Serge Zacher

Digital Twins for Education and Study of Engineering Sciences

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ZACHER Dr. Zacher Verlag and University of Applied Sciences Darmstadt, Germany

Prof. Dr. Serge Zacher

First of all let me introduce myself:

1962 – Dipl.-Ing. (*Diplom-Engineer of Automation*)

1967 – Dr.-Ing. (*Doctor of Engineering*)

1984 – Dr. sc. techn. (*Doctor of technical sciences*)

1991 – Professor of various Universities of Applied Sciences

18 books,
150 scientific papers,
4 patents.

Content

Introduction: What is a digital twin?

Generally a digital twin is a software-model of some real system.

There are known two kinds of digital twins:

- for industrial production

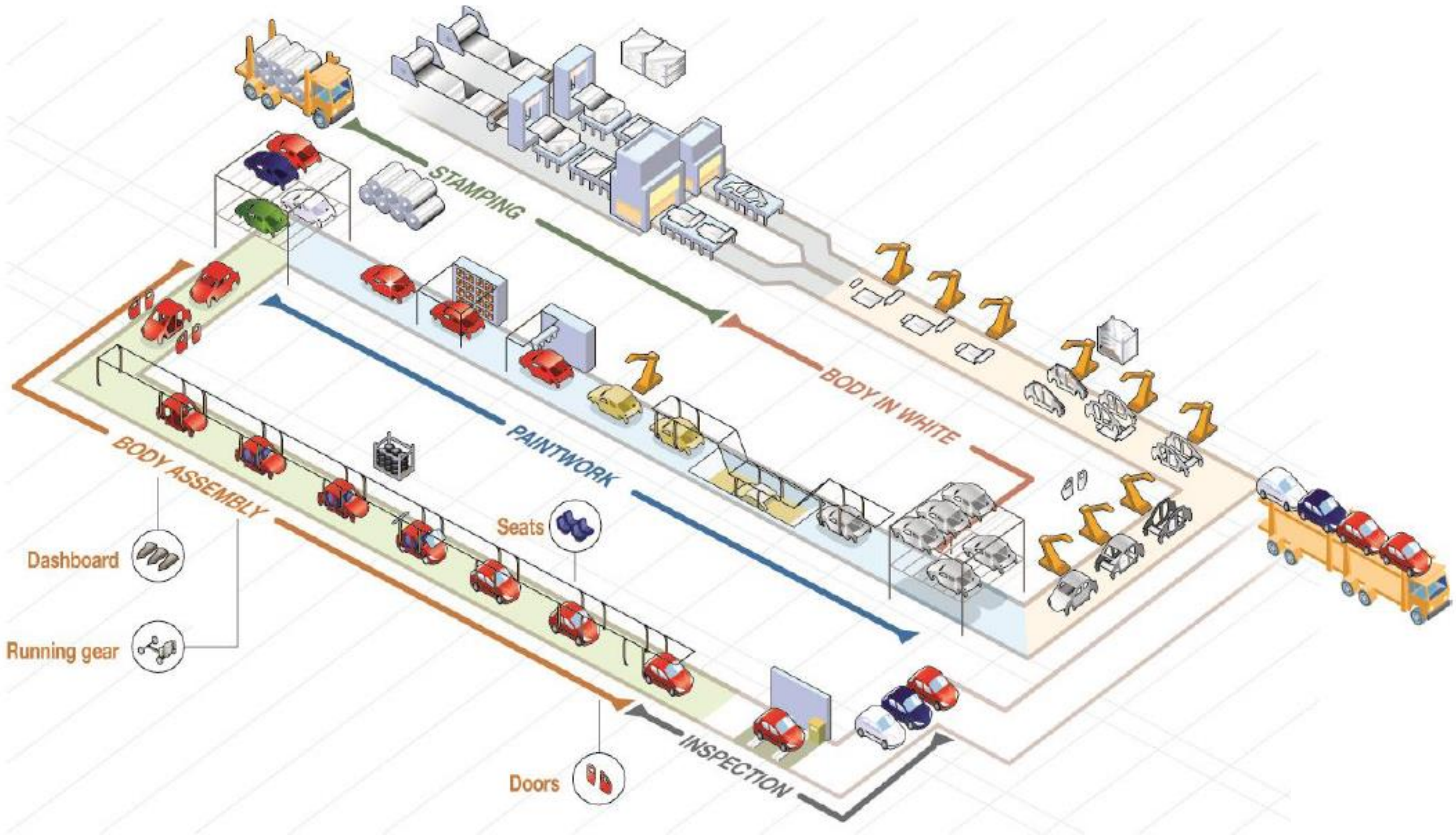
  A prototype for some product, ordered by a customer. It shell be used on all stages of industrial production of this ordered product, compering the actual state with the model und correcting the differences. A “virtual world” will be created from the “real word” and both “worlds” communicate with each other.

- for study and education

  A software-model of industrial plants, which are simulated and visualized similar to its industrial originals and synchronized with them.

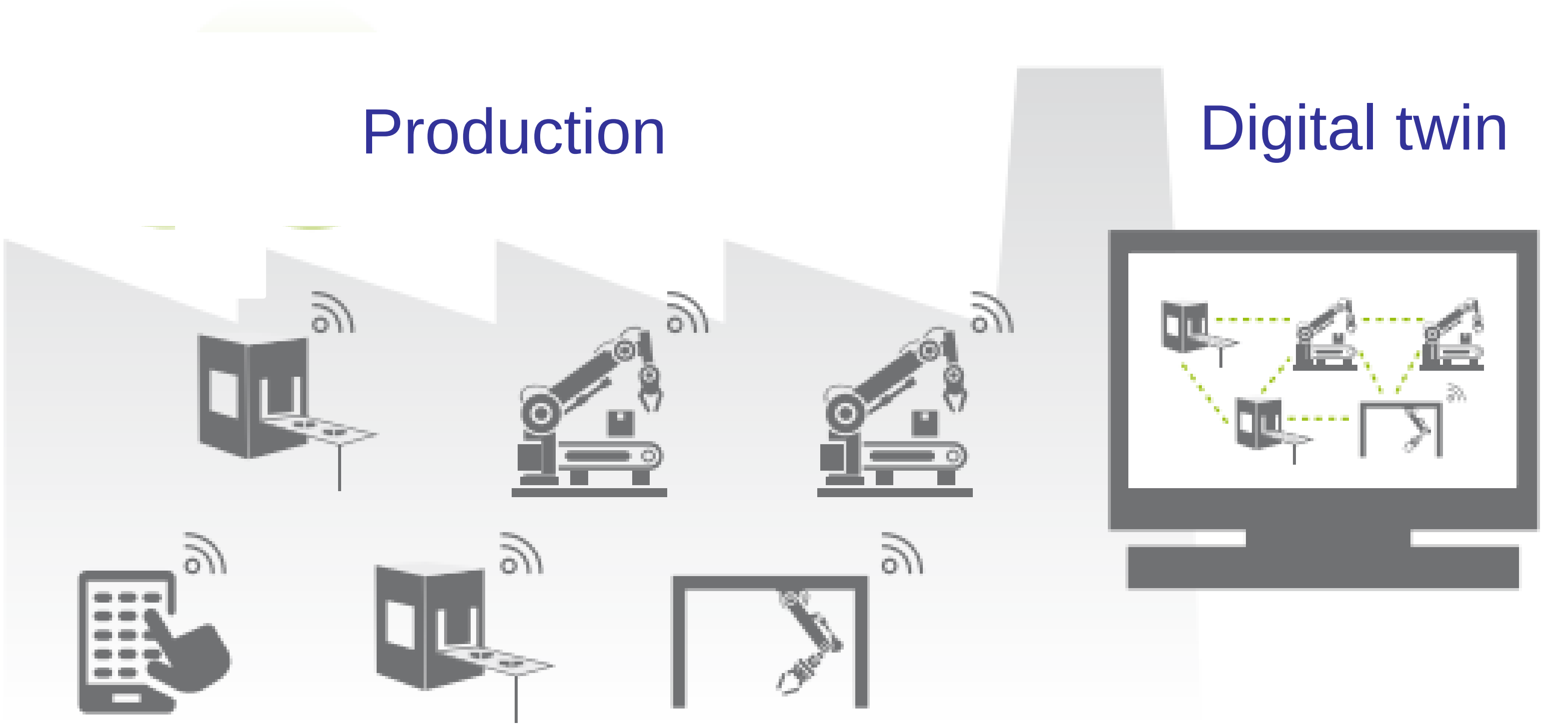
1 Digital twins for industrial production

The conventional production is a sequence of operations undependent of the features of the ordered product.



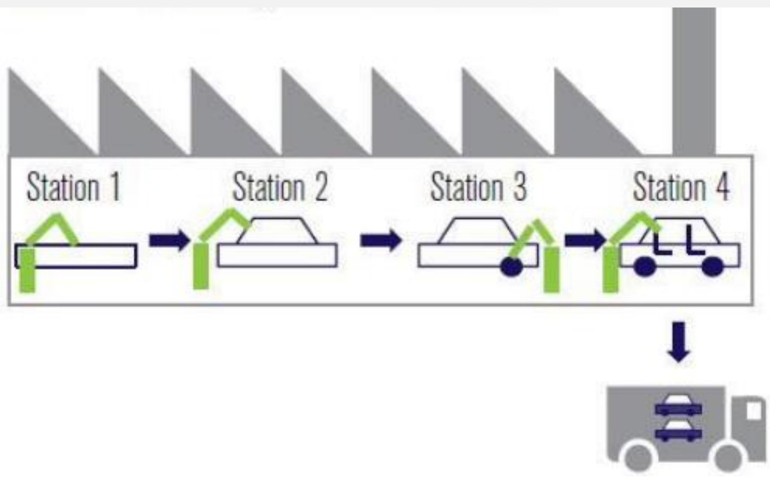
1 Digital twins for industrial production

Instead of it a digital twin gathered all operations needed for product and controlled the production according to it.



1 Digital twins for industrial production

Digital twin versus conventional production



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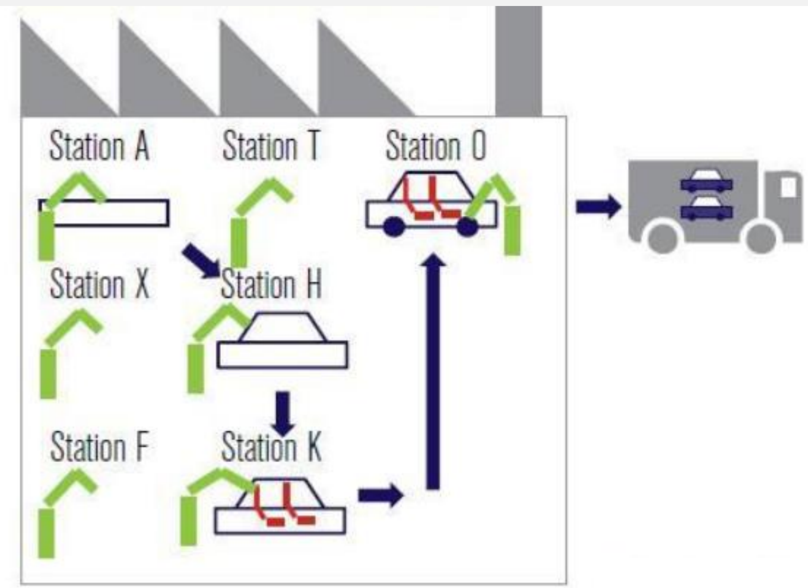


Conventional production ⇔ Production using digital twin

2 Digital twins for education and study

2.1 Why digital twins are needed

A necessary part by the study of engineering sciences at universities are practical exercises on the real technological devices.
But only few educational institutions are financially supported enough to implement a real industry process in own campus or to build their own well-equipped laboratories.

To solve this problem the following laboratories are possible:

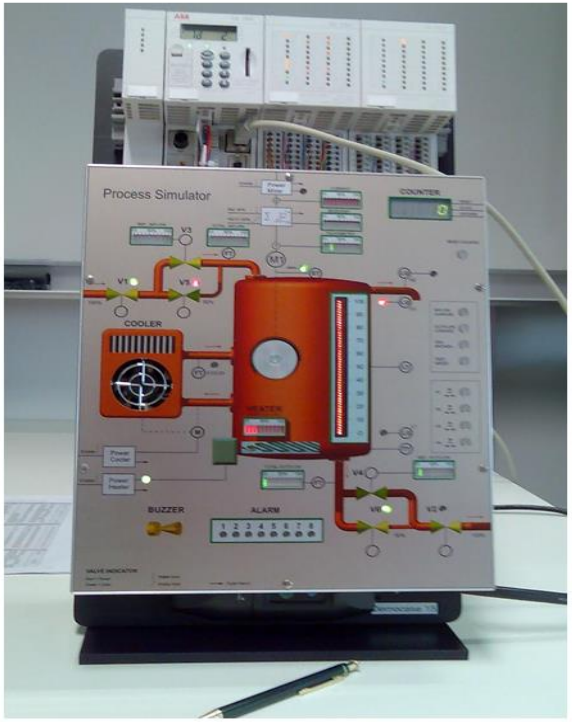
- Real world: pilot devices or its hardware-models
- Virtual world: simulations instead of real devices
- Weblaboratories: real devices placed far from user
- Digital twins: vizualized and synchronized simulations

2 Digital twins for education and study

2.2 Real world: Pilot plants and hardware models

Pilot plants are physical models of the real systems, which development and use are associated with high costs.

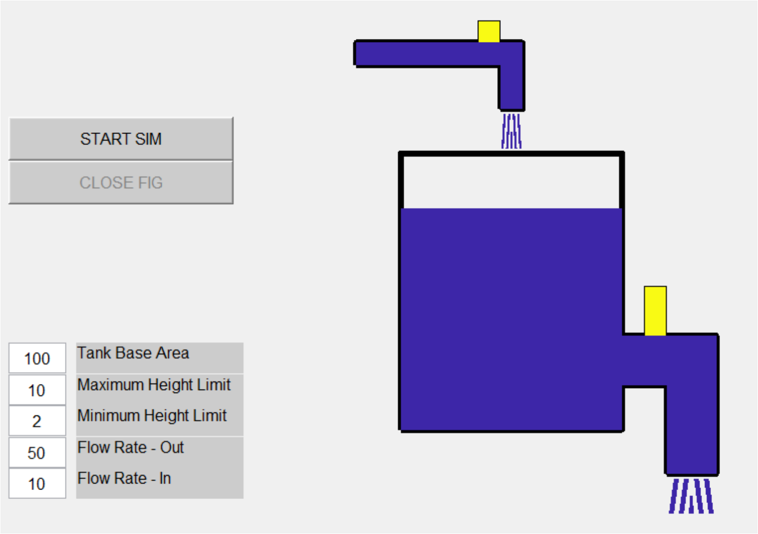
A hardware-model is a box with the microcontroller, located inside. On the front panel of such a box are LEDs, which pictured the simulated industrial process.

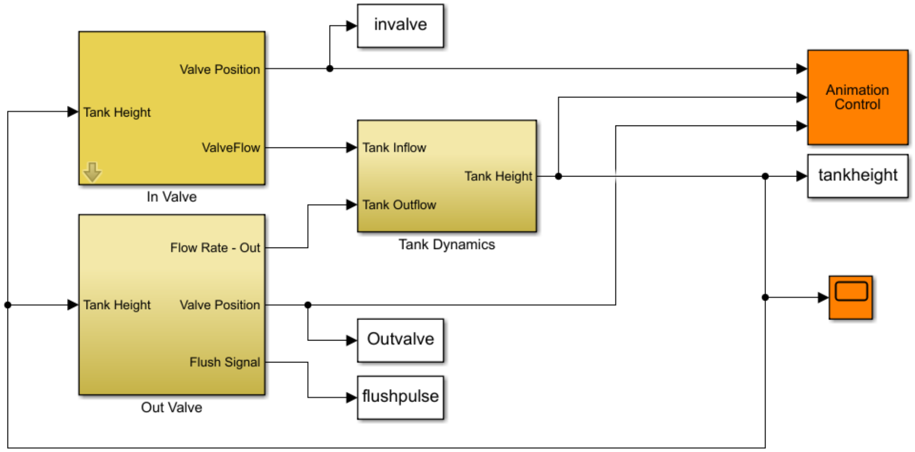


2 Digital twins for education and study

2.3 Virtual world: simulations

The success of programming and software design had opened a new way of costs reducing for laboratories by engineering, namely: the software-models (see an example of level-control).





Anyway the virtual world has a significant disadvantage:
it cannot replace the practical exercises on the real industrial devices.

2 Digital twins for education and study

2.4 Web Laboratories: remote control of real world

Real device

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UTC Engineering Labs OnLine
Experimental Lab Results
The University of Tennessee at Chattanooga

Experiment #33247

Date = 12/16/2007 4:41:12 AM
Name = Eduard+Imhof
Location = de-2007-emcs
User-email address = imhof@heimannsensor.de

System = SPEED
Experiment = STEP
Length of experiment(sec) = 20

Baseline Input(%) = 60
Height of the Step(%) = -20
Time of Step(sec) = 5
RESULTS FOR STEP INPUT
Time(sec)        Input Value(%)   Output(RPM)
     0.000             60.000          0.000
     0.015             60.000          0.000
     0.030             60.000          1.770
     0.044             60.000          0.000
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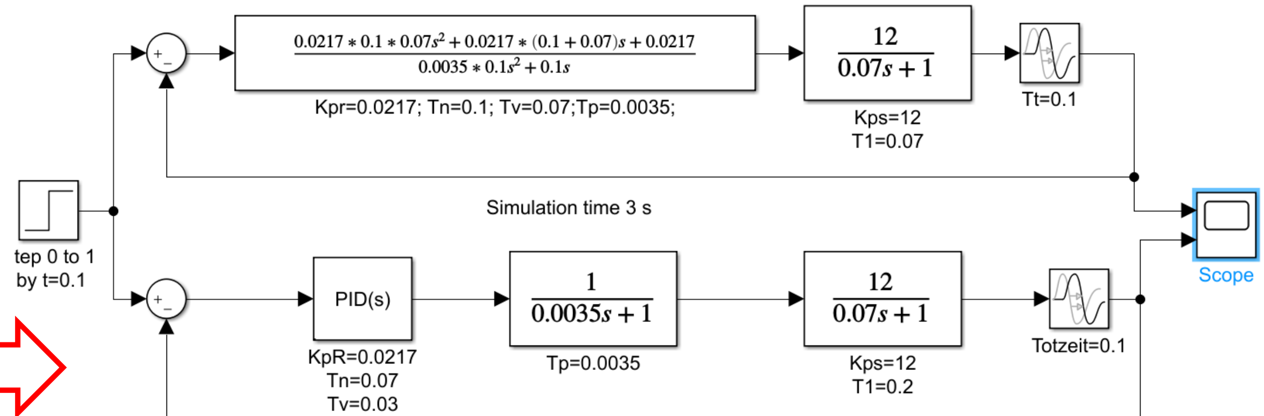
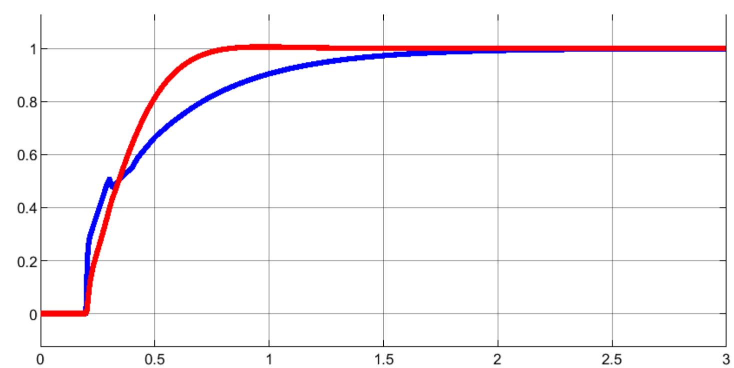


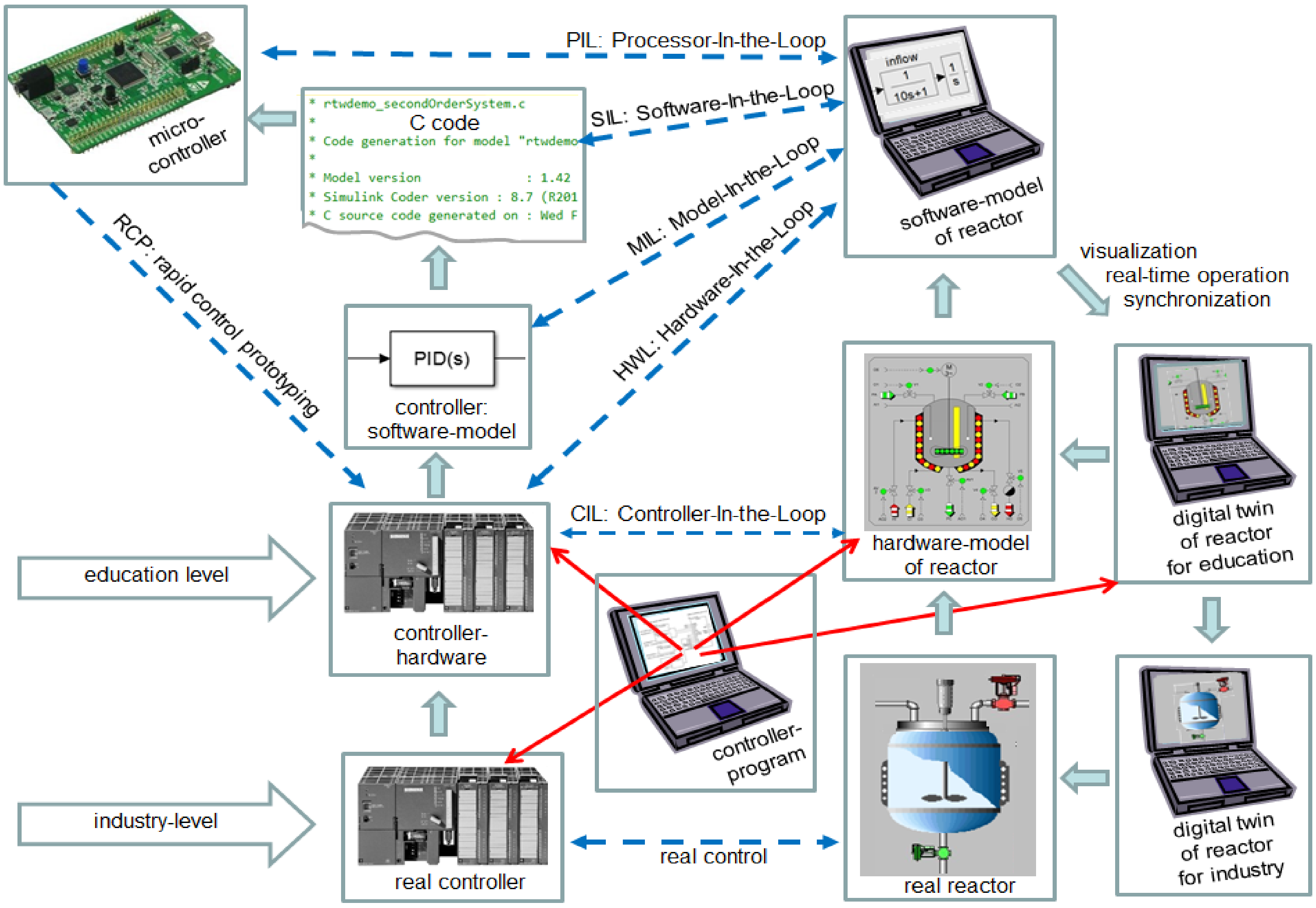
External user

The WebLab is a combination of remote control of labor equipment with the databank and virtual tools for data transfer from one campus to the external user of another campus.



3 Development of digital twins

3.1 Stages of simulations: MIL / SIL / PIL



3 Development of digital twins

3.2 What are MIL / SIL / PIL?

Model-in-the-Loop:

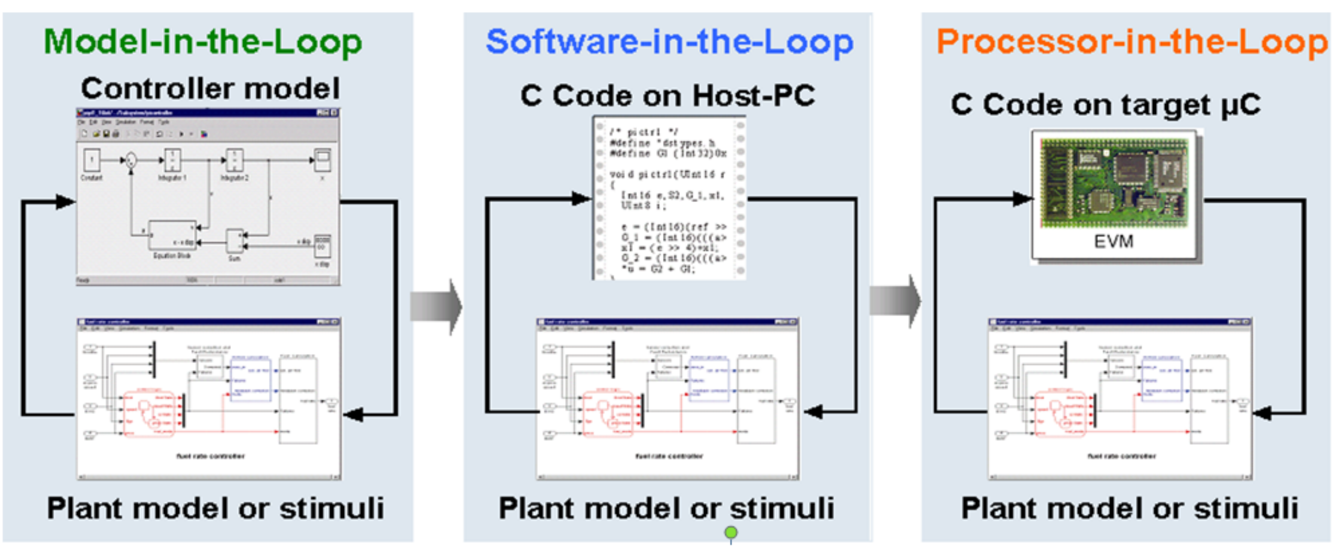
Real controller and real plant are simulated with the same software.

Software-in-the-Loop:

Controller code is executed together with the software-model of the plant on the same host.

Prozessor–in-the Loop

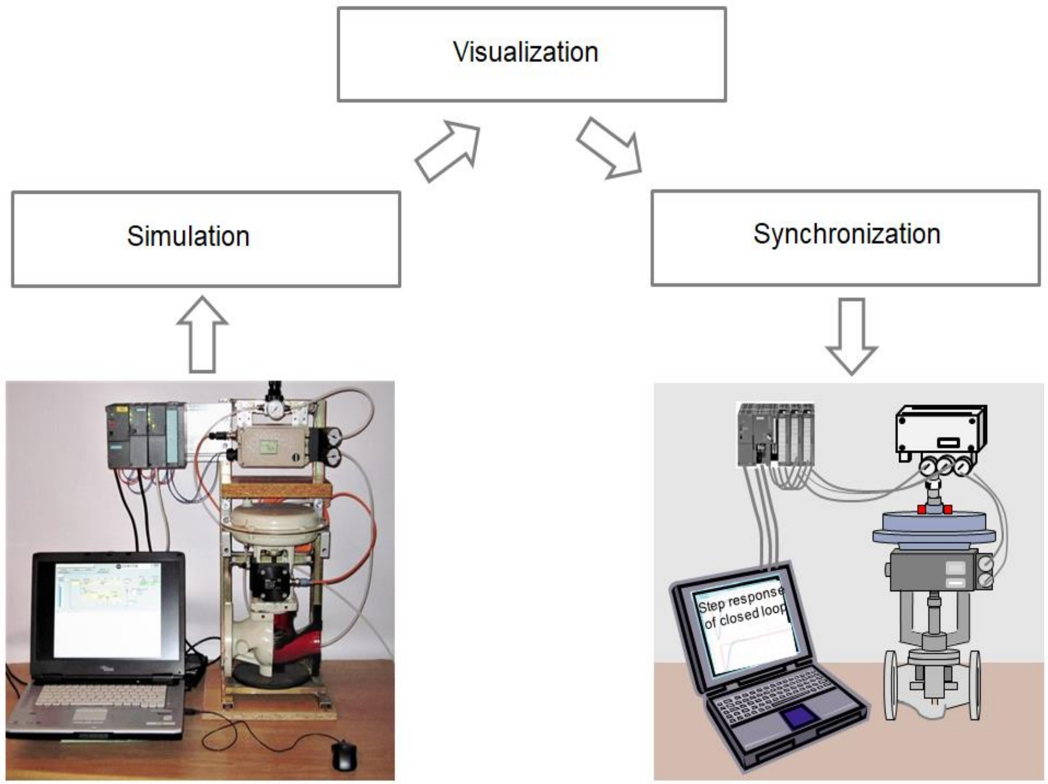
Model of the plant is executed on one host (PC) and the controller code is implemented on another host (a board).



3 Development of digital twins

3.3 Stages of development of digital twins

A digital twin is a simulated and visualized software-model of an original system, which looks exactly like original system, operates in real time so, that its operations are synchronized with the original system

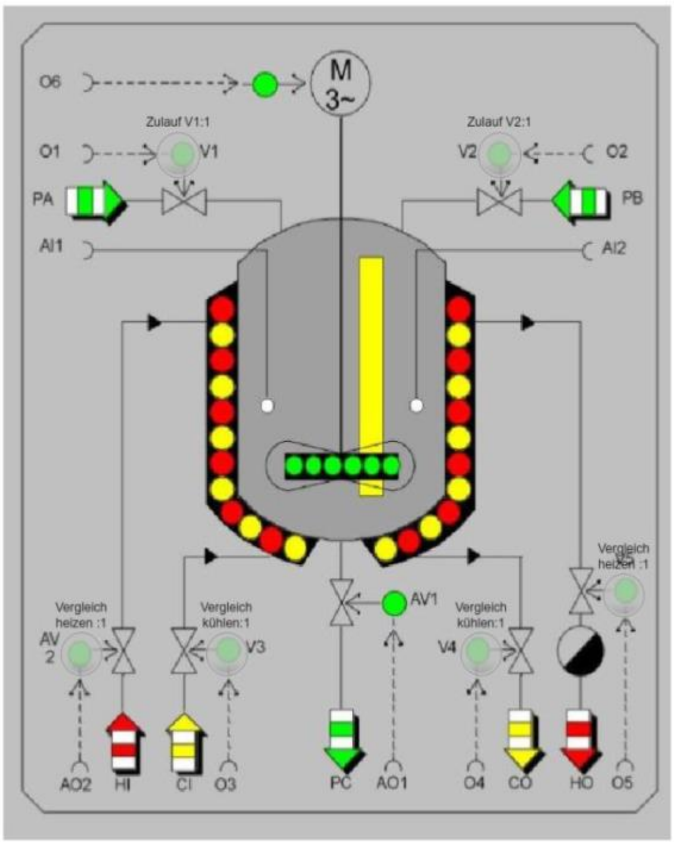


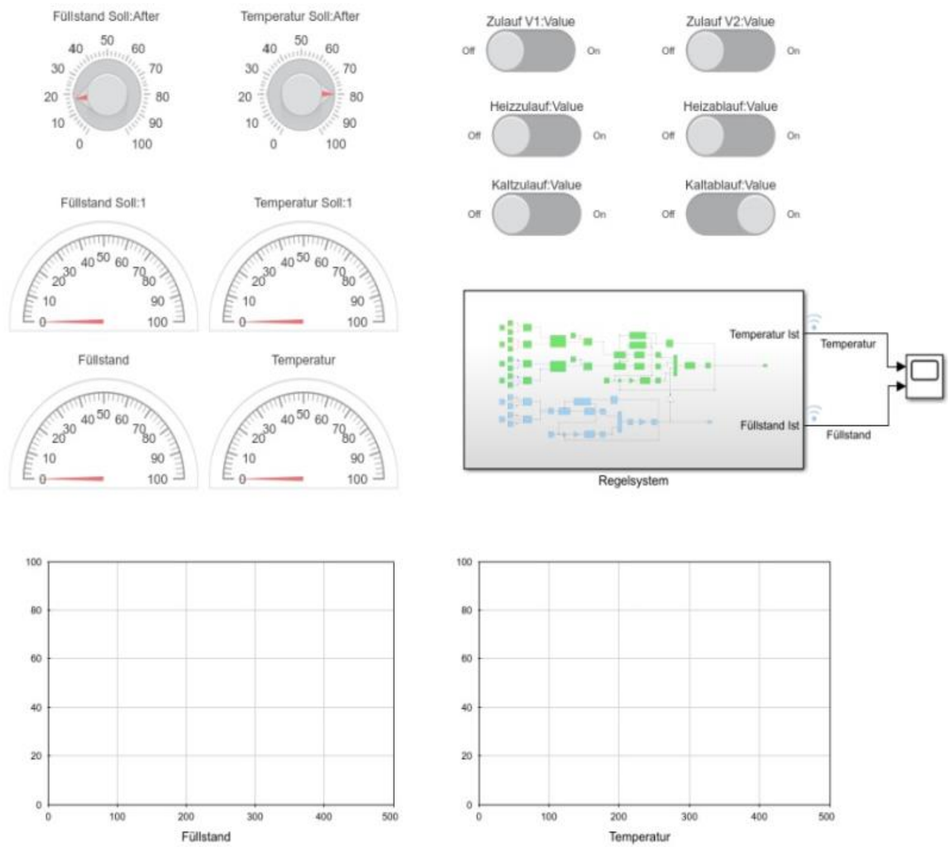
Device
Digital Twin

4 Examples of digital twins

4.1 The temperature- and level-control of AEG-Board ET722

https://www.zacher-international.com/Projekte/DHBW_Stuttgart/ET722_DigZwi/ET722_DigZwi_Sz_Gur.mp4



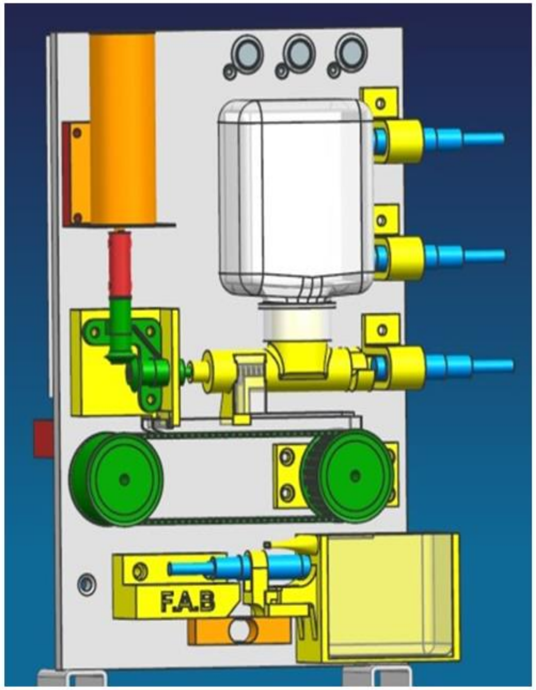


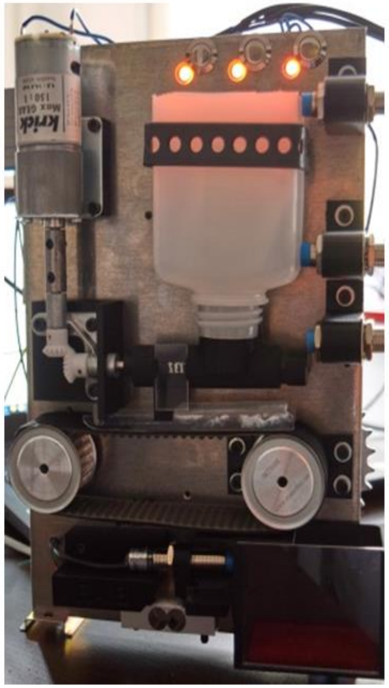
4 Examples of digital twins

4.2 Self-designed mechatrinocal device

https://www.zacher-international.com/C22_Team_Projekt/DigiZwi/DigZwi_Foerderstrecke.mp4

A hardware-model of a conveyor system was first designed with the CAD SIEMENS NX. Then the hardware-model was build. Finally a digital twin using the same CAD was completed with MCD software (Mechatronics Concept Designer from SIEMENS) to develop a digital twin to simulate the dynamics of conveyor.





4 Examples of digital twins

4.3 The digital twin of an „OSLO 3“ hardware-model with AC-700 field controller of ABB

https://www.zacher-international.com/C22_Team_Projekt/Digitaler_Zwiling_L_H/DZLH.mp4

The simulation is perfectly visualized and synchronized,
so that is no difference seen between the original device and digital twin.

4.4 Evaluation of costs

Costs for an education laboratory with 15 working places

Position	*Costs for real 15 devices*	*Costs for a digital twin*
Fee per our	100	100
Weeks	3	1
Days a week	5	5
Total fee	24,7%	8,2%
Price of device	62,3%	4,15%
PLC costs (real control)	10%	0,67%
License for simulation software	--	26,9%
License for CAD	--	18,86%
License for PLC simulation	--	24,48 %
Installation costs	2,96%	--
Total Costs	100%	74%

The cost savings by digital twins against real devices is 26%.

Summary

The benefits of digital twins for education and study:

- easier preparation for the training or experiments. The work with digital twins can be started immediately, because no hardware is required to be installed or tested.
- an unlimited number of people can work with a digital twin and apply it.
- the adaptability and expandability depending on the training goal. The digital twins presented in this paper are perfect for learning basic knowledge in many courses of automation and PLC programming. Digital twins can also be used as illustrative material for more complex training goals. This enables the trainer to create extensions as needed according to specific questions of the training participants.

Summary

The disadvantage of digital twins for education and study:

- the design effort, which is, however, only one-off.
- the high costs for CAD-licences.
- the adaptation of the model to the real time.
- the implementation of real PLC algorithms into simulation software.
- the visualization of the LED level indicators of real PLC with a bar of simulation software.
- limited computing capacities even by relatively simple simulation tasks.

Conclusion

- Digital twins are important for industry and university studies.
- They are indispensable tools in today's technology and university world.
- The internship with digital twins can be made easier and more comfortable than in classic laboratory rooms.

Thank you for attention!

Please let me know if you have any questions or comments:
info@szacher.de

END
of virtual presentation

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