OPTIMAI

Optimizing Manufacturing Processes through Artificial Intelligence and Virtualization.

Industry 4.0 – Digital Transformation in Industry

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› Optimizing Manufacturing Processes through Artificial Intelligence and Virtualization.

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- ✓ 16 Partners
- ✓ 8 Countries

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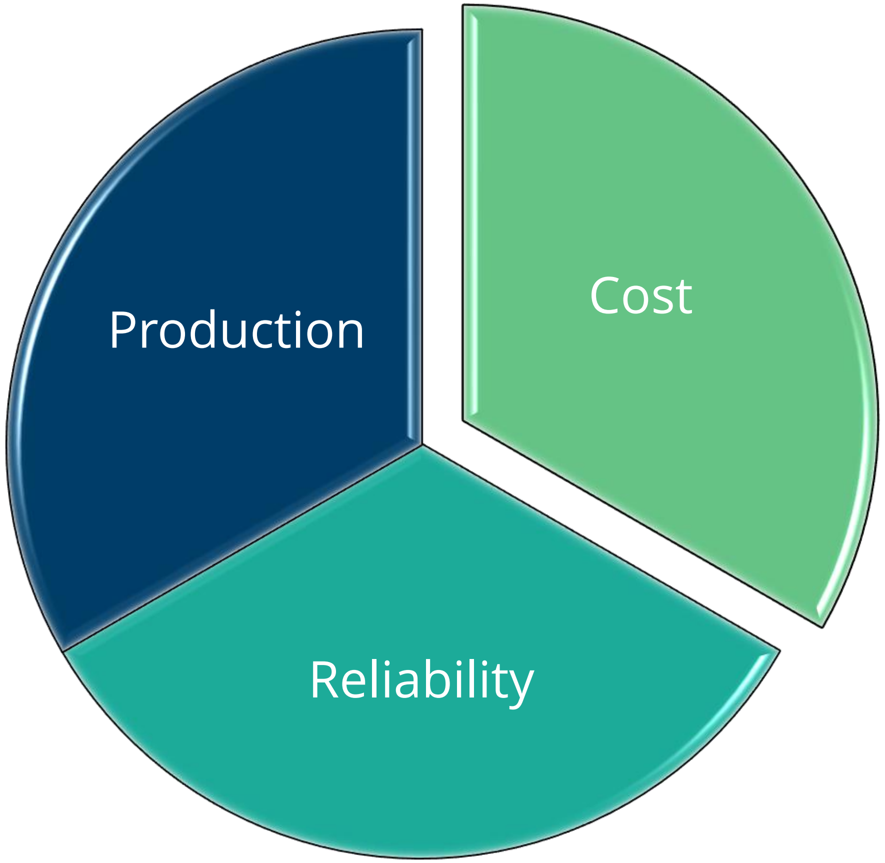
Motivation and Objectives

Motivation:

- Modern industry has a saying

«Cheap, Reliable, Fast
Choose two out of threee.».

- There is always a **compromise** between production time, quality and resources need in the production process.



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Motivation and Objectives

Objectives:

Reduce compromise by:

- Installation of **smart sensors** that implement **Artificial Intelligence** methods for monitoring the production process and quality control.

- Digital representation of the production in a **virtual environment (digital twins)** aiming the simulation, the optimization and the planning of production.

Fault Detection → Root Cause Analysis → Solution Suggestion

Trial-and-Error in the actual production line

+	−
Immediate result	Errors are expensive in terms of time and money

Trial-and-error in a Virtual Environment

+	−
Zero-cost for testing	Requires simulation infrastructure (but only once)

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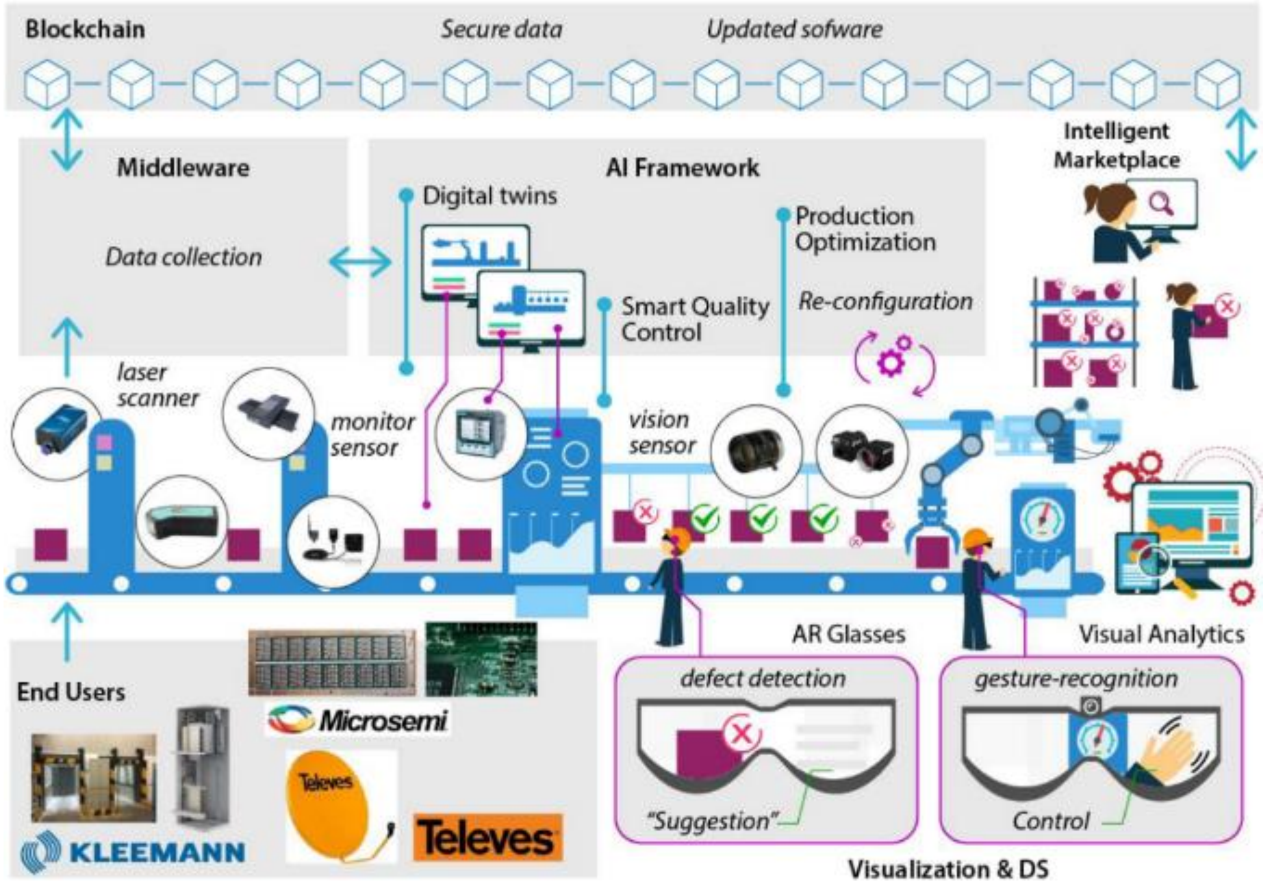
Basic Idea

Steps:

- Installation of **Smart Sensors** along the production line.
- **Real-time** production monitoring.
- Use of **Artificial Intelligence** τo detect and diagnose faults at early stages.
- Use of **Digital Twins** and simulations.
- Use of **Augmented Reality** to deliver messages and control production.

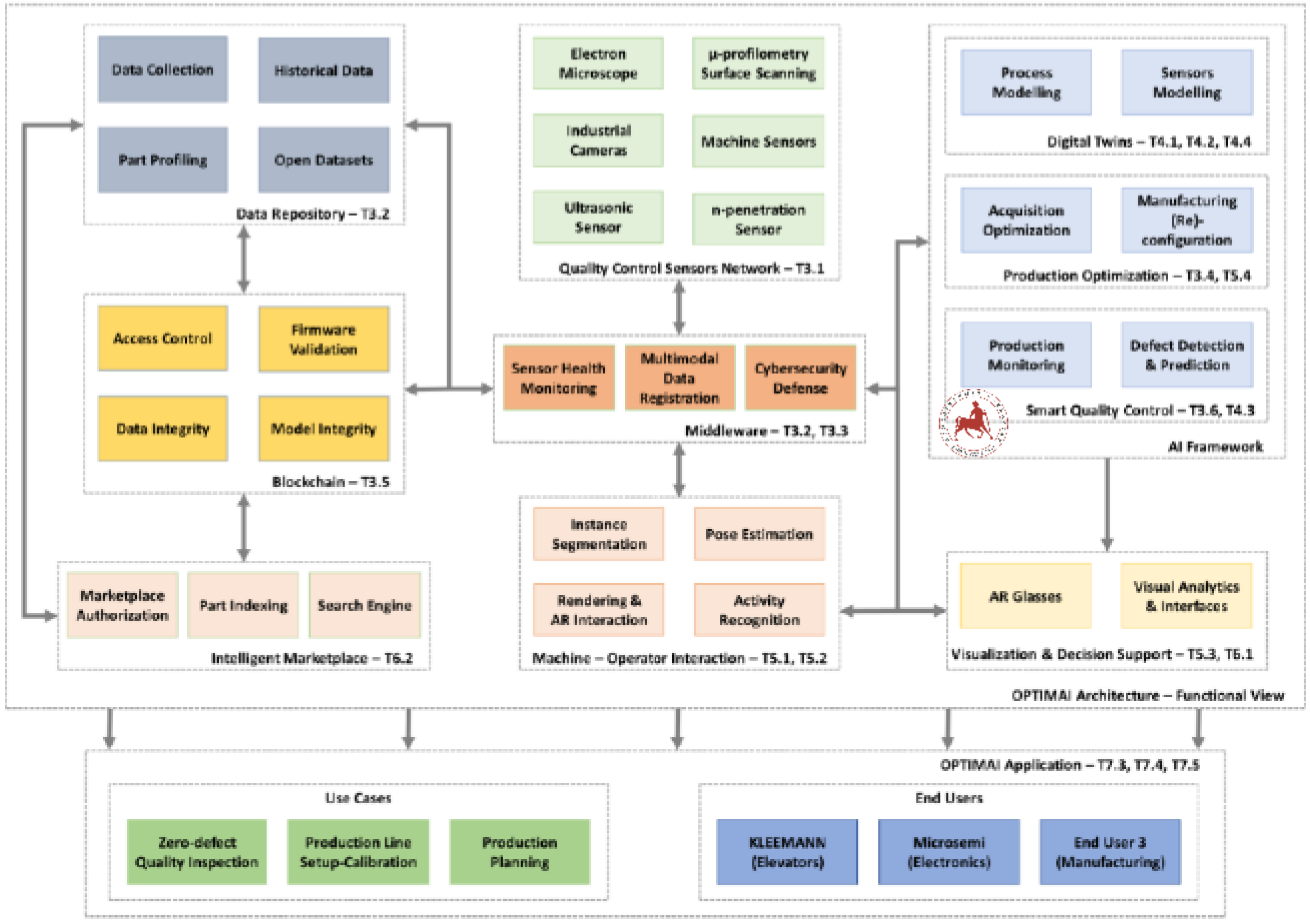


Architecture

OPTIMAI is a modular platform for management and planning the production.

Its functionality relies on the collaboration of **multiple modules**:

- Quality Control
- Artificial Intelligence
- Digital Twins
- Production Optimization
- Decision Support
- etc.



Use cases

UC1

Zero-Defect Quality Inspection

Monitoring the production targeting **Zero-defect Manufacturing**.

UC2

Production line setup-calibration

Fault detection and prediction. Real-time data analysis using Artificial Intelligence for (re)configuration/calibration of machinery.

UC3

Production Planning

Scenario Exploration. Use of simulations and digital twins towards a more efficient production planning.

Pilot sites

OPTIMAI will installed and employed at three Pilot sites:

Microsemi (Ireland): Fabrication of microchips.

- Goal: Detect defective dies, identify cause of defects.

KLEEMANN (Greece): Manufacturing of elevators

- Goal: Detect sub-optimal operation of the Power Hydraulic Unit.

Televes (Spain): Fabrication of antennas

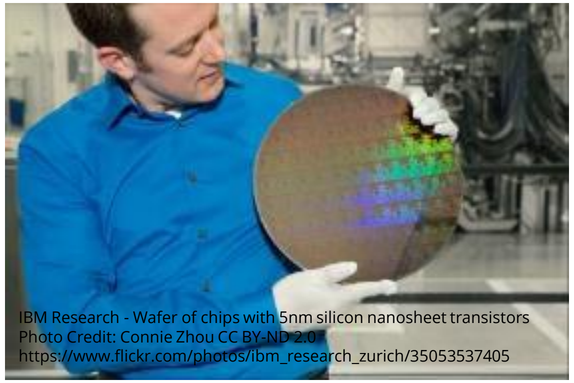
- Goal: Detect defective antennas (damage, assembly).

Artificial Intelligence

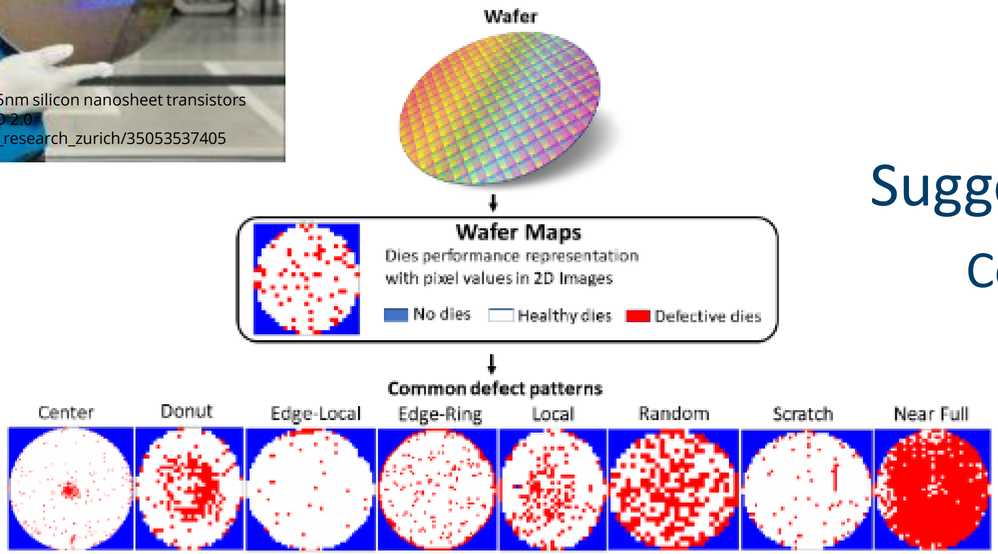
for defect detection

Defect detection and analysis on wafers (1/2)

Dies are produced in batches on wavers. A special probe identifies defective dies and produces a visualization of the distribution of defects (wafer map).



IBM Research - Wafer of chips with 5nm silicon nanosheet transistors
Photo Credit: Connie Zhou CC BY-ND 2.0
https://www.flickr.com/photos/ibm_research_zurich/35053537405



Statement of the problem:

(1) Recognize patterns of defects.

(2) Correlate patterns with production parameters to identify cause of defect.

Suggested solution

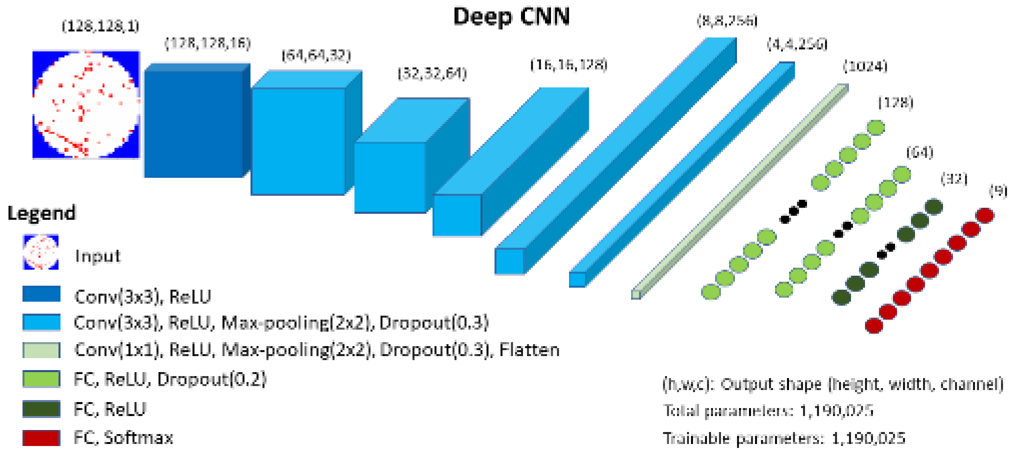
Convolutional Neural Networks (CNNs)

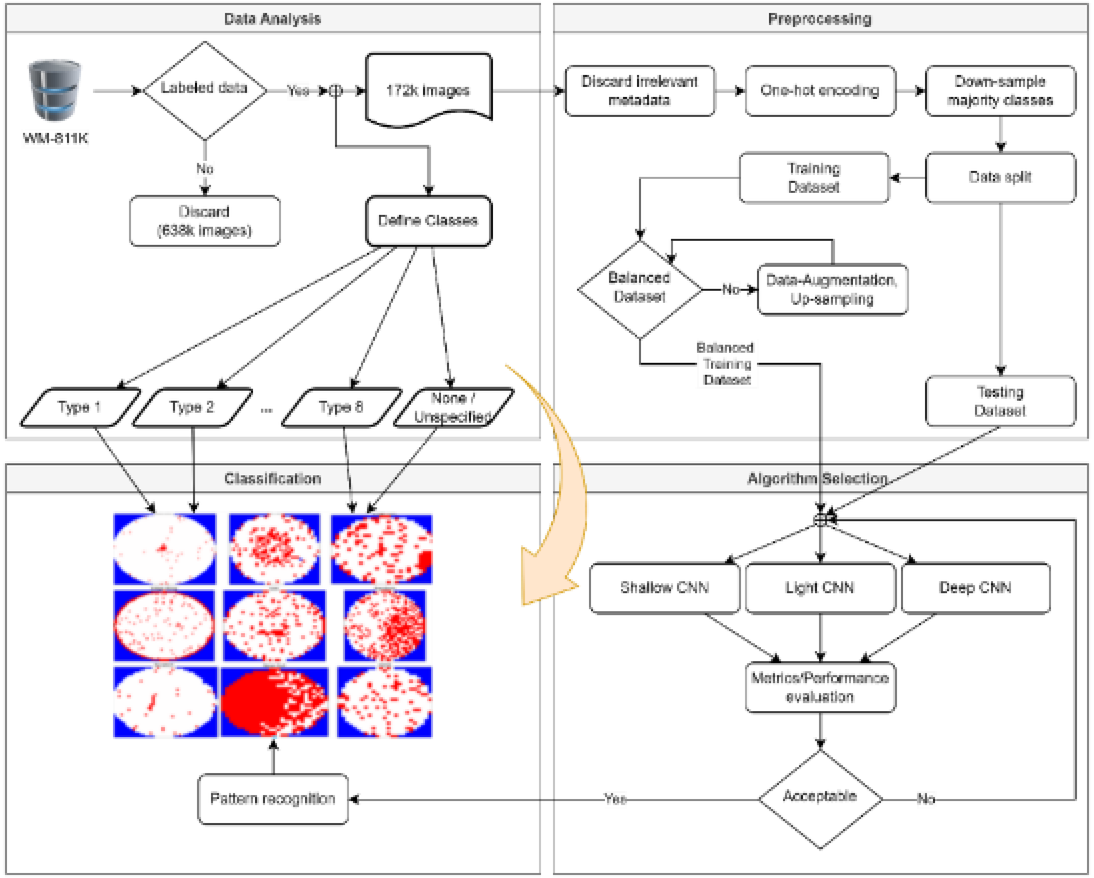
Defect detection and analysis on wafers(2/2)

Approach & Implementation:

- Implementation of numerous architectures.
- Assessment of architectures and models.
- Selection of optimal solution in terms of

  Accuracy, Reliability, Speed.





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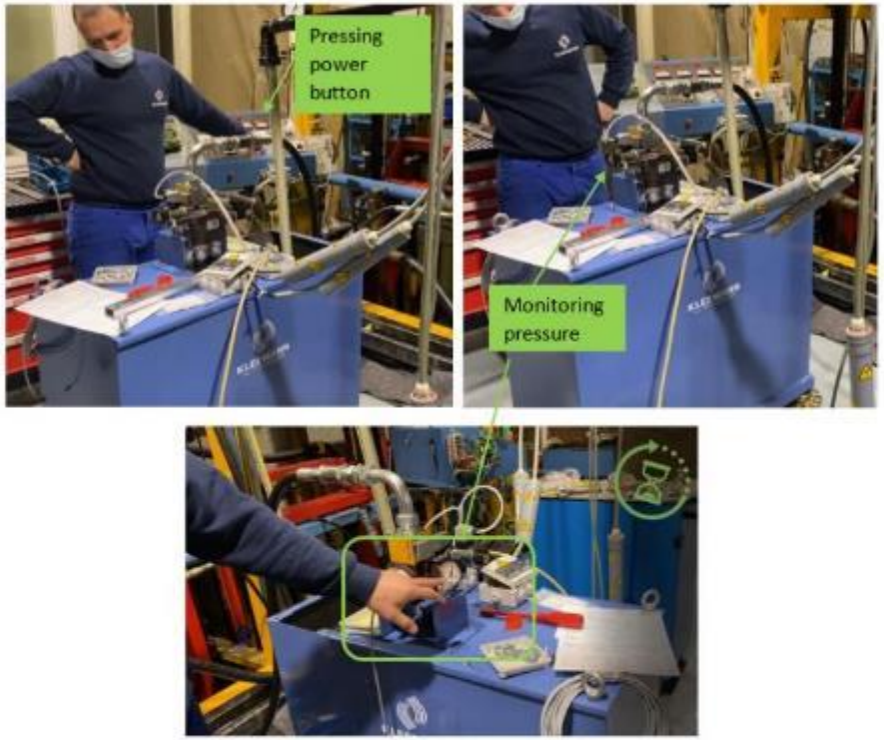
Defect detection in elevator hydraulic power unit (1/2)

The HPU is assembled and operated. An expert technician monitors a groups of measurements (pressure, velocity, noise) to determine if operation is optimal or not.



Statement of the problem:

Operational parameters should be considered in combination

- Time-consuming and error-prone process.
- No defective timeseries available.

Suggested solution:

CNN- and LSTM-based Autoencoders.

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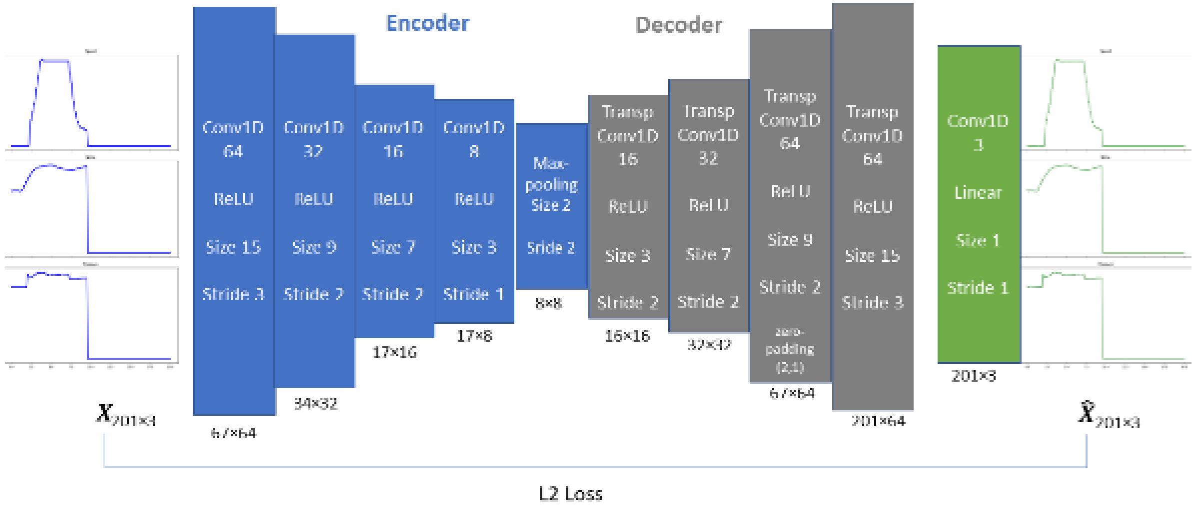
Defect detection in elevator hydraulic power unit (2/2)

Approach & Implementation:

- Assessment of existing methodologies.
- Due to the lack of defective products, the model had to "**learn by itself**" if an operation is optimal or not.

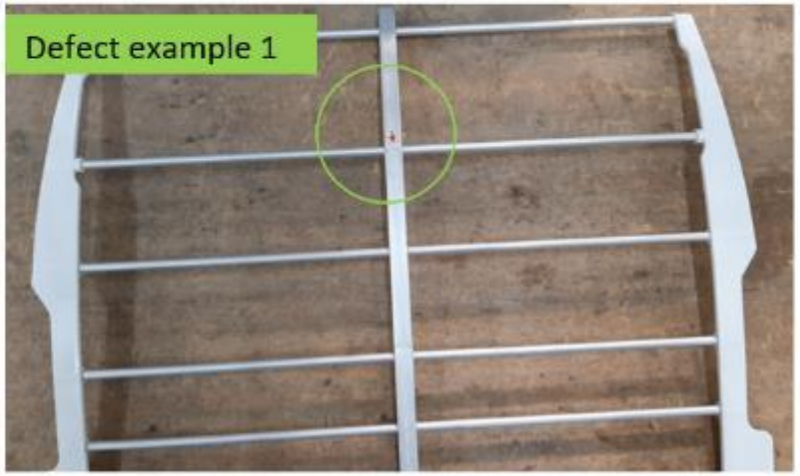
Detector	Accuracy
WT-CNN classifier	96%
LSTM-based AE	91%
CNN-based AE	94%

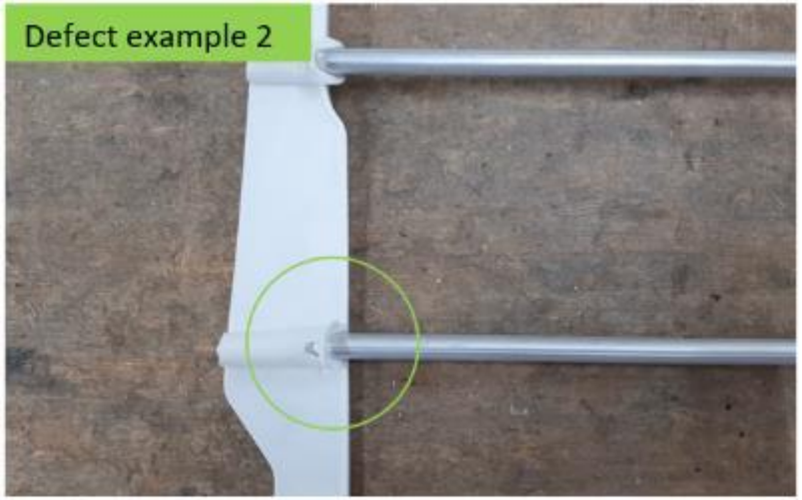
CNN AE



Defect detection in antennas

Antennas are produced in an automated production line.





Statement of the problem:

Defects during assembly (wrong parts).

Defects due contacts (misalignment, cracks).

Suggested solution:

Use of AI – Task in progress.

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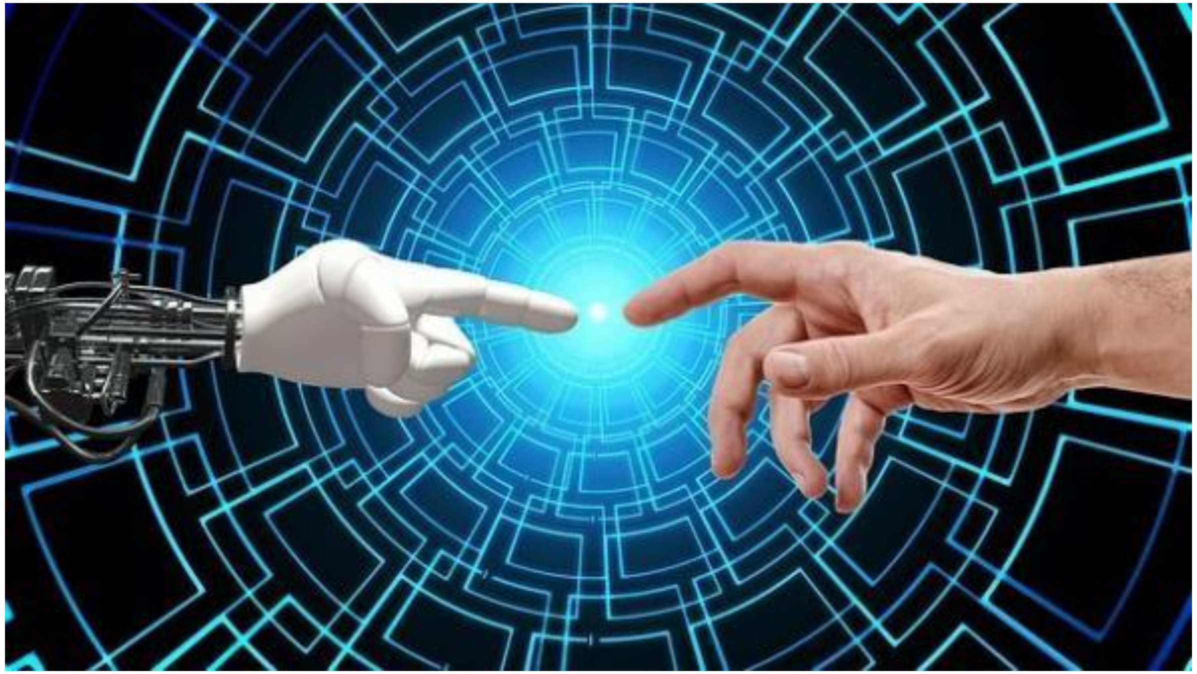
Conclusions

Conclusions

Artificial Intelligence methods:

- can **automate** the detection and diagnosis of defective products.
- can **“understand”** defective products without prior training.
- **do not replace human intelligence** but simplifies operations by automated repeating and time-consuming processes.



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