What is a digital twin?

A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making

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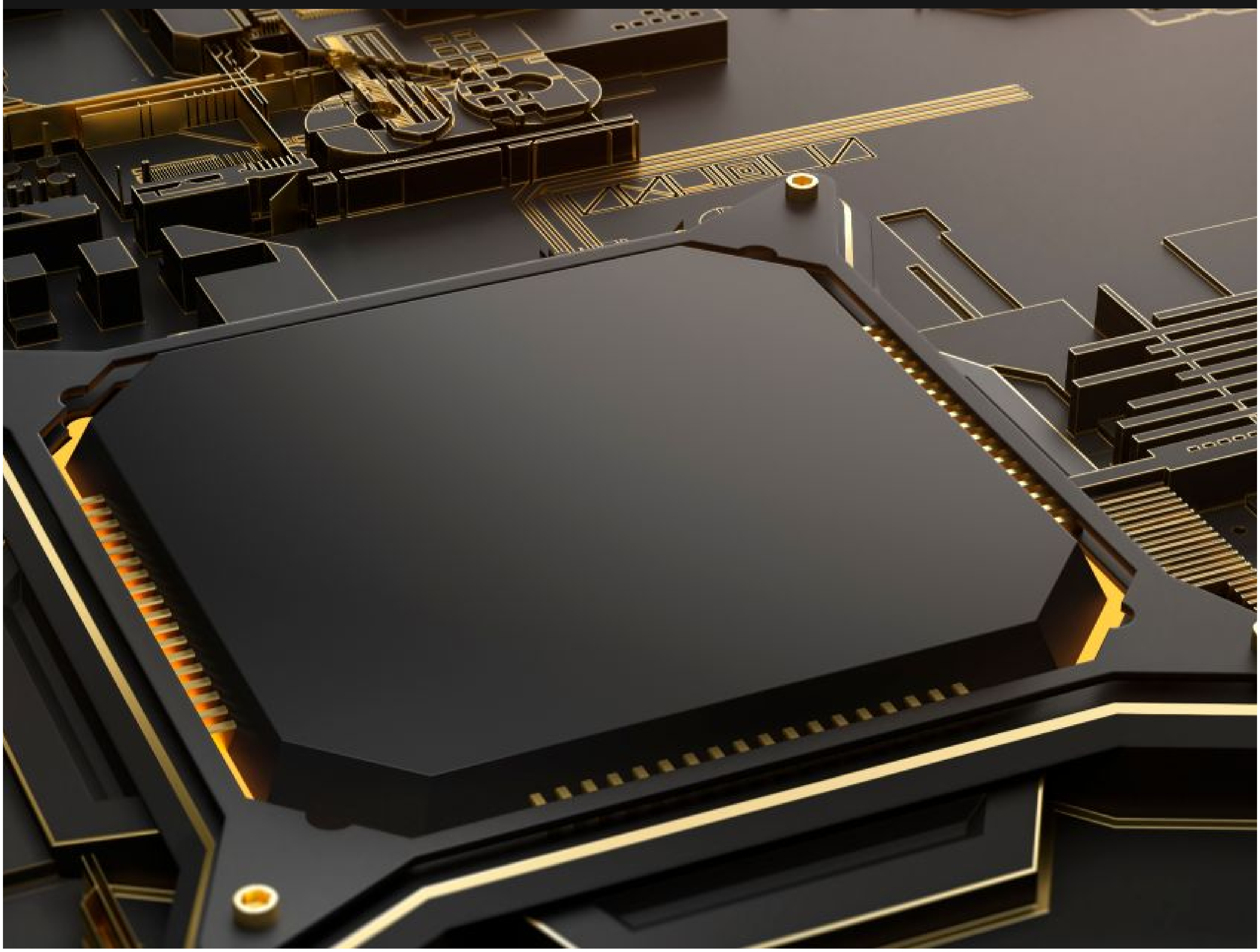

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How does a digital twin work?

A digital twin is a virtual model designed to accurately reflect a physical object. The object being studied — for example, a wind turbine — is outfitted with various sensors related to vital areas of functionality. These sensors produce data about different aspects of the physical object's performance, such as energy output, temperature, weather conditions and more. This data is then relayed to a processing system and applied to the digital copy.

Once informed with such data, the virtual model can be used to run simulations, study performance issues and generate possible improvements, all with the goal of generating valuable insights — which can then be applied back to the original physical object.

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Digital twins vs. simulations

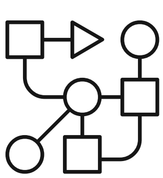
Although simulations and digital twins both utilize digital models to replicate a system's various processes, a digital twin is actually a virtual environment, which makes it considerably richer for study. The difference between digital twin and simulation is largely a matter of scale: While a simulation typically studies one particular process, a digital twin can itself run any number of useful simulations in order to study multiple processes.

The differences don't end there. For example, simulations usually don't benefit from having real-time data. But digital twins are designed around a two-way flow of information that first occurs when object sensors provide relevant data to the system processor and then happens again when insights created by the processor are shared back with the original source object.

By having better and constantly updated data related to a wide range of areas, combined with the added computing power that accompanies a virtual environment, digital twins are able to study more issues from far more vantage points than standard simulations can — with greater ultimate potential to improve products and processes.

Types of digital twins

There are various types of digital twins depending on the level of product magnification. The biggest difference between these twins is the area of application. It is common to have different types of digital twins co-exist within a system or process. Let's go through the types of digital twins to learn the differences and how they are applied.



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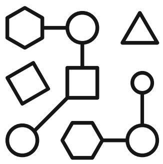
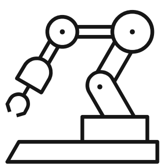
Component twins/Parts twins

Component twins are the basic unit of digital twin, the smallest example of a functioning component. Parts twins are roughly the same thing, but pertain to components of slightly less importance.



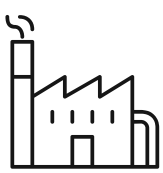
Asset twins

When two or more components work together, they form what is known as an asset. Asset twins let you study the interaction of those components, creating a wealth of performance data that can be processed and then turned into actionable insights.



System or Unit twins

The next level of magnification involves system or unit twins, which enable you to see how different assets come together to form an entire functioning system. System twins provide visibility regarding the interaction of assets, and may suggest performance enhancements.



Process twins

Process twins, the macro level of magnification, reveal how systems work together to create an entire production facility. Are those systems all synchronized to operate at peak efficiency, or will delays in one system affect others? Process twins can help determine the precise timing schemes that ultimately influence overall effectiveness.

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History of digital twin technology

The idea of digital twin technology was first voiced in 1991, with the publication of *Mirror Worlds*, by David Gelernter. However, Dr. Michael Grieves (then on faculty at the University of Michigan) is credited with first applying the concept of digital twins to manufacturing in 2002 and formally announcing the digital twin software concept. Eventually, NASA's John Vickers introduced a new term — "digital twin"— in 2010.

However, the core idea of using a digital twin as a means of studying a physical object can actually be witnessed much earlier. In fact, it can be rightfully said that NASA pioneered the use of digital twin technology during its space exploration missions of the 1960s, when each voyaging spacecraft was exactly replicated in an earthbound version that was used for study and simulation purposes by NASA personnel serving on flight crews.

Advantages and benefits of digital twins

Better R&D
The use of digital twins enables more effective research and design of products, with an abundance of data created about likely performance outcomes. That information can lead to insights that help companies make needed product refinements before starting production

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Greater efficiency
Even after a new product has gone into production, digital twins can help mirror and monitor production systems, with an eye to achieving and maintaining peak efficiency throughout the entire manufacturing process.

Product end-of-life
Digital twins can even help manufacturers decide what to do with products that reach the end of their product lifecycle and need to receive final processing, through recycling or other measures. By using digital twins, they can determine which product materials can be harvested.

Digital twin market and industries

While digital twins are prized for what they offer, their use isn't warranted for every manufacturer or every product created. Not every object is complex enough to need the intense and regular flow of sensor data that digital twins require. Nor is it always worth it from a financial standpoint to invest significant resources in the creation of a digital twin. (Keep in mind that a digital twin is an exact replica of a physical object, which could make its creation costly.)

On the other hand, numerous types of projects do specifically benefit from the use of digital models:

- **Physically large projects** Buildings, bridges and other complex structures bound by strict rules of engineering.
- **Mechanically complex projects** Jet turbines, automobiles and aircraft. Digital twins can help improve efficiency within complicated machinery and mammoth engines.
- **Power equipment** This includes both the mechanisms for generating power and transmitting it.
- **Manufacturing projects** Digital twins excel at helping streamline process efficiency, as you would find in industrial environments with co-functioning machine systems.

Therefore, the industries that achieve the greatest success with digital twins are those involved with large-scale products or projects:

- Engineering (systems)
- Automobile manufacturing
- Aircraft production
- Railcar design

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- Building construction
- Manufacturing
- Power utilities

Digital twin market: Poised for growth

The rapidly expanding digital twin market indicates that while digital twins are already in use across many industries, the demand for digital twins will continue to escalate for some time. In 2020, the digital twin market was valued at USD 3.1 billion. Some industry analysts speculate it could continue to rise sharply until at least 2026, climbing to an estimated USD 48.2 billion[1].

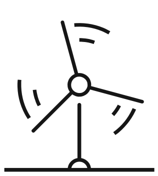
Improving manufacturing efficiency with digital twin

The use of end-to-end digital twins lets owner/operators reduce equipment downtime while upping production. Discover a Service Lifecycle Management solution created by IBM and Siemens.

Read how Siemens uses digital twins →

Applications

Digital twins are already extensively used in the following applications:



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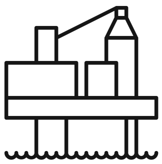
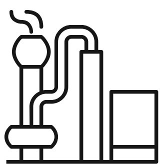
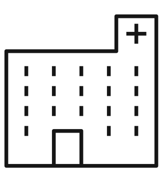
Power-generation equipment
Large engines — including jet engines, locomotive engines and power-generation turbines — benefit tremendously from the use of digital twins, especially for helping to establish timeframes for regularly needed maintenance.



Structures and their systems
Big physical structures, such as large buildings or offshore drilling platforms, can be improved through digital twins, particularly during their design. Also useful in designing the systems operating within those structures, such as HVAC systems.



Manufacturing operations
Since digital twins are meant to mirror a product's entire lifecycle, it's not surprising that digital twins have become ubiquitous in all stages of manufacturing, guiding products from design to finished product, and all steps in between.



Healthcare services
Just as products can be profiled through the use of digital twins, so can patients receiving healthcare services. The same type system of sensor-generated data can be used to track a variety of health indicators and generate key insights.

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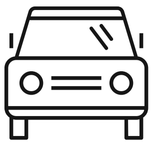

Automotive industry
Cars represent many types of complex, co-functioning systems, and digital twins are used extensively in auto design, both to improve vehicle performance and increase the efficiency surrounding their production.

Urban planning
Civil engineers and others involved in urban planning activities are aided significantly by the use of digital twins, which can show 3D and 4D spatial data in real time and also incorporate augmented reality systems into built environments.

The future of digital twin

A fundamental change to existing operating models is clearly happening. A digital reinvention is occurring in asset-intensive industries that is changing operating models in a disruptive way, requiring an integrated physical plus digital view of assets, equipment, facilities and processes. Digital twins are a vital part of that realignment.

The future of digital twins is nearly limitless, due to the fact that increasing amounts of cognitive power are constantly being devoted to their use. So digital twins are constantly learning new skills and capabilities, which means they can continue to generate the insights needed to make products better and processes more efficient.

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Learn how change will impact your industry in this article on transforming asset operations with digital twins.

Learn about transforming asset operations with digital twins

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