LMS
Laboratory for Manufacturing Systems & Automation

RIS Industry 4.0 Hubs

Artificial Intelligence for manufacturing

EIT Manufacturing is supported by the EIT, a body of the European Union

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Introduction

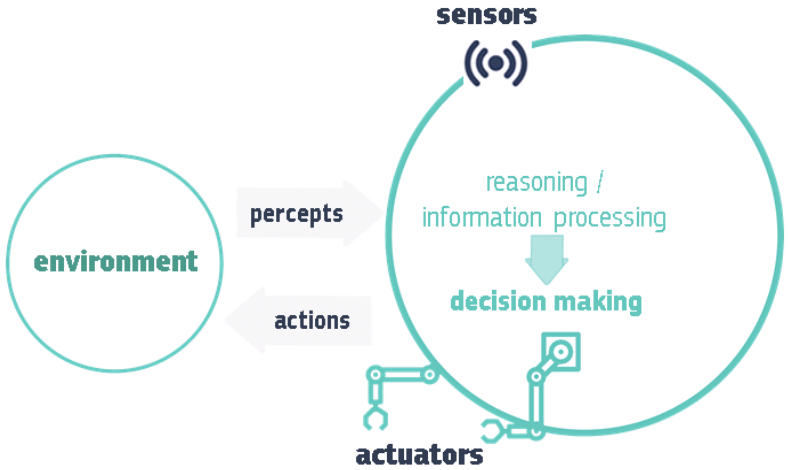
- In order to adapt to unexpected events and frequent changes manufacturing companies (including SMEs) need to become more flexible and reconfigurable.
- Capability to execute high-level tasks without detailed (re)programming and need of human intervention.
- The rise of new digital industrial transformation (Industry 4.0), with smart manufacturing currently on its forefront is changing the way that businesses operate.

What is considered as Artificial Intelligence (AI)?

- Simulation of human intelligence in machines.
- Machines learn to act and solve problems

Application areas of AI in manufacturing:

- Predictive Maintenance
- Additive Manufacturing
- Robotics
- Condition Monitoring (e.g. air quality)
- Decision Support Systems (e.g. production scheduling)
- Quality Control (i.e. defected products)



[Source: EU High Level Group in AI, A DEFINITION OF AI:MAIN CAPABILITIES AND DISCIPLINES, 2019]

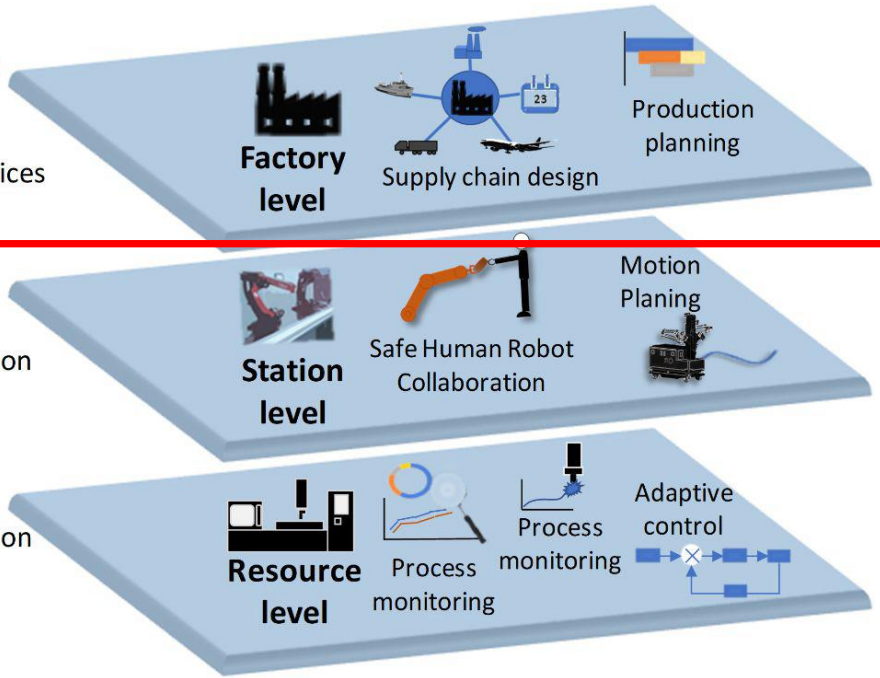
Hierarchical model of Manufacturing system

AI enhanced applications

- Manufacturing systems design
- Design of supply chains
- Production planning
- Context aware informatin services

- Motion planning
- Task planning
- Safe Human-Robot Collaboration
- Machine vision

- Process monitoring & control
- Process parameters optimization
- Quality assessment
- Tool wear prediction



Key Enabling Technologies

Advances in information technologies, including:

- Internet of Things (IoT),
- Cyber-Physical Systems (CPS),
- Big Data / Analytics,
- RFID Technologies,
- Edge Computing and
- Cloud Computing

provide the foundations for Artificial Intelligence (AI) Applications to emerge under the vision of Industry4.0.

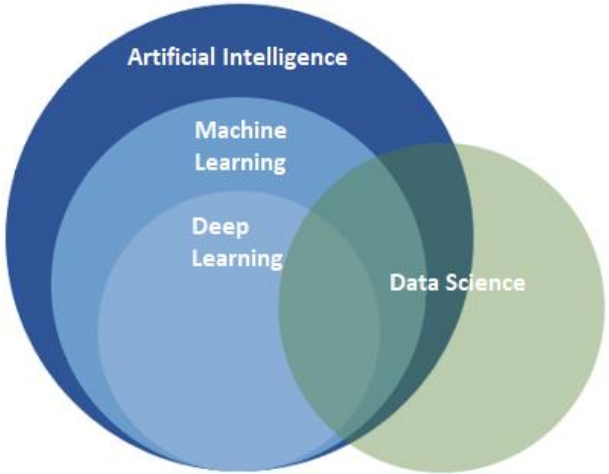
Data analytics methods such as:

- Machine Learning (ML)
- Deep Learning (DL) (e.g. neural networks)
- Mathematical Models (e.g. regression models)

can be applied to data from IoT devices.

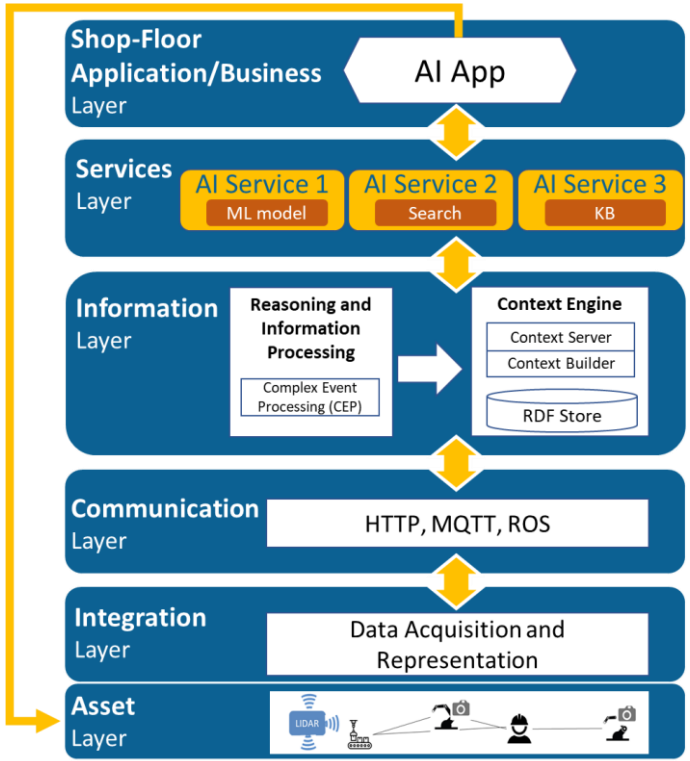
Enabling devices:

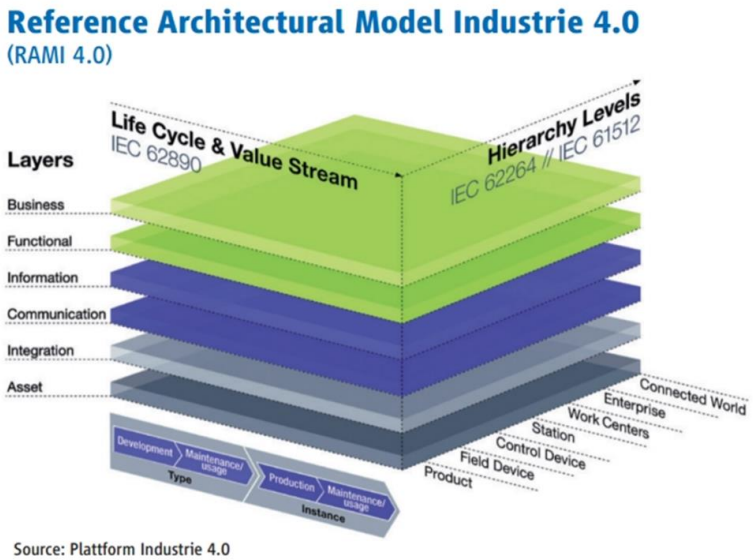
- Sensors
- Gateways
- Cloud Databases
- Human-Machine Interfaces (HMIs)



Applications of AI for optimizing the performance of manufacturing system

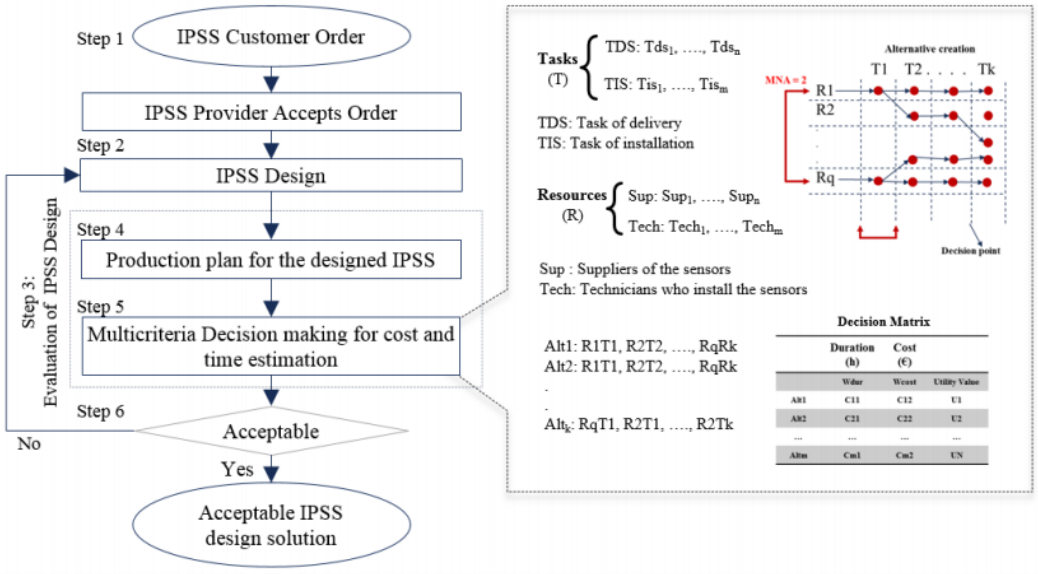
Platform for Artificial Intelligence in Manufacturing

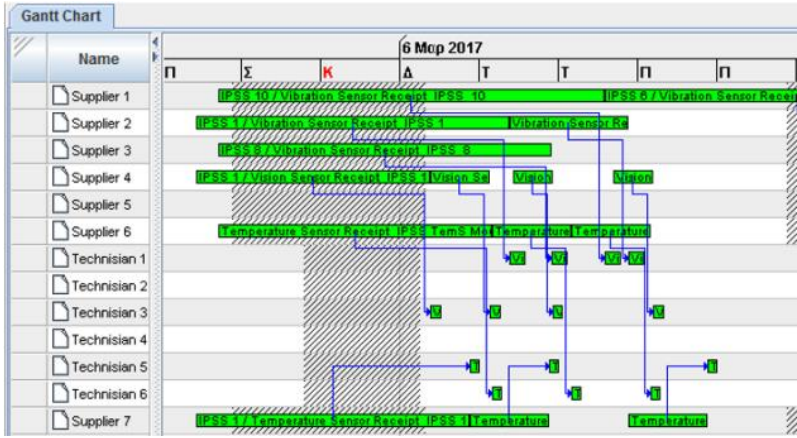




[Source: K. Alexopoulos, et. al , An industrial Internet of things-based platform for context-aware information services in manufacturing, International Journal of Computer Integrated Manufacturing, Volume 31, 2018 - Issue 11]

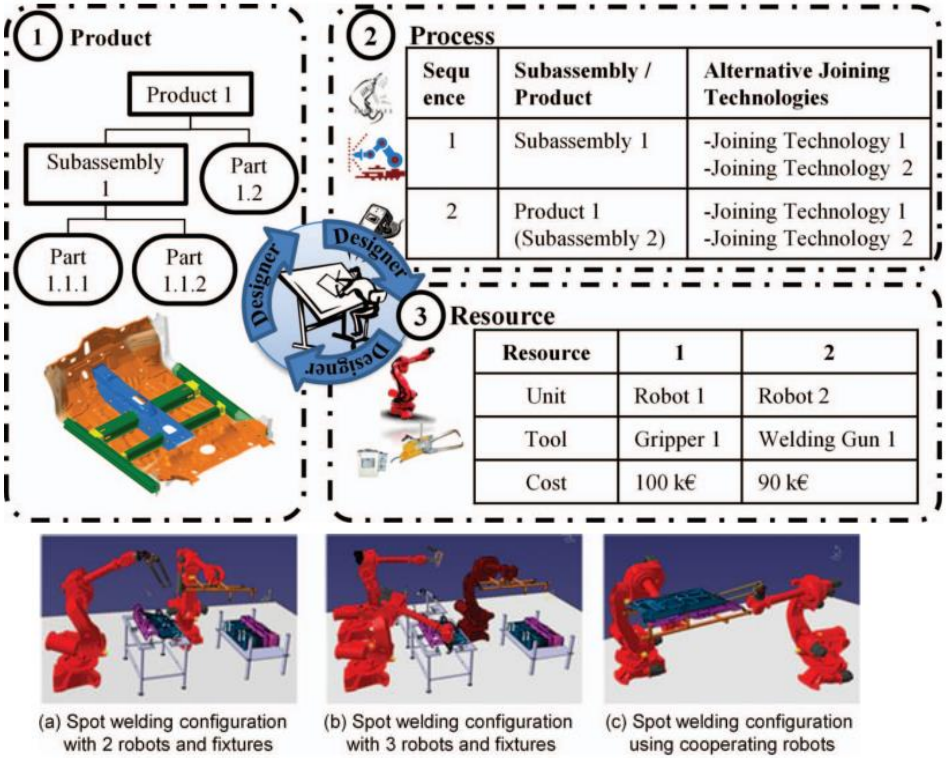
Jobs dispatching and scheduling

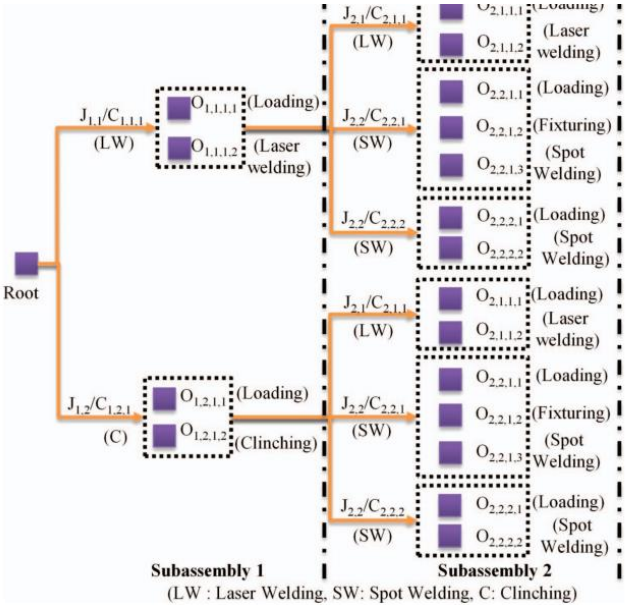




[Source: K. Alexopoulos, et. al,"Resource Planning for the Installation of Industrial Product Service Systems", IFIP International Conference on Advances in Production Management Systems, (ARMS2017),3-7 September, Hamburg, Germany, pp. 205-213 ,(2017)]

Design of Manufacturing Systems





[Source: Michalos, G, S Makris, and D Mourtzis. 2012. "An Intelligent Search Algorithm-Based Method to Derive Assembly Line Design Alternatives." International Journal of Computer Integrated Manufacturing 25 (3): 211–29.]

Digital Twin for Synthetic Data Generation

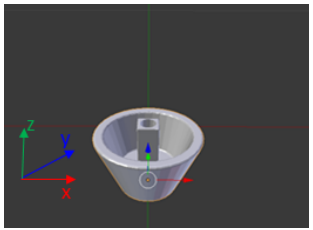
- Artificial Intelligence (AI) applications based on Machine Learning (ML) methods are widely accepted as promising technologies in manufacturing.

- However, ML techniques require large volumes of quality training datasets and in the case of supervised ML manual input is usually required for labelling those datasets.

- Such an approach is expensive, prone to errors and labour as well as time intensive, especially in a highly complex and dynamic environment as those of a production system.

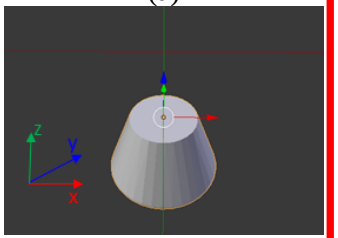
- Digital Twin models can be utilized for accelerating the training phase in ML by creating suitable training datasets as well as by automatic labelling via the simulation tools chain and thus alleviating user's involvement during the training phase.

Digital Twin for Synthetic Data Generation


(a)


(b)


(c)


(d)


(e)

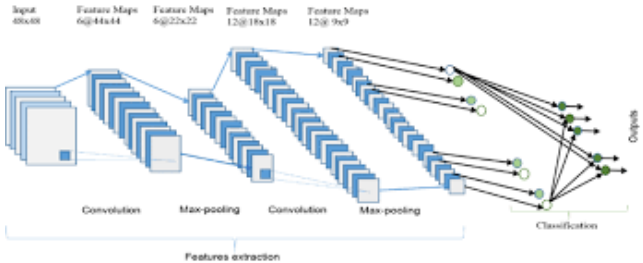

(f)

3D model of the part

Synthetic data

Real data

Inception v3 CNN model has been retrained on synthetic data sets



[Source: K. Alexopoulos, N. Nikolakis, G. Chryssolouris, "Digital twin-driven supervised machine learning for the development of artificial intelligence applications in manufacturing", International Journal of Computer Integrated Manufacturing, Volume 33, Issue 5, pg. 429-439, (2020).]

Outlook

- AI can offer several advantages in manufacturing companies and SMEs concerning important industrial aspects such as Predictive Maintenance, Condition Monitoring, Decision-making and Quality Control.
- Emerging Industry 4.0 technologies, such as the Internet of Things (IoT), Big Data analytics, Cloud computing and Machine Learning (ML), provide the necessary background for the development and implementation of AI-based systems in manufacturing.
- Key benefits of AI include prediction, simulation, resource optimization, optimized decision-making, fewer costs, safety and, in general, improved operational performance.
- Manufacturing companies have to face several challenges concerning AI adoption, due to their unique characteristics.
- Several manufacturing companies lack the adequate investment capabilities, knowledge on Industry 4.0 technologies and human resources in order to implement AI systems.
- There is not any general model or framework that provides guidance to manufacturing companies on how to develop and implement AI systems on their processes.

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