like wind turbines or entire urban landscapes. This technology allows stakeholders to monitor asset performance, identify potential issues, and improve decision-making in terms of maintenance and overall lifecycle management.

Key components of digital twins include:

Virtual Model:

This encompasses the digital portrayal of the physical object or system, incorporating details such as geometry, materials, and other relevant characteristics.

Sensors and Data Acquisition:

Embedded sensors within the physical object collect real-time data on its condition, operation, and surrounding environment.

Data Processing and Analytics:

Collected data undergoes processing and analysis to extract insights into the physical object's behavior, performance, and health.

Simulation and Modeling:

Virtual models and real-time data are used to conduct simulations and models, predicting behavior, simulating scenarios, and optimizing performance.

Integration with IoT and Connectivity:

Digital twins are frequently linked to the Internet of Things (IoT) infrastructure, facilitating seamless data exchange and communication between the physical object and its digital counterpart.

Visualization and User Interface:

Tools for visualizing the digital twin and its data are provided, offering users intuitive interfaces to interact with and analyze information.

Lifecycle Management and Decision Support:

Digital twins assist in decision-making across the entire lifecycle of the physical object, from design and manufacturing to operation and maintenance, by providing insights and recommendations based on data analysis.

Security and Privacy Measures:

Given the sensitive nature of the data collected, robust security measures are crucial to protect against unauthorized access and ensure data privacy.

Enabling technologies play a pivotal role in the development and implementation of digital twins, enhancing their functionality and effectiveness. Here's a concise overview of key enabling technologies:

Real-time Sensors/Actuators:

These components collect real-time data from the physical object or system, offering crucial inputs for the operation of digital twins.

Wireless Communication:

Facilitates seamless data transmission between sensors, actuators, and computing systems, ensuring timely updates and feedback.

Powerful Processors/Computing Systems/Cloud:

High-performance computing resources, including cloud infrastructure, manage the processing demands of digital twin operations, such as data analytics and simulations.

Modeling Techniques & Simulation:

Advanced modeling techniques and simulation tools generate precise virtual representations of physical objects or systems, enhancing the fidelity of digital twins.

Analytics:

Tools for data analytics extract meaningful insights from the extensive data collected by sensors, supporting decision-making and optimization processes.

Artificial Intelligence (AI):

AI algorithms enhance digital twins by enabling autonomous decision-making, predictive analytics, and adaptive behavior based on data patterns.

Augmented/Virtual/Mixed Reality:

Contribute to the development of virtual twins, providing immersive visualization and interaction capabilities for enhanced understanding and manipulation of digital twin models.

Visualization:

User-friendly visualization tools present digital twin data in an understandable format, facilitating interpretation and decision-making by stakeholders.

Security:

Robust security measures safeguard digital twin ecosystems against cyber threats, ensuring the integrity, confidentiality, and availability of sensitive data.

Internet of Things (IoT):

IoT and Industrial IoT (IIoT) technologies serve as the foundation of digital twins, offering connectivity, smart sensors, and embedded processors crucial for real-time data acquisition and control.

Digital Twins for Products:

- DTP - Digital Twin Prototype: Utilized for designing and analyzing products.
- DTI - Digital Twin Instance: Tracks individual product data for service and maintenance purposes.
- DTA - Digital Twin Aggregate: Aggregates data from all DTIs to create a comprehensive profile for the product.

Digital Twin for Smart Cities:

- A digital copy covering 3,750 sq.km.
- Replicas of 20 landmarks included.
- Data sourced from drones, sensors, and satellites used for the model.
- Constantly evolving with live data for forecasting city behavior and planning, addressing issues like climate catastrophes, overpopulation, and new building environmental impact assessments (EIAs).
- Monitors traffic flow for effective traffic management.
- Enables emergency planning and response.

AI in Digital Twins Technology:

The Role of AI:

Artificial intelligence enhances the efficiency of digital twins by providing insights beyond real-world sensor capabilities. It predicts future scenarios, independently decides on necessary tests based on received data, and predicts actions for desired outcomes. Algorithms swiftly identify abnormal information from sensors.

Three Levels of Sophistication for Digital Twins:

1. Monitors physical items.
2. Utilizes simulations.
3. Implements machine learning for continuous data analysis.

For more sophisticated results, digital twins may incorporate virtual reality, mixed reality, or internet of things (IoT).

Digital Twin vs. Virtual Twin:

A digital twin serves as a digital representation of a physical entity, system, or process, reflecting its real-world state with real-time data. On the other hand, a virtual twin is a simulation of a product or process, allowing users to test, predict, and refine designs without the constraints of real-world experimentation. While both technologies optimize operations, they differ in their applications and features.

Digital Twin:

- Data-driven, focusing on real-time analytics and optimization.
- Offers more passive interaction, with users monitoring and receiving data.
- Represents a single entity reflecting a unique physical counterpart.
- Establishes a continuous feedback loop with data from the real-world usage.

Virtual Twin:

- Experience-driven, emphasizing visualization and simulation.
- Involves more active engagement, with users adjusting parameters or interacting directly with the virtual environment.
- Can represent multiple scenarios or variations of a product or process.

- Provides a testing ground, with data going out to the product or process before real-world implementation.

What have I learned

The seminar delved into the concept of digital twins, virtual replicas leveraging real-time data from sensors. These twins enable monitoring and optimization throughout their lifecycle, from individual equipment to smart cities. Key components include virtual modeling, data acquisition, analytics, and IoT integration. Highlighting enabling technologies like AI and wireless communication, the seminar showcased diverse applications in product development and smart city management, emphasizing the transformative potential of digital twins across various domains.