DIGITAL TWIN

Digital twins were anticipated by David Gelernter's 1991 book Mirror Worlds. The concept and model of the digital twin was first publicly introduced in 2002 by Grieves, at a Society of Manufacturing Engineers conference in Troy, Michigan. Grieves proposed the digital twin as the conceptual model underlying product lifecycle management (PLM).

An Early Digital Twin Concept by Grieves and Vickers

The digital twin concept, which has been known by different names (e.g., digital engineering), was subsequently called the "digital twin" by John Vickers of NASA in a 2010 Roadmap Report. The digital twin concept consists of three distinct parts: the physical product, the digital/virtual product, and connections between the two products. The connections between the physical product and the digital/virtual product is data that flows from the physical product to the digital/virtual product and information that is available from the digital/virtual product to the physical environment.

WHAT IS DIGITAL TWIN?

A digital twin is a dynamic virtual copy of a physical asset, process, system or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes so you can predict possible performance outcomes and issues that the real-world product might undergo. A digital twin is also said to be a dynamic virtual copy of a physical asset, process, system or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes so you can predict possible performance outcomes and issues that the real-world product might undergo.

In simple terms, digital twins are virtual replicas of physical devices that data scientists and IT pros can use to run simulations before actual devices are built and deployed. Digital twins can also take real-time IoT data and apply AI and data analytics to optimize performance.

As an exact digital replica of something in the physical world, digital twins are made possible thanks to Internet of Things (IoT) sensors that gather data from the physical world and send it to machines to reconstruct. While the concept of a digital twin has been around since 2002 when Michael Grieves at the University of Michigan first used the terminology, it was IoT technology that made it affordable and accessible to many more businesses. By creating a digital twin, insights about how to improve operations, increase efficiency or discover an issue are all possible before it happens to whatever it’s duplicating in the real world. The lessons learned from the digital twin can then be applied to the original system with much less risk and a lot more return on investment.

When you take a minute to consider all the ways this could be useful for businesses, it’s easy to see how the potential for digital twin technology is just about limitless. That’s likely why digital twin technology was included on Gartner’s Top 10 Strategic Technology Trends for 2017 and 2018. Gartner predicted there would be 21 billion connected sensors by 2020, making digital twins possible for billions of things.

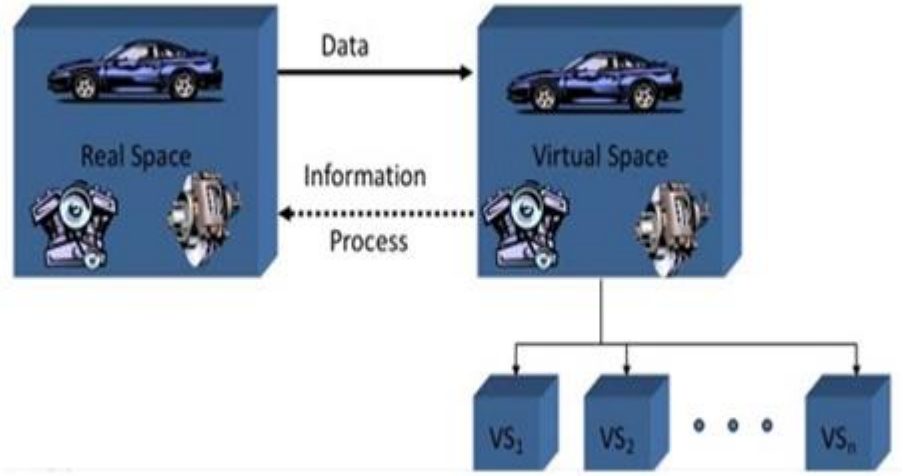

Fig1.1

FIVE REAL-LIFE EXAMPLES OF DIGITAL TWIN TECHNOLOGY

Manufacturing

Manufacturing is one of the key areas that digital twins are changing operations. Automotive manufacturers have taken digital twin technology to revolutionize the way cars are made. Ford develops seven digital twins for each model of vehicle it produces. Each twin covers a different aspect of production from design to build and operated. They also use digital models for the manufacturing process, production facilities and customer experience. For their production facilities, the digital twin accurately detects energy losses and pinpoints areas where energy can be conserved and overall production line performance improved. A real-life example is given below:

Automotive industry: running Tesla car replicas for remote diagnostics

Each new car produced by Tesla has its own digital twin. Sensors embedded in a vehicle constantly stream data about the environment and performance to the virtual copy that lives in the cloud. AI algorithms analyze these feeds to identify whether the car works as expected. If not, the problems are fixed by sending over-the-air software updates.

In this way, Tesla adapts the vehicle's configurations to different climate conditions, virtually improves its performance, and provides remote diagnostics, minimizing the need for visiting service centers. You can read about other approaches to vehicle maintenance in a dedicated article.

Health Care

Manufacturing isn't the only area digital twins can be used to improve processes – healthcare is also receiving a boost from the technology. Digital twins of patients or their organs enable practitioners to simulate procedures and specific environments before trying them in real life. Bandage sized sensors are used to collect real-life data and inform the digital twin to improve health care. Digital twin technology can be used to generate a virtual twin of a hospital to review operational strategies, capacities, staffing, and care models to identify areas of improvement, predict future challenges, and optimize organizational strategies. They are also applied for modeling organs and single cells or an individual's genetic makeup, physiological characteristics, and lifestyle habits to create personalized medicine and treatment plans.

Energy Systems

Energy is another sector benefitting from digital twins. GE's wind farm has increased productivity by as much as 20%. The real-time information fed to their digital replicas from sensors on each of the turbines enables more efficient designs and even suggests changes for making each active turbine more effective.

Twin Hotels

Simulating real-life events and situations in restaurants is helping the hospitality sector improve the configuration of kitchens and dining areas for better people flow. Hotels are also jumping in on the emerging tech to analyze the use of their facilities and deliver personalized service to each guest.

Twin Cities

If digital twins of factories, hotels and wind farms can improve efficiencies and processes, how about an entire city? Singapore and Shanghai both have complete digital twins that work to improve energy consumption, traffic flow and even help plan developments. Smart cities are fast becoming a reality, providing an excellent way to reduce pollution and increase the wellbeing of residents.

TYPES OF DIGITAL TWINS

In essence, all these types of digital twins are the same – they represent an object or process virtually and help to predict key factors like the running time or foreseeable damage. What the different types differ in, however, is the area of application. Let us now go through all types to get a more precise picture of the differences.

Component Twins / Parts Twins

As the name suggests, this is the twin of a single component in the entire system. How now? Is every screw in a car virtually reproduced in order to be able to make predictions about its service life? No, of course not, these are real key components that have a direct impact on performance and functionality. A second application is consisting of components that are not quite as important but are subject to constant high or jerky influences.

Asset Twins

Asset Twins are the next higher level of digital twins. They describe how individual components work together as an entire asset – for a better understanding: A good example of this is an engine or a pump. Asset Twins can receive information from Component Twins or be a collection of Component Twins themselves. While component twins are more concerned with the stability and durability of individual parts, Asset Twins allow you to explore an entire system. You can check how and how well individual parts work together and discover potential for improvement without having to screw around with real engines or machine gearboxes. So, you can virtually – and consequently real – reduce mean time between failures and mean time to repair as well as fuel consumption while increasing factors like performance.

System or Unit Twins

The system twins, also known as unit twins, work on a higher level. They combine individual Asset Twins and give you the opportunity to check how individual assets work together – comparable to Asset Twins that combine individual Component Twins. Let's stick to our car example: The System Twin combines all assets that are necessary for propulsion and all assets that are necessary for electricity and all assets that are needed for the bodywork, etc. The System Twin is a system that can be used for all the different types of applications.

For the sake of understanding, perhaps the example of the car factory is a bit simpler: here a System Twin brings together all the units necessary for the production of a component of the finished car. System Twins are also all about improving the collaboration between individual assets – so that the end result is maximum performance with minimum wear and tear or time consumption.

Process Twins

When a System Twin represents the production units for a single part of a car, the Process Twin represents an entire production facility and provides insight into the collaboration of all units. And then factors such as timing become important. In the closed-loop of an entire process, individual units can also produce too quickly, leading to an excess of certain individual parts and thus to high storage costs or other logistical challenges. It is only at this level that the entire complexity of monitoring via digital twins becomes really clear. Because a process only becomes functional and effective when all units, assets, and components fulfill their purpose.

THE BENEFITS OF USING DIGITAL TWINS

1) **Accelerated risk assessment and production time**

With the help of a digital twin, companies can test and validate a product before it even exists in the real world. By creating a replica of the planned production process, a digital twin enables engineers to identify any process failures before the product goes into production. Engineers can disrupt the system to synthesize unexpected scenarios, examine the system's reaction, and identify corresponding mitigation strategies. This new capability improves risk assessment, accelerates the development of new products, and enhances the production line's reliability.

2) **Predictive maintenance**

Since a digital twin system's IoT sensors generate big data in real-time, businesses can analyze their data to proactively identify any problems within the system. This ability enables businesses to more accurately schedule predictive maintenance, thus improving production line efficiency and lowering maintenance costs.

3) **Real-time remote monitoring**

It is often very difficult or even impossible to get a real-time, in-depth view of a large physical system. However, a digital twin can be accessed anywhere, enabling users to monitor and control the system performance remotely.

4) **Better team collaboration**

Process automation and 24×7 access to system information allows technicians to focus more on inter-team collaboration, which leads to improved productivity and operational efficiency.

5) **Better financial decision-making**

A virtual representation of a physical object has the ability to integrate financial data, such as the cost of materials and labor. The availability of a large amount of real-time data and advanced analytics enables businesses to make better and faster decisions about whether or not adjustments to a manufacturing value chain are financially sound.

Drawbacks or disadvantages of Digital Twin

Following are the drawbacks or disadvantages of Digital Twin:

➡The success of technology is dependent on internet connectivity.

➡The security is at stake.

➡The digital twin concept is based on 3D CAD models and not on 2D drawings.

➡Digital twin will be required across entire supply chains.

➡The challenges involved here include globalization and new manufacturing techniques. Managing all these design data for digital twin among partners and suppliers as the physical product evolves will be a challenge.

ROLE OF DATA ANALYTICS IN DIGITAL TWIN