METADATA (*)

TOPIC B – Training Unit 3: Digital Twin

Source

Partner: **LCM** – Lessons 1 and 2

Contents were developed using the following sources:
from: Nath, S.V., van Schalkwyk, P. (2021): Building Industrial Digital Twins, Packt Publishing Ltd., ISBN 978-1-83921-907-8

Partner: **SCCH** – Lesson 3

Partner: **URSALEO** – Lesson 4

Project: TRINEFLEX - Transformation of energy intensive process industries through integration of energy, process, and feedstock flexibility, Grant agreement ID: 101058174

Ownership

Lesson 1 (What is a Digital Twin?) and Lesson 2 (Physics based modeling and simulation)
Linz Center of Mechatronics GmbH, Thomas Gross

Michael Mayr, Georgios Chasparis (SCCH) - Lesson 3 (Overview of data-based predictive modeling for digital twins)

John Burton (URSALEO) - Lesson 4 (Visualization)

Abstract

This training on Digital Twins encompasses basic introductions for newcomers as well as deeper insights and special topics for experienced audiences. It covers the creation and application of digital twins in various sectors, focusing on TRINEFLEX's implementation, physics-based modeling, and predictive simulations. The training unit also delves into machine learning techniques and the challenges of Big Data, concluding with the concept of visual digital twins for effective data integration and visualization.
The training unit structure is simple: a particular audience will follow the digital twin introduction lesson and then proceed with relevant special topics (lesson 2, 3 and 4).

Structure

- Lesson 1: What is a Digital Twin?
  This lesson provides a brief introduction aimed at a lay audience. This includes different approaches to creating a digital twin, how it can mean something different to different processes or sectors. This lesson gives a general overview and is not specific to any specific sector.
- Lesson 2: Physics-based modeling and simulation
  An introduction to physics-based modeling and simulation, underscoring its critical role in establishing predictive digital twins. Participants will learn about diverse simulation methodologies and applications across various industrial sectors.

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- Lesson 3: Overview of data-based predictive modeling techniques for digital twins
  An overview of machine learning in the context of supervised predictive modeling techniques for the development of digital twins in industry. It also discusses challenges in the design and deployment of data-based predictive models in the context of Big Data.

- Lesson 4: Visualization
  Visualization of large quantities of data can be achieved through a 'visual digital twin'. This is a graphical representation of the facility and equipment combined with data from various sources. Sources include sensor data, simulated data, calculated data, asset data, documentation and even maintenance data.

Learning Outcomes

Upon completing this training unit, participants will understand the fundamentals and varied applications of digital twins, grasp the significance of physics-based modeling and simulation in creating predictive digital twins, and comprehend the approaches and challenges of machine learning for data-based predictive modeling. Additionally, they will acquire skills in visualizing and integrating diverse data sources through visual digital twins for effective analysis and decision-making, equipping them to understand digital twin technologies in their respective industries.

For Lesson 1, participants will learn about the foundational concepts and varied applications of digital twins across different sectors. Additionally, the different approaches to creating and implementing digital twins in various industrial processes are discussed.

For Lesson 2, participants will explore the significance of physics-based modeling and simulation in constructing predictive digital twins. The session covers diverse simulation methodologies and their practical applications across multiple industries

For Lesson 3, participants will learn about the general problem of machine learning in the context of supervised predictive modeling. In addition, data processing steps as well as learning methodologies are discussed.

For Lesson 4, participants will delve into the techniques for visualizing and integrating complex data sets using visual digital twins. The lesson encompasses the handling of sensor data, simulated outcomes, and other relevant information for effective data presentation and analysis.

Intended Audience

This training is designed for researchers and decision-makers and should serve as a basis for further discussions on data preprocessing and modelling decisions.

Pre-requisites

The training unit is high-level and requires no in-depth knowledge in any of the lessons.

Language: English

Format: Video mp4, PDF

Expected workload

Expected workload is 40 minutes.

References/Complementary additional training material:

the contents of lesson 3.3 were developed using the following sources, also useful as additional in-depth information

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- Luftensteiner, S., Mayr, M., Chasparis, G. C., & Pichler, M. (2021). Avubdi: A versatile usable big data infrastructure and its monitoring approaches for process industry. Frontiers in Chemical Engineering, 3. https://doi.org/10.3389/fceng.2021.665545
- Himmelbauer, J., Mayr, M., Luftensteiner, S. (2022). From Data to Decisions - Developing Data Analytics Use-Cases in Process Industry. In Database and Expert Systems Applications - DEXA 2022 Workshops. DEXA 2022. Communications in Computer and Information Science, vol 1633. Springer, Cham. https://doi.org/10.1007/978-3-031- 14343-4_8
- *Luftensteiner, S. and Zwick, M. (2023) 'Improving Virtual Sensor Models by Censored Online Data', Procedia Computer Science, 217, pp. 938–947. Available at: https://doi.org/10.1016/j.procs.2022.12.291.*
- *Shyam, R. and Chakraborty, R. (2021) 'Machine Learning and Its Dominant Paradigms', 8, p. 2021. Available at: https://doi.org/10.37591/JoARB.*
- *Introduction to ML and AI - MFML Part 1 (2021). Available at: https://www.youtube.com/watch?v=IYWt-aCnE2U (by Google).*
- Nath, S.V., van Schalkwyk, P. (2021): Building Industrial Digital Twins, Packt Publishing Ltd., ISBN 978-1-83921-907-8

(*) The structure of the Metadata for the Training Units derives from the training Metadata model developed within the Leonardo da Vinci project LINKVIT (2013-15, GA N. 2013-IT1-LEO05-04046)

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