

About Models and Digital Twins

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Let us share

Investigating the *idea/concept/technology* ? of **digital twin** for a while ...

and reading the article :

What Is Digital Twin Technology - And Why Is It So Important ?

www.forbes.com/sites/bernardmarr/2017/03/06/

By Bernard Marr

its became more clear for me !

Let us share the concerns.

Some references

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Real and Virtual Spaces, Grieves, 2002

PLM : Product Lifecycle Management

Conceptual Ideal for PLM

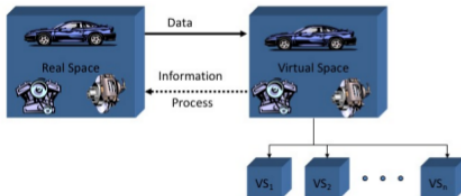


Figure 3

Dr. Michael Grieves, University of Michigan, Lurie Engineering Center, Dec 3, 2002

FIGURE – By Grieves, University of Michigan, (2002)

the virtual object is more than a model of the object

VSs : a system could be through destructive tests inexpensively

What is a model ? some definitions (CS but not only)

There are **two main notions of models in computer science.**

Model

An **approximation of the reality by a mathematical structure.** An object O is a model of a reality R , if O allows one to answer all the questions about R .

Logics, theory of models / Herbrand

A model of a theory T is a structure in which the axioms of T are valid.

A structure S is a model of a theory T , or S satisfies T if all formula of T is satisfied in S .

Hoare

A scientific theory is formalised as a mathematical model of reality, from which can be deduced or calculated the observable properties of a well-defined class of processes in the physical world.

Pairing technology pioneered in aerospace, NASA

NASA was the first to dabble with **pairing technology** (the precursor to today's digital twin) as far back as the early days of space exploration.

How do you operate, maintain, or repair systems when you aren't within physical proximity to them ? That was the challenge NASA's research department had to face when developing systems that would travel beyond the ability to see or monitor physically.

And when disaster struck Apollo 13, it was the **innovation of mirrored systems still on earth that allowed engineers and astronauts to determine how they could rescue the mission.** Today, NASA uses digital twins to develop new recommendations, roadmaps, and next-generation vehicles and aircraft.

from Bernard Marr's article, 2017

Digital twin, since 2002,now, thanks IoT

What is it ?

A digital twin is a virtual model of a process, product or service.

This **pairing of the virtual and physical worlds** allows analyses 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.

Michael Grieves, University of Michigan, first wrote of the concept using the digital twin terminology in 2002.

What is new ?

CPS, Cloud, Industry 4.0, IoT, ...

How does a digital twin works ?

A digital twin : a bridge between the physical and digital world

First, **smart components** that use sensors to gather data about real-time status, working condition, or position **are integrated with a physical item**. 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.

Lessons are learned and opportunities are uncovered within the virtual environment that can be applied to the physical world — ultimately to transform [your] business.

Digital twins are a dynamic software model of a physical thing or system (Gartner)

Since 2002 - Long and active practice in Aerospace, NASA

“The ultimate vision for the digital twin is **to create, test and build our equipment in a virtual environment**”

“**Only when we get it to where it performs to our requirements do we physically manufacture it.** We then want that physical build to tie back to its digital twin through sensors so that the digital twin contains all the information that we could have by inspecting the physical build.”

(John Vickers, NASA's leading manufacturing expert and manager of NASA's National Center for Advanced Manufacturing)

DT prototype, DT instance, DT environment

The current keen interest

There will be **billions of things represented by digital twins within the next five years**. These proxies of the physical world will lead to new collaboration opportunities among physical world product experts and data scientists whose jobs are to understand what data tells us about operations.

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.

from Bernard Marr's article, 2017

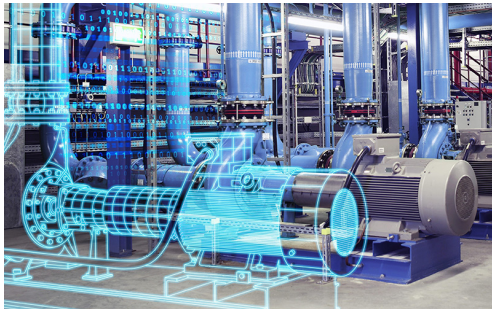
The current keen interest

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.

"For every physical asset in the world, we have a virtual copy running in the cloud that gets richer with every second of operational data,"

Ganesh Bell, chief digital officer, general manager of Software & Analytics, GE

The current keen interest - Industry



Manufacturing America, attendmia.com/blog/2019/02/27/explore-the-latest-manufacturing-technology/

So, which vision of a digital twin ?

My current vision

An **enriched/augmented formal model** of a physical and active object, allowing one to study and predict the behaviour of the object prior to its building and to make evolve, and even repair, the object during its life.

Some concerns and issues to investigate

- Which models/analyses fit well for which categories of objects ?
- Build efficient (heterogeneous) models and enrich them (HW, RT, CPS, HCI...); adapt the analysis tools
- How faithful is the digital twin compared to the twin object ? Verification
- How to cross-compare the twins (after their evolution) ?
- Decision in case of behaviour divergence ?
- ...

What about your understanding of Digital twins ?

