Gemelli Diversi
«Digital Twin nella impresa manifatturiera»

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Digital replica of real world
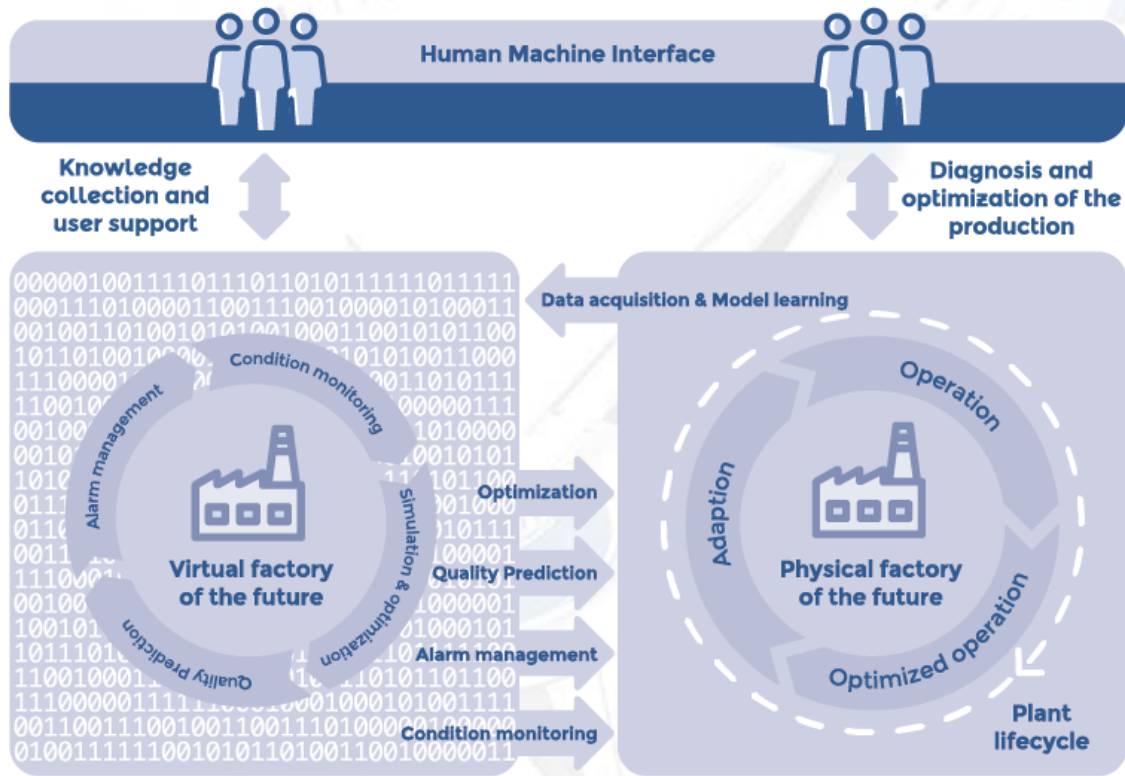
- A digital twin is a virtual representation of a process or a product.

- It can be used in product design, simulation, monitoring, optimisation and servicing

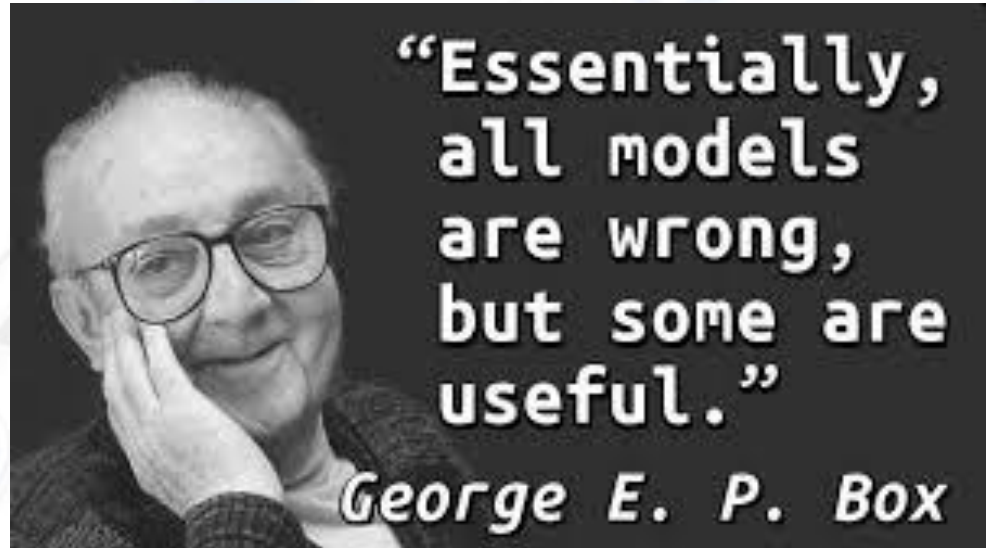- It is an important concept in the Industry 4.0
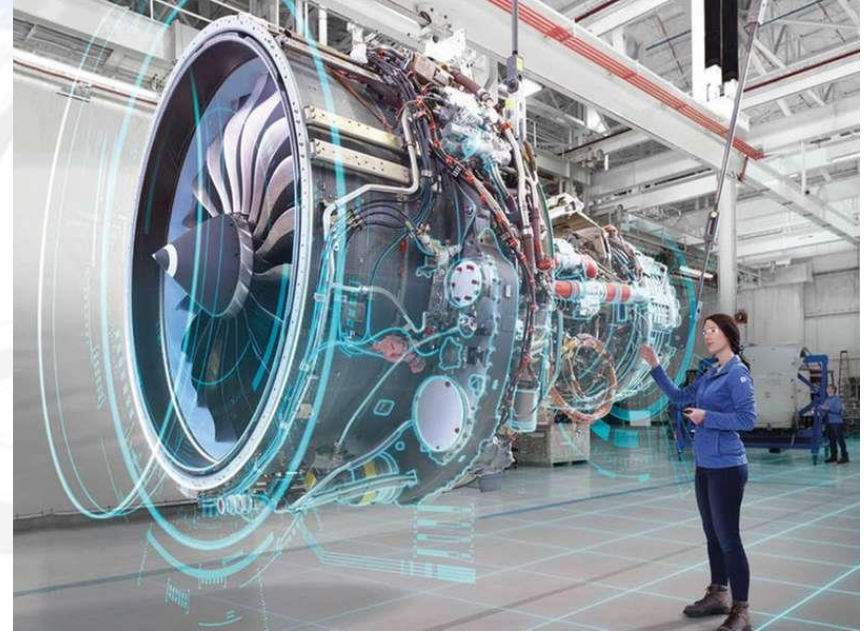
Digital Twin

Source: IMPROVE
European Project
http://improve-vfof.eu/

- Model of real process/product is the key aspect for creating a Digital Twin

"Essentially, all models are wrong, but some are useful."

George E. P. Box

Models (1) : Dynamical models

- Dynamical models : describes the evolution of a system in time when external forces are applied.

  ⇒Comes from physical knowledge of the system

  ⇒Requires model parameters identification.

  ⇒Software tools for modelling and simulate part of complex system

Example: Hybrid Electric Vehicle Modeling and Simulation

The effort in this example is paid to:

- Construct the virtual replica of the system to predict dynamic evolution of the system.
- Tune model parameters to obtain a model with behavior close to reality.

Hybrid Electrical Vehicle Model
**Balance Fidelity and Speed**

Models (2) : Kinematic models
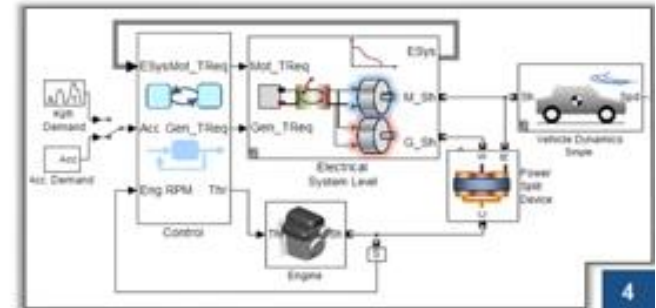
- Kinematics models : describes the motion of a mechanical system.

  ⇒Models are derived from mechanical CAD 3D.

  ⇒Tools for automatic build from CAD software.

  ⇒Motion characteristics should be defined manually.

  ⇒Product behavior can be modelled using friction parameters and collision forces.

Example: Kinematic simulation.

The effort in this example is paid to (providing that mechanical structure is acquired automatically form 3D CAD).

- Introduce motion constraints.
- Connect control software.
- Model product interaction.
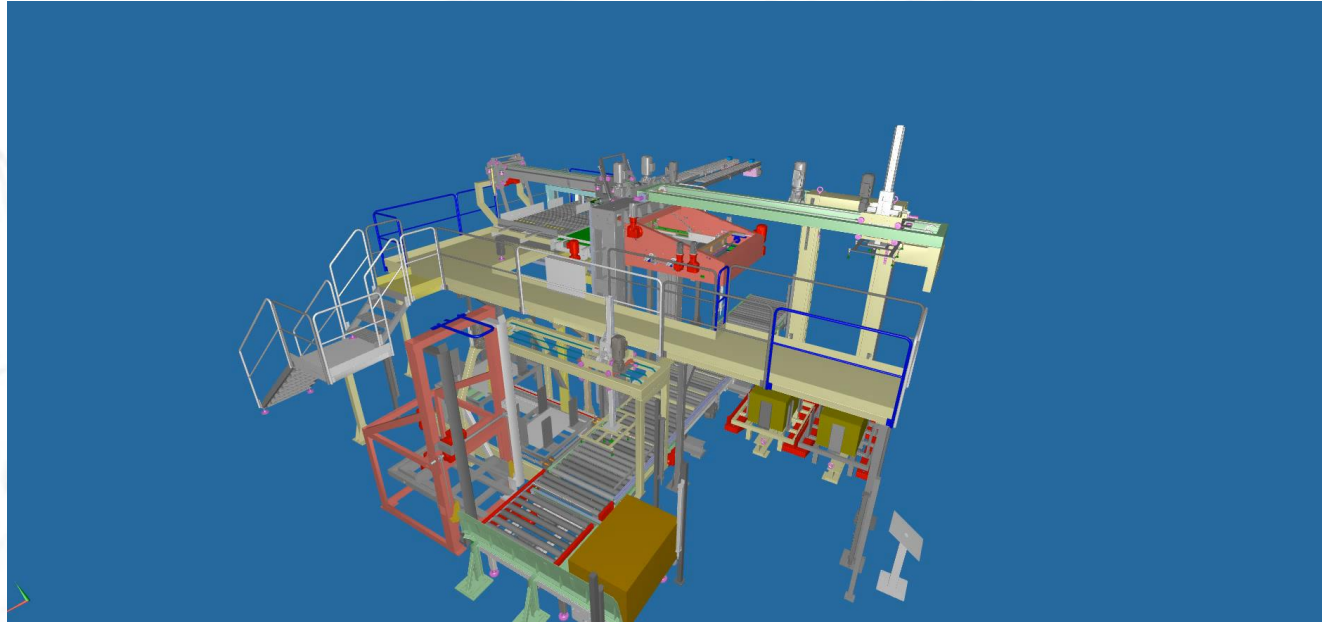
Models (3) : Discrete events.

- Discrete event models : capture the global behavior a of machine (e.g. is working/is not working).

  ⇒Used to simulate complex system such as production lines, assembly system, etc.

  ⇒Uses statistical information on machine (MTBF, MTTR) to derive long term performance index.

  ⇒Useful in "what-if" analysis.

# Example: Discrete event simulation.

The effort in this example is paid to:
- Create the model.
- Identify statistical parameters (e.g. MTBF, MTTR, etc.).
- Run simulation campaigns with different initial conditions.

Models (4) : Immersive model
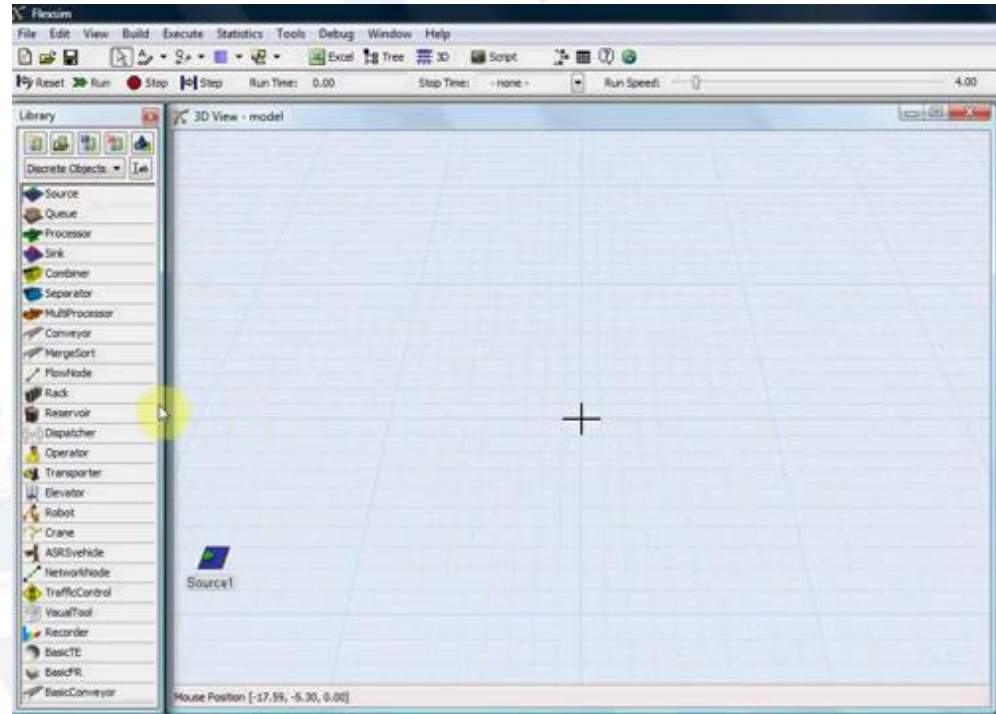
- Immersive models : merge the user experience with a virtual replica of the system.

- Can be a mix between real and virtual environment (augmented reality)

- Or is a full virtual environment (virtual reality).

    $\Rightarrow$ Come from virtual reconstruction of real components.

The effort in this example is paid to:
- Construct the virtual replica of components.
- Localize components on real machine with natural or artificial landmarks.
- Develop contents for operators' support.
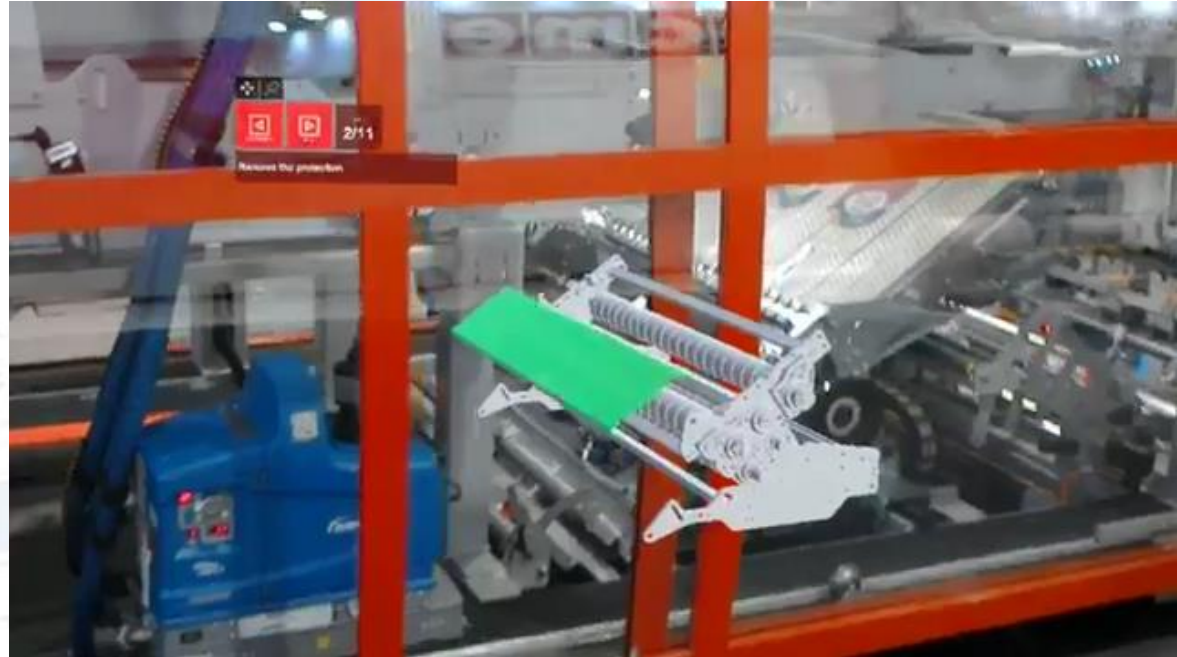
Information

- The goal of a any Digital Twin project is to use information to derive models (dynamic, kinematic, discrete event, immersive).

- To shorten cost and improve model accuracy it is essential to re-use information developed in the design process.

- However the main issue still exist:

  – How close is the digital twin to be useful?

  (Il Sistema reale e virtuale sono *Gemelli diversi?)*

Lessons learnt

- Digital Twin aims to be a replica of the real process/product.

- It can be useful, but the creation, parameter tuning, usage... are all to be considered in the cost/benefit ratio.

- Tools for information management (e.g. automatic extraction of the model from CAD) are very important for Digital Twin development.