International Journal of Research in Engineering, Science and Management
Volume-2, Issue-10, October-2019
www.ijresm.com | ISSN (Online): 2581-5792

Study of Applications of Digital Twins

Dhrumil S. Shah[1], Seema Shah[2]
[1]Student, Dept. of Computer Engg., Mukesh Patel School of Technology Management & Engg., Mumbai, India
[2]Professor, Dept. of Computer Engg., Mukesh Patel School of Technology Management & Engg., Mumbai, India

***Abstract*: Digital twins provide the opportunity to observe and simulate current and future behaviour of cyber-physical systems in a non-invasive way. At the same time, digital representations of real-world assets allow to compare multiple situations in parallel and to estimate effects of planned interventions. Such simulations can be used in cyber-physical systems to make predictions about the future and prevent failures. However, it is complex to build a model that accurately represents the real-world and connects real-world assets to technically-oriented data streams produced by these assets. In this paper, we present a novel approach to model so called Industrial Data Streams. Such streams are produced by assets in the real world and are integrated on a message-oriented middleware. Streams are annotated using the concept of semantic labels, which allows to assign characteristics such as location or type of the underlying assets to data streams. Our contribution consists of a semantic schema representation that categorizes similar data streams, allowing subscribers to consume similar data from multiple assets within a single data analytics pipeline. Therefore, our approach paves the way for a more intuitive management of digital twin representations from industrial assets.**

***Keywords*: digital twins**

1. Introduction

Digital twin provides an effective way for the cyber-physical integration of manufacturing. Meanwhile, smart manufacturing services could optimize the entire business processes and operation procedure of manufacturing, to achieve a new higher level of productivity. The combination of smart manufacturing services and digital twin would radically change product design, manufacturing, usage, MRO and other processes. Combined with the services, the digital twin will generate more reasonable manufacturing planning and precise production control to help achieve smart manufacturing, through the two-way connectivity between the virtual and physical worlds of manufacturing. This paper specifies and highlights how manufacturing services and digital twin are converged together and the various components of digital twin are used by manufacturers in the form of services. Digital twin technology helps companies improve the customer experience by better understanding customer needs, develop enhancements to existing products, operations, and services, and can even help drive the innovation of new business. It is a concept that is embodied in your approach to product lifecycle management and digital manufacturing. Digital twin technology enables an electronic description of a physical part or product. Sensors can collect data from the physical product and send it back to the digital twin, and this communication can help optimize the product's performance. Digital twin technology helps companies improve the customer experience by better understanding customer needs, develop enhancements to existing products, operations, and services, and can even help drive the innovation of new business.

For example, GE's "digital wind farm" opened up new ways to improve productivity. GE uses the digital environment to inform the configuration of each wind turbine prior to construction. Its goal is to generate 20% gains in efficiency by analyzing the data from each turbine that is fed to its virtual equivalent.

2. Overview of digital twin

A digital twin is a representation of a physical object or system. A digital twin is a computer program that takes real world data about a physical object or system as inputs and produces as output predictions. The key component of a digital twin is a digital thread. Quite simply, a digital twin is a virtual model of a process, product or service. This pairing of the virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations.

Thomas Kaiser, SAP Senior Vice President IOT, put it this way: "Digital twins are becoming a business imperative, covering the entire lifecycle of an asset or process and forming the foundation for connected products. A digital twin is a complete and operational virtual representation of an asset, subsystem or system, combining digital aspects of how the equipment is built (PLM data, design models, manufacturing data) with real-time aspects of how it is operated and maintained. The capability to refer to data stored in different places from one common digital twin directory enables simulation, diagnostics, prediction and other advanced use cases.

3. Type of software used in digital twin

Digital twin software provides a virtual representation or stimulation of a physical asset and is used to monitor the performance IOT device management or computer-aided engineering (CAE) software.

4. Role of phase of digital twin

Design: Simulation and visualization during the design phase can be used to verify and inspect the overall 3-D design and make sure all parts fit together. Simulations include mechanical, thermal and electrical as well as interrelationships between these aspects.

System integration: 3-D visualizations on a system level can verify constraints such as spatial footprint and physical connections. By connecting to the digital twins of other components, interactions can be simulated, including data transfer and control functionality as well as mechanical and electrical behavior and what-if scenarios. Integration effort on site and the associated downtime for the customer is reduced.

Diagnostics: Observation of the digital twin, for example in a 3-D visualization, can support troubleshooting. Virtual-reality glasses can provide field technicians with an overlay over the real equipment to visualize parameters. Simulations can add non-observable data, such as temperatures of non-accessible parts or material stress.

Prediction: Past and present operational and sensor data in combination with predictive algorithms provide insights into the condition of equipment and the likelihood of different failure modes. This helps plan rational maintenance and reduce unplanned downtime.

Advanced services: If all the advanced service parameters (IoT connectivity, analytics algorithms, etc.) are preconfigured in the digital twin, they can be enabled when the equipment is installed and the customer subscribes to these services. In the optimal case, no further engineering is required.

5. Applications of digital twin

Manufacturing: Digital Twin is poised to change the current face of manufacturing sector. Digital Twins have a significant impact on the way products are designed manufactured and maintained. It makes manufacturing more efficient and optimized while reducing the throughput times.

Automobile: Digital Twins can be used in the automobile sector for creating the virtual model of a connected vehicle. It captures the behavioral and operational data of the vehicle and helps in analyzing the overall vehicle performance as well as the connected features. It also helps in delivering a truly personalized/ customized service for the customers.

Retail: Appealing customer experience is key in the retail sector. Digital twin implementation can play a key role in augmenting the retail customer experience by creating virtual twins for customers and modelling fashions for them on it. Digital Twins also helps in better in store planning, security implementation and energy management in an optimized

Healthcare: Digital Twins along with data from IoT can play a key role in the health care sector from cost savings to patient monitoring, preventative maintenance and providing personalized health care.

Smart Cities: The smart city planning and implementation with Digital Twins and IoT data helps enhancing economic development, efficient management of resources, reduction of ecological foot print and increase the overall quality of a citizen’s life. The digital twin model can help city planners and policymakers in the smart city planning by gaining the insights from various sensor networks and intelligent systems. The data from the digital twins help them in arriving at informed decisions regarding the future as well.

Industrial IoT: Industrial firms with digital twin implementation can now monitor, track and control industrial systems digitally. Apart from the operational data, the digital twins capture environmental data such as location, configuration, financial models etc. which helps in predicting the future operations and anomalies

Digital twins is used mainly in automotive, manufacturing and in medical industries. The components are connected to a cloud-based system that receives and processes all the data the sensors monitor. This input is analyzed against business and other contextual data. A digital twin supports and removes uncertainty during design and configuration while supporting applications and ensuring availability and reliability through condition monitoring and advanced services.

Remote robotics
Monitoring in equipment
Smart home command system
Monitor and enhance our mental and brain performance

6. Types of digital twins

A. *Parts twinning*

The foundation of digital twinning is the need for robust parts twinning. At this level, the virtual representations of the individual components give engineers the capability to understand the physical, mechanical, and electrical characteristics of a part. For example, many computer-aided design/manufacturing (CAD/CAM) solutions today offer the ability to perform a variety of analyses relating to durability, including static stress and thermal stress. Electronic circuit simulation software, for example, tells us how electronic components will react as various electrical signals are injected into a circuit. It requires a mathematical model of sufficient complexity to be able to best predict real-world behaviors under a variety of scenarios.

B. *Product Twinning*

Twinning individual parts offers useful insights but twinning the interoperability of parts as they work together helps to enable product twinning. Being able to understand how parts interact with each other and their environment allows for optimization of the constituent parts, thereby maximizing operating characteristics and minimizing things such as a mean time between failures (MTBF) and mean time to repair (MTTR).

C. *System Twinning*

At the next higher level, system twinning allows engineers to operate and maintain entire fleets of disparate products that work together to achieve a result at a system level. Think of an energy grid that can spin up or spin down electrical generation by monitoring the demand. Now imagine this possibility across all types of system families. Groups that build and manage communication systems, traffic control systems, or industrial manufacturing systems will have an unheard-of ability to monitor and experiment with their systems to achieve unparalleled efficiency and effectiveness.

D. Process Twinning

Digital twinning isn't just limited to physical objects; it can be used to twin processes and workflows as well. Process twinning empowers the optimization of operations involved in refining the raw materials production of finished goods. Purely business-focused workflows, even those that still have humans in the loop, would also benefit from DT modeling, allowing managers to tweak inputs and see how outputs are affected without the risk of upending existing workflows, which would otherwise cause business to grind to a halt. Process twinning will enable senior corporate leadership to monitor key business metrics in a much more data-driven manner than has been previously possible.

7. Benefits of digital twins

1. Faster production times
2. More efficient delivery and supply chains
3. Improved productivity and operational efficiencies
4. Providing remotely configuring customized products to customers
5. Improved customer service
6. Prediction of maintenance issues before the occurrence of breakdowns
7. Reduced maintenance costs
8. Improved Overall Equipment Effectiveness (OEE) through minimized downtime.
9. Enhanced reliability of production and equipment lines
10. Improved profits on a sustaining basis

8. Approach

To create a digital twin for environments with Industrial Data Streams, we suggest an intuitive and easily adoptable model. First, we define the meaning of data streams and how different data streams containing similar data can be compared or combined. We define how data streams can be combined based on the meaning. After defining the meaning of individual streams we need to categorize them into our domain and model how they are connected.

A. Data streams

A data stream has two parts, the actual data that contains the information of observations made by the data source, a continuous stream of events, and a description of the meaning of the individual values.

B. Virtual sensor

The virtual sensor technique is basically used for comparing data with its meaning and not by its representation. For example, when we have a virtual sensor called sp: temperature with an id, timestamp, and a measurement value modeled in form of an Event Property Primitive, each Event Schema containing such a sensor should have the predicate has Virtual Sensor sp: temperature.

C. Semantic labelling

We use semantic labels to group individual data streams together. Two data streams with the same semantic label are in the same group. One data stream can have multiple labels. A Semantic Label is an RDF class and instances of that class must have the property RDFS: label. Our goal

is to have a lightweight solution to annotate data streams with semantic information. This information can then be used to construct a domain model, which can be extended with further information.

9. Conclusion

As seen in the case study, it was for the first time possible to create a Digital Twin automatically through current information from the cyber-physical system. It was illustrated how to create a Digital Twin of a body-in-white production system for rough and concept planning projects. The automatic creation of a bill of resources through mapping form robotic simulation and the CPS makes a Digital Twin for concept planning more accurate. Furthermore, it offers the possibility of an automated update on demand. This paper shows that the general concept to create a current resources structure and update the layout works. Through such an automated creation of a Digital Twin, a great deal money and time can be saved. On one side, there is the money that can be saved through the creation of a current concept planning state instead of manually generated documentation. On the other side, a great deal of money can be saved through a more independent mandate for follow-up orders. This is enabled through detailed information about the production system by using the Digital Twin. Another benefit is that product planners can influence the development of new cars by current production data from the Digital Twin so that it can be produced more accessible with the consistent production system. The most important advantage is offered through the Digital Twin for production planning by integration of the new vehicle and vehicle derivative into the existing production system. This is given by saving time through a quick inventory of planners. Furthermore, they can acquire more detailed information about the layout by overlaying the 3D point cloud of the real production system with the digital model.

References

[1] https://www.allerin.com/blog/applications-of-digital-twin