Machinaide project summary 2019-2023

Case Aalto Smart Factory
–How to blend industrial machines with digital world

Finnish consortium and all WP’s & all partners
Work Packages and Goals

- **WP1**: Use Cases, requirements and evaluation
- **WP2**: Interoperability between Digital Twin ecosystems
- **WP3**: Processing of multiple Digital Twin’s data
- **WP4**: Innovative Human Machine Interfaces for DT’s and services
- **WP5**: Information usage across the machine Life cycle
- **WP6**: Business models
- **WP7**: Dissemination
- **WP8**: Project management
Use cases
Turkish Use case

- 1600T press line in Ermetal press factory
  - 1 press (800T) & 1 robot (fully automated) selected as project application area
- Real-time data monitoring & collecting
- Anomaly detection based collected data
- Performing predictive maintenance simulations

Key Objectives

Increase in hours/failure rate
Decrease in maintenance costs
Dutch use cases

Agricultural use-case:
• Improving Lely Juno machine installation using KE-chain

3D printing use case
• Data Collection & Data platform
• Software updates
Korean Use case

- Build a test bed for Autonomous Mobile Robots (AMRs) based material handling process
- KMAC Digital Twin Platform
Finnish partners

- Digital Twin Documents & Web, Connections, HMI, AIIC
- Business models
- Smart Factory app & simulation, Worklist app
- Data management & processing
- Virtual Grinding machine
- Crane interface, APIs, HMI
From old machines to smart ecosystems

Old tech to new tech
Ecosystem

Smart Factory with Crane and Grinder

Physical

Virtual

Digital Twin based Smart Factory Simulations

Enterprise Systems

ERP  MES  APS

Connectivity

Smart Factory Control room with Analytics

DTW

HMI
Digital Twin Document and Digital Twin Web (DTW)

DTW
Digital twin documents

Twinbase

Twinaide

KMAC DT testbed

KE-chain
WP1 & WP2: Layers (Industrial IoT & Workshop systems)

Workshop and Machine layer has a lot of interfaces & technologies

Digital twin web
OPC UA, REST API, GraphQL, etc

Virtual Smart Factory

+ Digital twins

Roll Grinding line
Press line
Additive manufacturing
Robotic cattle feeder
Material Handling

Digital twin web
OPC UA, MQTT, low-level IO, XML, REST API, GraphQL, ODBC, Oracle 11g, PLCSIM, SIMiT, Socket ActiveX, C, JSON, Beckhoff ADS etc

Crane
Roll Grinder
Aalto AIIC & RollResearch International

Presses
Robots
Additive manufacturing unit
Lely Juno

Additive Industries & Lely

Crane
AMR

ETRI/CIP Material Handling testbed
Developed virtual grinding machine

• Real CNC hardware (Siemens Sinumerik 840D sl) operating in simulation mode
  • Other studied option: Virtual CNC

• Communication over OPC UA with other DTs

• Information flow in both directions
  • Status information
  • Commands
Demonstration videos

- Ideal GRP, 3 min
- Remion, 2 min
- Crane domain (Aalto, RRI, KC), 5 min
Machinaide Final ITEA Review

Markus Ranta – March 21, 2023
HMI prototypes

Hololens AR

Crane control using XR
Virtual model can be run as standalone system or connected to a real crane. Both systems are connected to DT documents and DTW.

Varjo VR

Operator training in VR
Crane driving and smart features can be trained in realistic virtual environment.

Low code mobile app

Smart factory app
Material moves and machine operations as a Worklist for the operators.
<table>
<thead>
<tr>
<th>Partner Name</th>
<th>Title</th>
<th>Degree</th>
<th>Author</th>
<th>Date</th>
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<tbody>
<tr>
<td>AALTO</td>
<td>Real-time two-way data transfer with a digital twin via web interface</td>
<td>MSc</td>
<td>Jani Hietala</td>
<td>5.2.2020</td>
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<td>AALTO</td>
<td>IoT-based Smart Crane data-analysis and visualization</td>
<td>Bachelor</td>
<td>Joel Mattila</td>
<td>3.5.2020</td>
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<td>AALTO</td>
<td>Communication between machines in smart factories</td>
<td>MSc</td>
<td>Joel Mattila</td>
<td>23.11.2021</td>
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<td>AALTO</td>
<td>A Mixed Reality Interface for DigitalTwin Based Crane</td>
<td>MSc</td>
<td>Tu Xinyi</td>
<td>15.10.2021</td>
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<td>AALTO</td>
<td>User Experience Challenges in Designing Industrial Internet of Things Applications</td>
<td>Bachelor</td>
<td>Anna Nikander</td>
<td>25.8.2020</td>
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<td>AALTO</td>
<td>Multivariate fuzzy modelling of time-series data</td>
<td>MSc</td>
<td>Tuomas Keski-Heikkilä</td>
<td>24.07.2021</td>
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<td>AALTO</td>
<td>API-based Digital Twins</td>
<td>PhD</td>
<td>Riku Ala-Laurinaho</td>
<td>10.12.2021</td>
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<td>AALTO</td>
<td>Discovering the Digital Twin Web—From singular applications to a scalable network</td>
<td>PhD</td>
<td>Juuso Autiosalo</td>
<td>17.12.2021</td>
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<td>AALTO</td>
<td>Framework for Virtual Reality digital ser-vices leveraging digital twin-based crane</td>
<td>MSc</td>
<td>Chao Yang</td>
<td>7.9.2021</td>
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<td>AALTO</td>
<td>“Towards Industrial Metaverse: Combining Digital Twins and Extended Reality in Industry 5.0 Applications”</td>
<td>PhD</td>
<td>Tu Xinyi</td>
<td>Started 3/2021</td>
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<td>AALTO</td>
<td>“Data-driven framework for digital applications leveraging digital twin-based Machine”</td>
<td>PhD</td>
<td>Chao Yang</td>
<td>Started 10/2021</td>
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<td>AALTO</td>
<td>“Digital Twin Document for enabling self-organizing smart factories.”</td>
<td>PhD</td>
<td>Joel Mattila</td>
<td>Started 1/2022</td>
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<td>REMION</td>
<td>Fuzzy modeling system for Regatta</td>
<td>BSc</td>
<td>Janne Saukkio</td>
<td>5/2022</td>
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<td>RRI</td>
<td>Flexible human machine interface for roll machining automation, Aalto University, School of Electrical Engineering</td>
<td>MSc</td>
<td>Olli Raudaskoski</td>
<td>June 2022</td>
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<td>Partner Name</td>
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<td>AALTO</td>
<td>Elsevier Computer standards and interfaces</td>
<td><a href="https://acris.aalto.fi/ws/portalfiles/portal/83366076/computers_11_00065.pdf">https://acris.aalto.fi/ws/portalfiles/portal/83366076/computers_11_00065.pdf</a></td>
<td>1.5.2021 (published)</td>
<td>Comparison of REST and GraphQL interfaces for IIoT (Riku Ala-Laurinaho et al.)</td>
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<td>Submitted in 2022</td>
<td>Multivariate fuzzy modeling (Riku Ala-Laurinaho, Juuso Autiosalo, Tuomas Keski-Helikkilä, Miika Valtonen, Kari Tammi)</td>
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<td>AALTO</td>
<td>MDPI Machines</td>
<td><a href="https://www.mdpi.com/2075-1702/10/4/225">https://www.mdpi.com/2075-1702/10/4/225</a></td>
<td>Published 23.3.2022</td>
<td>Using Digital Twin Documents to Control a Smart Factory: Simulation Approach with ROS, Gazebo, and Twinbase (Joel Mattila et al.)</td>
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<td>AALTO</td>
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<td><a href="https://doi.org/10.3390/app12126030">https://doi.org/10.3390/app12126030</a></td>
<td>14.6.2022</td>
<td>Extended Reality Application Framework for a Digital-Twin-Based Smart Crane (Chao Yang et al.)</td>
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Summary & Conclusions

• Interoperability & Updates
  • Digital Twin Web
  • Device management & software updates
  • Machine interfaces & APIs

• Data processing
  • Factory data (ecosystem level) and Machine/asset level
  • System level modelling: Anomaly detection

• HMI
  • HMI development: Several AR/VR/XR devices
  • Smart factory app: Worklist feature

• Dissemination & future work
  • Plenty of publications and thesis works
  • Research to business project started and is ongoing
Any questions?

• Thank you!