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Predictive AI To Feed Simulation

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It started with my inability ...

... to reply directly to a simple statement:

Your simulation does not help me to predict
how my customers will behave next week.

Obviously, this is true!

Have I overseen a real business need? And what could have been a good reply to this statement?

Let me tell the story from the beginning!



Simulation of a Real World Case Study



(Infraserv Logistics GmbH, 2023)



Our Real World Case Study

Key Facts

- Space for more than 21,000 pallets
- 9 separate warehouse sections
- Storage of multiple LGK storage classes
- A wide temperature range from -6 to 20 degrees Celsius

(Infraserv Logistics GmbH, 2023)

Employees may simulate process variants

- by changing processing times and resources and
- for different sets of „simplified“ orders.

A dashboard may

- visualize the processes as they occur and
- give different overviews.



Process-Simulation.Center (P-S.C) & Dashboard

Process-Simulation.Center (P-S.C)

- Petri net based Integrated Management System (IMS)
- nearly 500 registered, almost academic users
- Uses high-level Petri-Nets as a universal modeling and simulation language for dynamic systems
- Simulation of processes controlled by limiting resources

Dashboard

- Dashboard app especially developed for the business partner
- Administration of master file data
- Visualizes the process flow in the course of a day



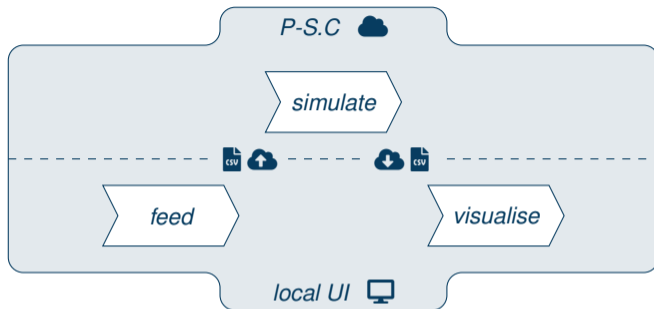
Shift from Real World to Digital World

The following **steps** have been conducted:

- 1 Identify the process to transfer pallets into and out of the stock.
- 2 Specify the data necessary to control this process.
- 3 Develop a data driven model for the process.
- 4 Develop a user interface to administrate the simulation input data.
- 5 Develop a user interface to visualize the simulation results.



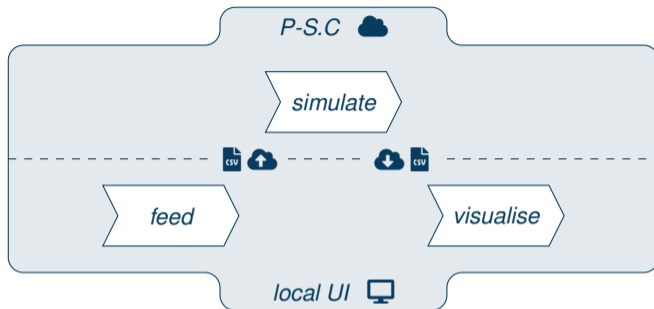
Shift from Real World to Digital World



Phase *feed*: Master file data management on resources, times, and orders. Data is supplied in CSV format.



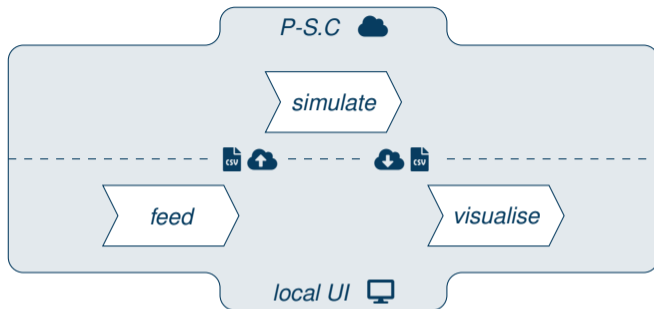
Shift from Real World to Digital World



Phase *simulate*: **P-S.C** simulation of the warehouse movements on the base of this data.



Shift from Real World to Digital World



Phase *visualize*: The exported simulation results are loaded up to the **Warehouse-Dashboard** for visualization.



A first impression





Outcomes that have been identified!

What we achieved

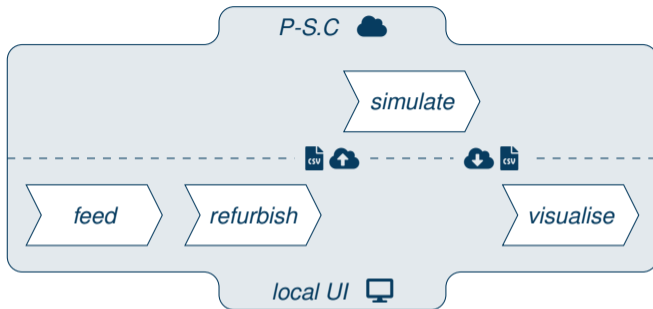
- We could explain thresholds of the last week.
- We could establish schedules for the future hardened for expected changes.

What we failed at

- But we cannot foresee which changes can be expected, automatically.
- And the practitioner cannot, too.



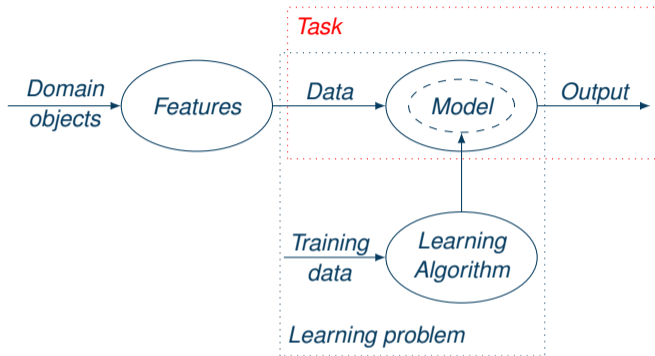
A new step



Phase *refurbish*: Can Predictive AI (and especially ML) help for this task?



Machine Learning



(Flach, 2012)



Classification vs. Regression

Definition

- 1 In mathematical notation, a classifier is a function $y = f(x)$, where x is the input data item and y is the output category:
- 2 In regression, we try to understand the data points by discovering the curve that might have generated them.

derived from (Mattmann, 2020)

Application

- 1 **Classification** could help to predict which transports may be unpunctual.
- 2 **Regression** could help to predict how many minutes transports may be unpunctual.



Assumption and Prerequisites

Assumption

There are **reasons** for being late. They might be unknown to the customer, but their existence can be derived from patterns in past data.

Prerequisites

- We need a system to find the patterns in the past and to apply it to future data.
- We need to collect the **relevant** past data, i.e. data that includes these patterns.

Examples

- Are there shipping agents that often are late?
- Are there producers that always are early?
- Are midweek deliveries more reliable than ones on Mondays?



Prototypical Implementation

Sometimes, one book is all you need!

- **NumPy** provides data types and functions for easier handling of complex structures, such as vectors and matrices.
- **pandas** is designed for more complex structures and their easy handling. One strength is its extensive functionality for table structures.
- **Matplotlib** is used for visual analyses and plotting.
- **scikit-learn** contains many ML algorithms that can be easily used in your own program.
- **Keras** can build artificial neural networks.
- **TensorFlow** extends Keras with additional well performing functionalities and can handle large and complex data structures.

(Karatas, 2024)



Given, Useless, and Needed Order Data

Attribute	Description
<i>id</i>	order id
<i>product</i>	product group chem or pharma
<i>total</i>	total amount of pallets requested
<i>status</i>	initial or current order status
<i>ramp</i>	target ramp
<i>arrival</i>	scheduled time of arrival
<i>preparation</i>	scheduled time of completed staging
<i>fillHandover</i>	amount of pallets in handover areas
<i>fillRamp</i>	amount of pallets at target ramp
<i>fillTruck</i>	amount of pallets in truck
<i>usedGate</i>	used resource <i>gate</i>
<i>usedSGS</i>	used resource <i>SGS</i>
<i>usedVHS</i>	used resource <i>VHS</i>
<i>timestamp</i>	timestamp of the latest state change



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<i>arrival</i>	scheduled time of arrival



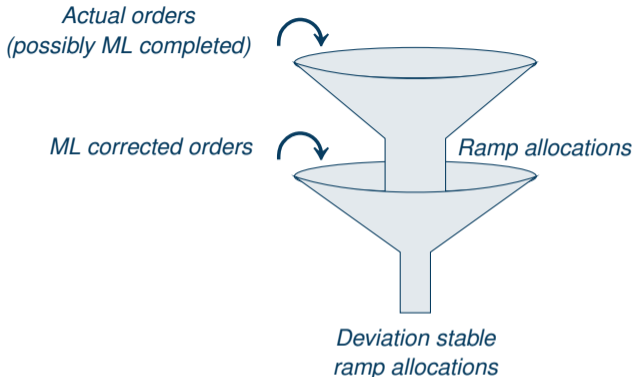
Given, Useless, and **Needed** Order Data

Attribute	Description
<i>total</i>	total amount of pallets requested
<i>status</i>	status (inbound or outbound)
<i>arrival</i>	scheduled time of arrival (broken up)
<i>delay</i>	actual arrival time or delay
<i>distance</i> *	inside or outside the industry park
<i>agent</i>	shipping agent
<i>producer</i>	of the good

* might be difficult to know in advance



Outlook on how to apply this!



- Find an industry partner with real world data, probably not ISL.
- Test the ML approach.
- In the case of success, integrate the method into the P-S.C, and
- present the results at the SIMUL 2025 conference.

Feel free to contact us!

.... check out our website **Group for Applied Processsimulation (GAPS)**

<https://www.hs-worms.de/en/gaps/>



... and reach of for any kind of project, whether its in teaching or another real world.

- Flach, Peter (2012): *Machine Learning - The Art and Science of Algorithms that Make Sense of Data*. Cambridge University Press, Cambridge, 9. Aufl.
- Infraserv Logistics GmbH (2023): Overview hazardous substances warehouse. <https://www.infraserv-logistics.com/en/isl/news/news/> (last accessed 15.08.2023).
- Karatas, M. (2024): *Development of AI applications (in German: Eigene KI-Anwendungen programmieren)*. Rheinwerk Computing, Bonn.
- Mattmann, C., Hg. (2020): *Machine Learning with TensorFlow*. Manning, Shelter Island, NY, 2. Aufl.