Digital Factory - Industrial AI

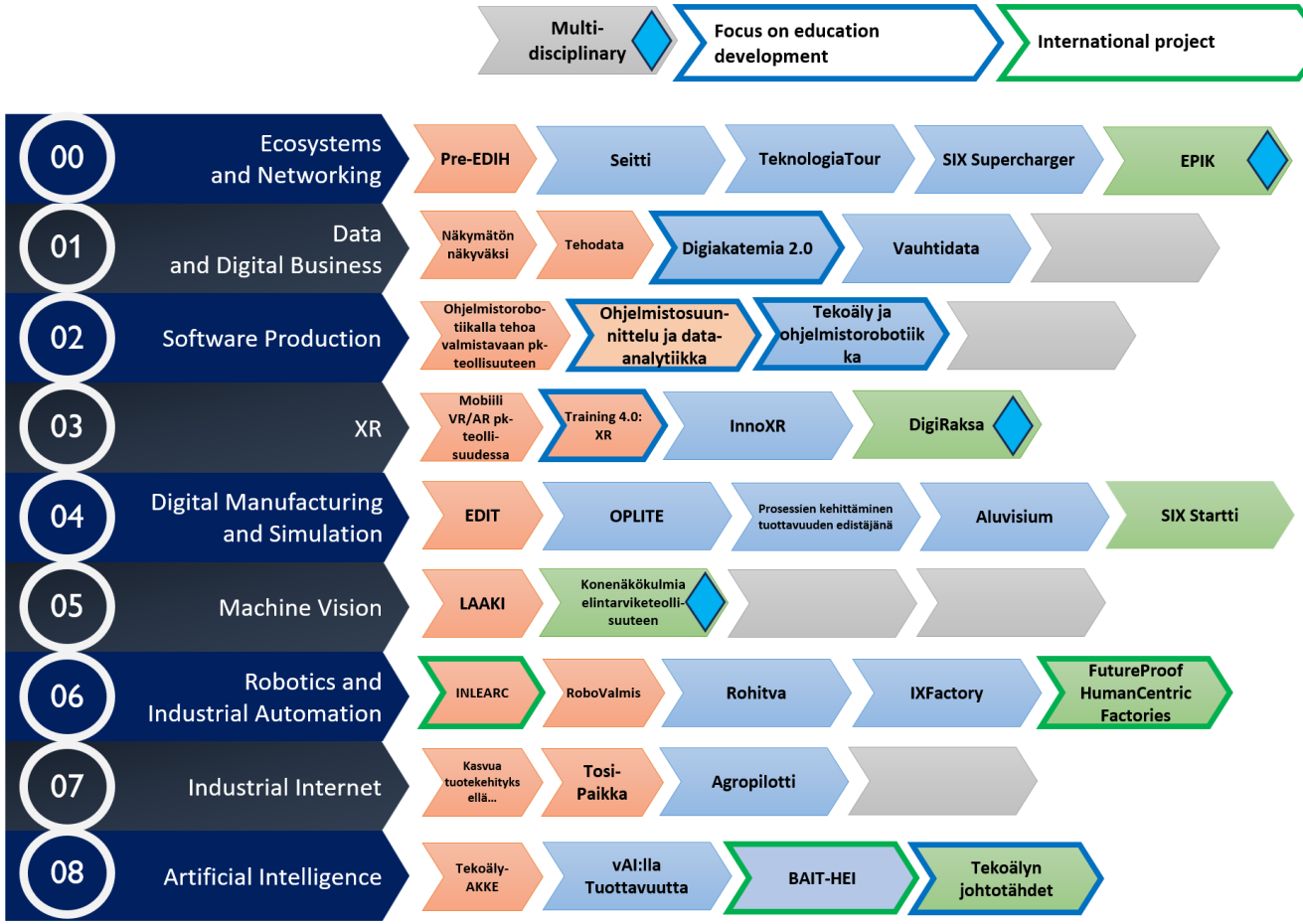
11.2.2025 Toni Luomanmäki, Senior lecturer

Session agenda

- Industrial AI at Seinäjoki University of Applied Sciences (Toni Luomanmäki, Senior Lecturer)
  - Digital Factory reseach group
  - Laboratories
  - Introduction to AI demonstrations
- AI Demonstrations (Hannu Hakalahti, Specialist, RDI)
  - Rapid Design Optimization of a Sheet Metal Part by Applying a Neural Network
  - Integration of Optimization Methods into Simulation Technology for Manufacturing via Warehouse Optimization
  - Route search utilizing reinforcement learning in Simulation model
- Experiences of Co-pilot Agents (Teemu Virtanen, Project Manager)
- 5-10 min for questions and conversation

Digital Factory Reseach Group

“Research and development of digitalization in manufacturing industry across the entire value chain”



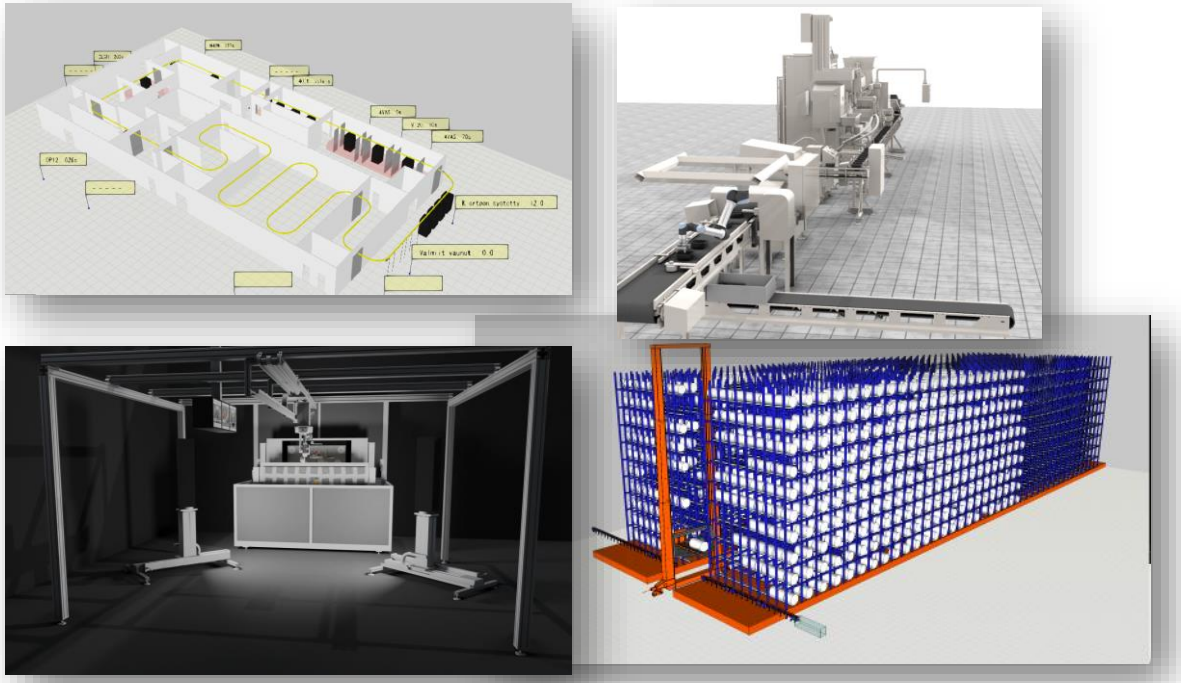
- Budget for 2025 ~2,3 milj. €
- 9 themes covers most of the activity
- Close collaboration with the industry
- Mainly EU-funded projects but also direct business with the industry

SEAMK

Production Simulation (Digital Twin)

- One of the key competences of the research group
- Simulation of a multi-domain manufacturing and production systems has been long-lasting and continuing service in our RDI
  - First activities around 30 years ago and numerous simulation projects since

- Packaging line simulation
- Painting line simulation
- FMS system simulation
- Stamping and bending cell simulation
- Rotating device virtual reality environment
- Assembly robotization and high-bay warehouse simulation
- Food industry production line robotization simulation
- Hydraulic cylinder production line simulation
- Robotized machining cell simulation
- Refrigeration equipment operation visualization
- Food dispensing line simulation
- Profile extrusion production simulation
- Robotized packaging cell simulation
- Robotic welding simulation
- Press cell simulation
- Food industry intra-logistic simulation



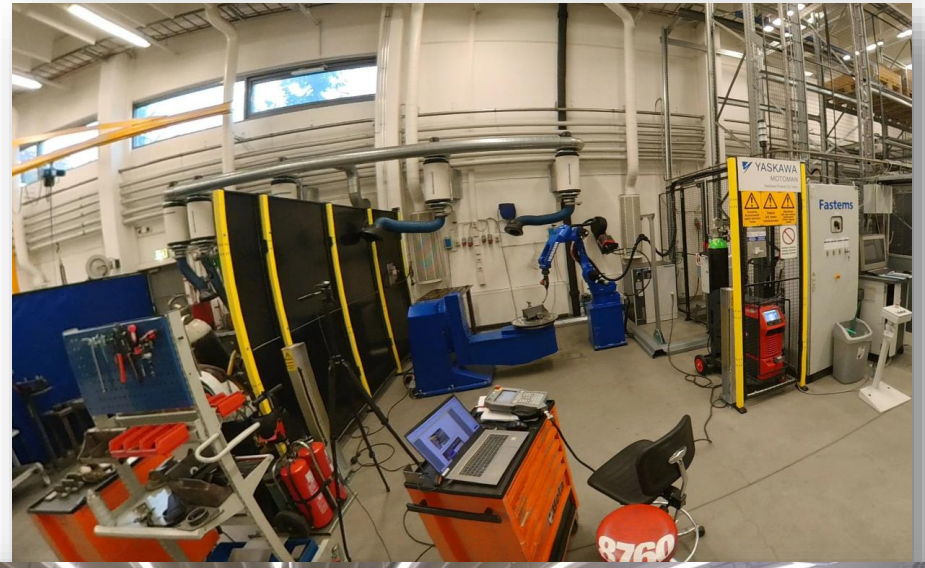
SEAMK

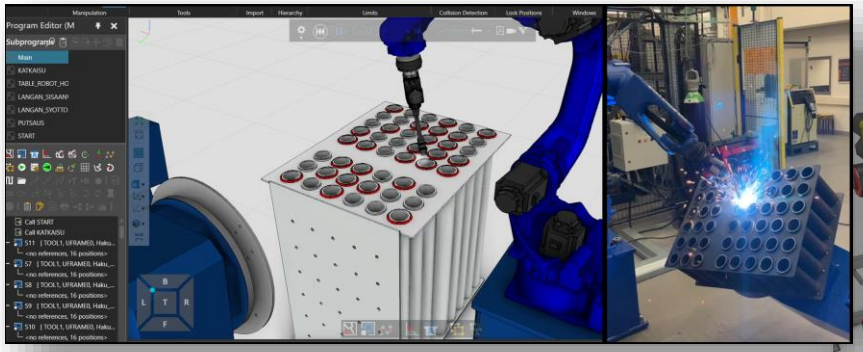
Laboratories

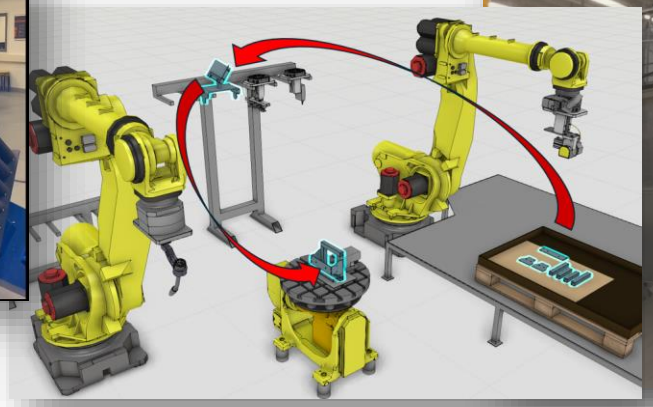
- IXFactory
  - Running project aiming to build smart manufacturing laboratory
    - Robotics, machine vision, digital twins, OT, AI
    - Full-scale production process
    - Investments / merging existing tech
- XRLAB
  - Laboratory of Extended Reality
  - Various technology / solutions available
  - XR development services for business’

Laboratories

- Laboratory of Mechanical Engineering
  - Equipment available for sheet metal working, machining, welding, FMS, measuring, turning and milling.



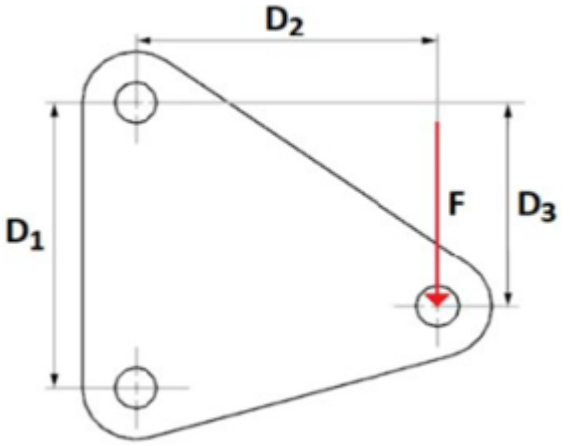




AI Demonstration 1

Rapid part shape optimization applying neural networks

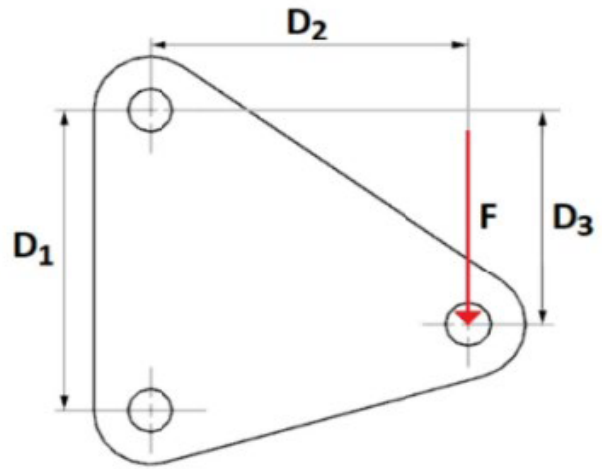
- Problem
  - In mass customization, a customer wants to change the paremeters of the product individually -> system needs to perform stress analycis for the desing quicly
  - Traditional parametric design optimization in CAD software is slow (several minutes per iteration)
  - Topology optimization produces complex geometries unsuitable for conventional manufacturing.
- Solution
  - Neural network-based design optimization for rapid parametric adjustments.
  - Web integration into an ERP system for real-time design modifications and order placement.

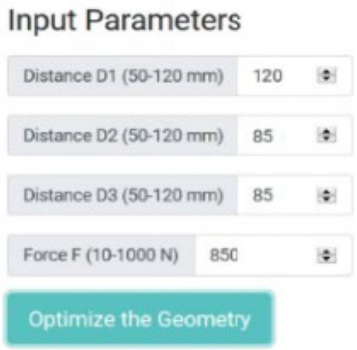


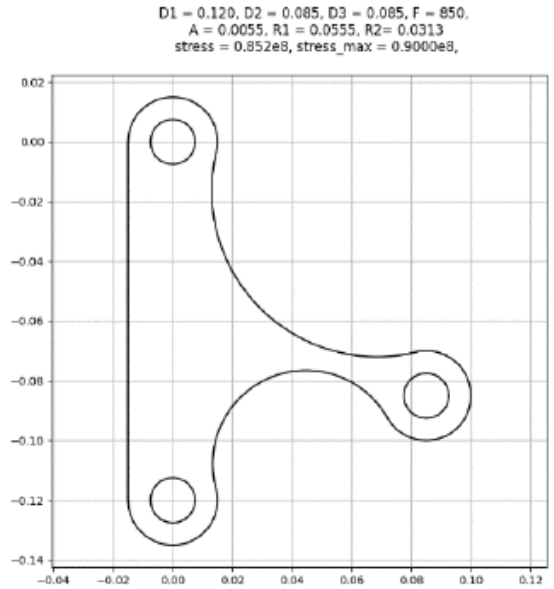
AI Demonstration 1

Rapid part shape optimization applying neural networks

- Optimization time reduced to 3-5 seconds (vs. minutes in traditional CAD)
- Validated accuracy (MAE ~1.2 MPa) with real-world stress simulations
- End-to-end automation from online customization to CNC-ready files
- Potential for scaling to complex parts & full smart manufacturing workflows





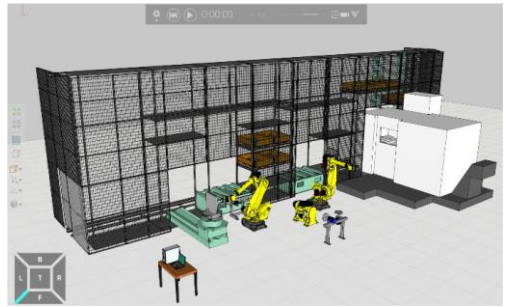


SEAMK

AI Demonstration 2

Integration of Optimization Methods into Simulation Technology for Manufacturing via Warehouse Optimization

- Production lines are often very complex and dynamic systems
  - Simulation offers a flexible environment for modeling behavior of such systems
  - Due to complexity, discrete event simulation tools themself are not able to provide solutions for complex challenges
  - Optimization methods integrated with simulation tools can solve complex challenges

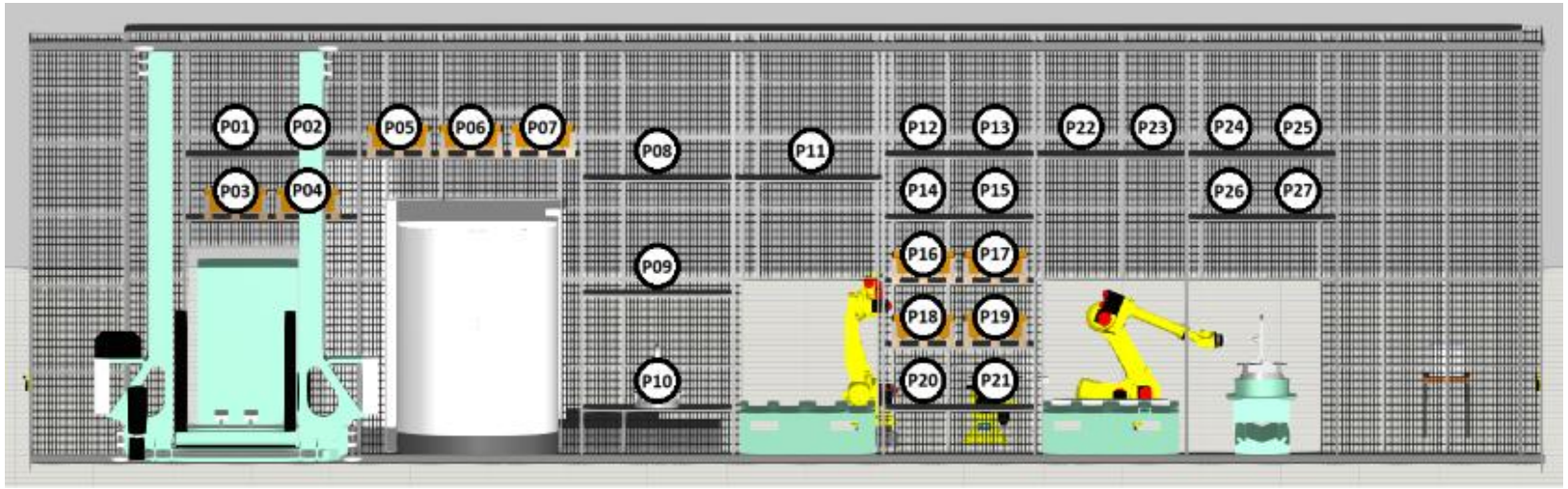


- Demonstrate the integration of genetic algorithms (GA) with 3D discrete-event simulation (DES)
  - Optimize warehouse operations, specifically pallet transfers within a flexible manufacturing system (FMS)

AI Demonstration 2

Integration of Optimization Methods into Simulation Technology for Manufacturing via Warehouse Optimization

- The production sequence was generated randomly (3 sets of 9 transfers)
  - Pallets initial position in the storage
  - Pallets end position in the storage
  - Results production plan (27 operations)



SEAMK

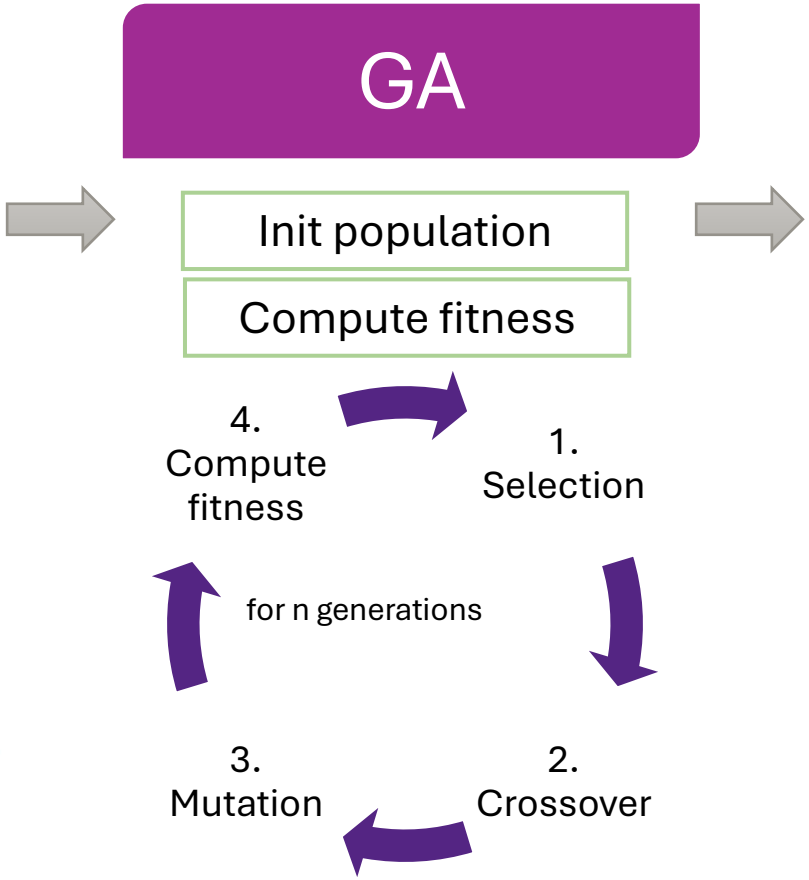
AI Demonstration 2

Integration of Optimization Methods into Simulation Technology for Manufacturing via Warehouse Optimization

Random production plan as input

```
'1': {'sku': 'epallet', 'src': 'P27', 'dst': 'P03', 'pid': 1},
'3': {'sku': 'epallet', 'src': 'P15', 'dst': 'P23', 'pid': 3},
'2': {'sku': 'epallet', 'src': 'P19', 'dst': 'P14', 'pid': 2},
'5': {'sku': 'epallet', 'src': 'P20', 'dst': 'P26', 'pid': 5},
'4': {'sku': 'epallet', 'src': 'P24', 'dst': 'P02', 'pid': 4},
'7': {'sku': 'epallet', 'src': 'P22', 'dst': 'P13', 'pid': 7},
'6': {'sku': 'epallet', 'src': 'P05', 'dst': 'P18', 'pid': 6},
'9': {'sku': 'epallet', 'src': 'P07', 'dst': 'P17', 'pid': 9},
'8': {'sku': 'epallet', 'src': 'P12', 'dst': 'P01', 'pid': 8}
```

- Direction: minimum
- Genes: [1, 2, 3, 4, 5, 6, 7, 8, 9]
- Population size: 1000
- Number of generations: 40
- Elite size: 10
- Mutation rate: 11 %
- Selection: tournament of 3 chromosomes
- Crossover: partially matched crossover (PMX)
- Mutation: swap.



Optimized production plan as output

```
'2': {'sku': 'epallet', 'src': 'P19', 'dst': 'P14', 'pid': 2},
'8': {'sku': 'epallet', 'src': 'P12', 'dst': 'P01', 'pid': 8},
'9': {'sku': 'epallet', 'src': 'P07', 'dst': 'P17', 'pid': 9},
'7': {'sku': 'epallet', 'src': 'P22', 'dst': 'P13', 'pid': 7},
'3': {'sku': 'epallet', 'src': 'P15', 'dst': 'P23', 'pid': 3},
'4': {'sku': 'epallet', 'src': 'P24', 'dst': 'P02', 'pid': 4},
'6': {'sku': 'epallet', 'src': 'P05', 'dst': 'P18', 'pid': 6},
'5': {'sku': 'epallet', 'src': 'P20', 'dst': 'P26', 'pid': 5},
'1': {'sku': 'epallet', 'src': 'P27', 'dst': 'P03', 'pid': 1}
```

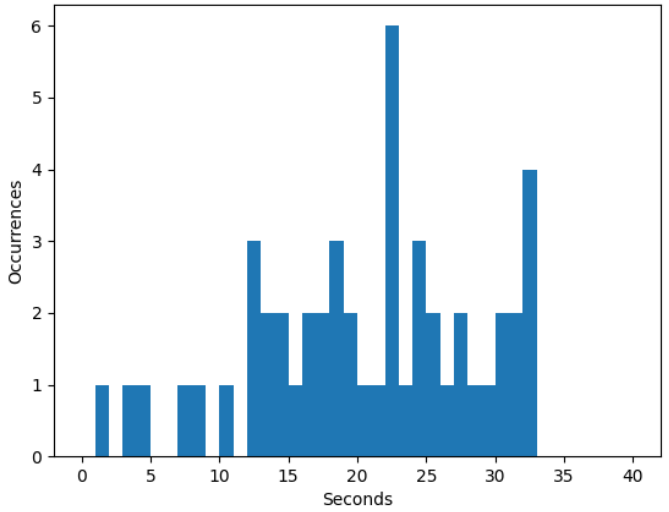
9! = 362 880

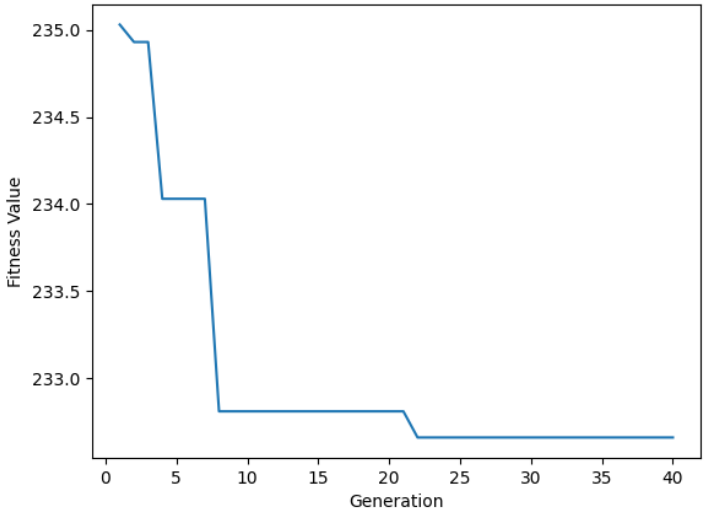
SEAMK

AI Demonstration 2

Integration of Optimization Methods into Simulation Technology for Manufacturing via Warehouse Optimization

- The simulation was run 50 times with and without the genetic algorithm
- The total duration of the transfers was reduced by circa 20,5 seconds on average. This represents about an 8,1 % reduction in transfer time



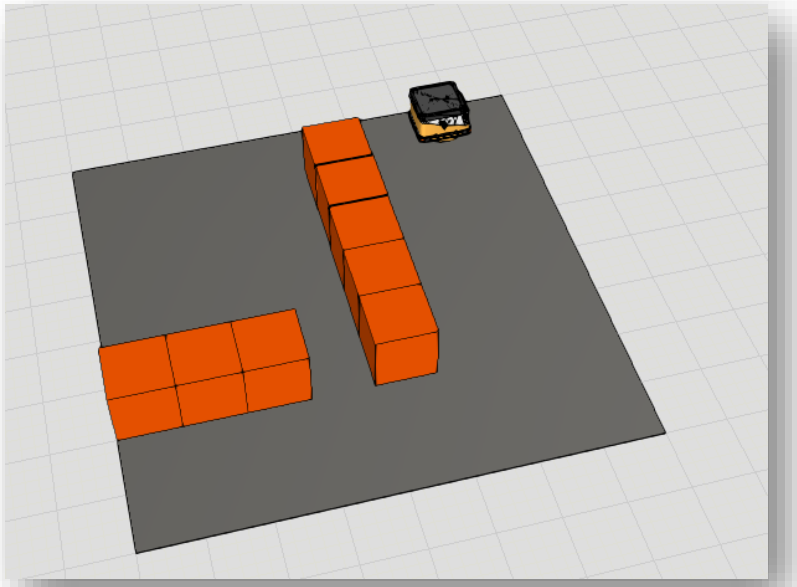


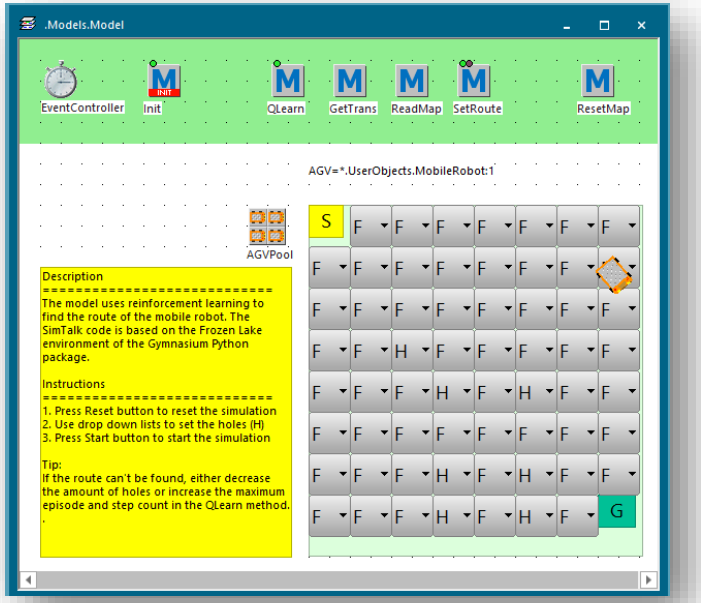
SEAMK

AI Demonstration 3

Route search utilizing reinforcement learning in Simulation model

- The object was to implement optimization algorithms with discrete event-based simulation tools (DES)
- Reinforcement learning methods was utilized to search the route for the mobile robot





Thanks!

- Next Hannu Hakalahti and the live AI demonstrations