Various Applications of Digital Twins

A thesis in two parts

Graduate

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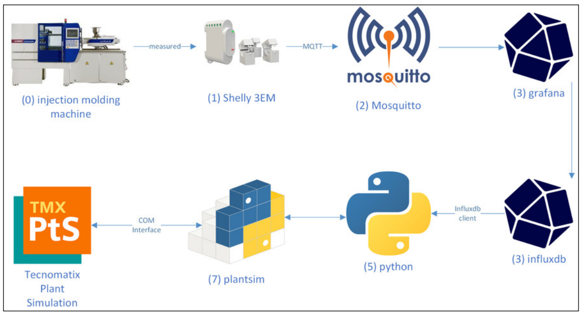
Introduction: Industry 4.0 and artificial intelligence have brought both new challenges and opportunities in manufacturing. Simulation represents one opportunity, a crucial technology for optimizing time to market, resources, and costs. The concept of a digital twin (DT), a sophisticated simulation merging physics-based modeling and real-time data, plays a fundamental role in detecting anomalies and enabling real-time control, predictive maintenance, data analytics, and machine learning, which enhances manufacturing operations and supply chain collaboration.
This master's thesis explores DTs in research and industry, implementing connections between real-world assets and their digital counterparts and applying DTs in an industrial context. It aims to contribute to the understanding and utilization of DTs across domains, showcasing their potential to enhance operations and optimize processes.

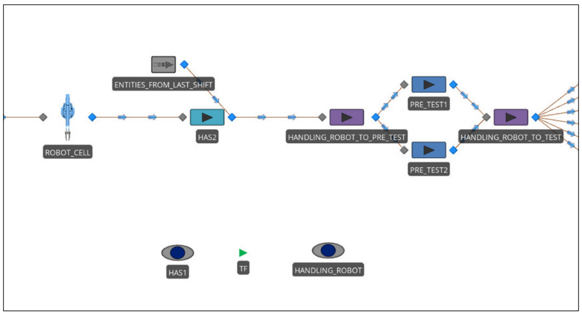
Approach: Part 1 establishes a seamless link between the smart factory's virtual model and its physical infrastructure, using Siemens' Tecnomatix Plant Simulation and accessing data through Siemens' MindSphere. This validates the DT approach through real-machine tests, highlighting its challenges and opportunities. Part 2 verifies DT effectiveness in real scenarios, enhancing manufacturing processes. This involves analyzing the assembly cell, creating a digital replication, and testing optimizations.
The overall process of creating a digital asset and conducting the simulation in this thesis follows a typical iterative approach, involving conceptual design, input analysis, model development, verification, and validation. The procedure for Part 1 includes reviewing prior work, clarifying project tasks and requirements, exploring tool possibilities and limitations, identifying key performance indicators, and developing a comprehensive toolchain concept. The methods in Part 2 include breaking down production times, conducting a bottleneck analysis, gathering relevant parameters, focusing on bottlenecks or search algorithms, creating the digital replica, analyzing results, generating optimization scenarios, and testing the optimizations.

Result: The thesis explores and tests two DT applications, creating digital models for conceptual testing. Part 1 focuses on stabilizing the experimental connection and transitioning it to an autonomous mode, while Part 2 involves manual measurements but shows potential for an automatic connection with the right data. The DTs demonstrate two key benefits: virtualizing sensors for real-time production optimization and providing real-time information for informed decision-making in production. These insights lead to continuous improvements and informed decision-making in manufacturing. To improve the accuracy of the digital model, refining the categorization of production states for reduced deviation between simulation and measurement is recommended. For Part 2, further experiments to validate the model and enhance its capabilities are suggested, including incorporating various product configurations and establishing autonomous and real-time measurement of process parameters. These recommendations aim to strengthen the digital model and fully leverage the potential of DTs in manufacturing processes.

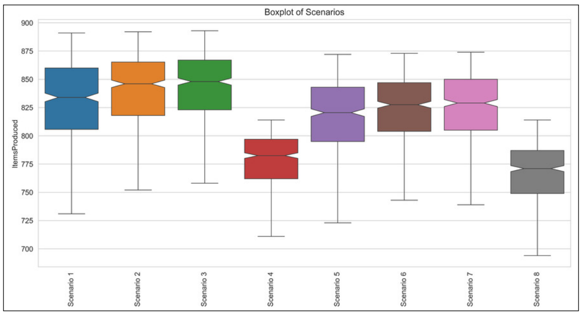
process flow diagram of the toolchain in part 1
0 OST 1shelly 2mosquito 3,4 influx 5 python 6 pypi 7 Siemens



Section of the Simio model of part 2
Own presentment



Boxplots of a selection of simulated scenarios in part 2 with 500 simulations each in a monte carlo approach
Own presentment



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