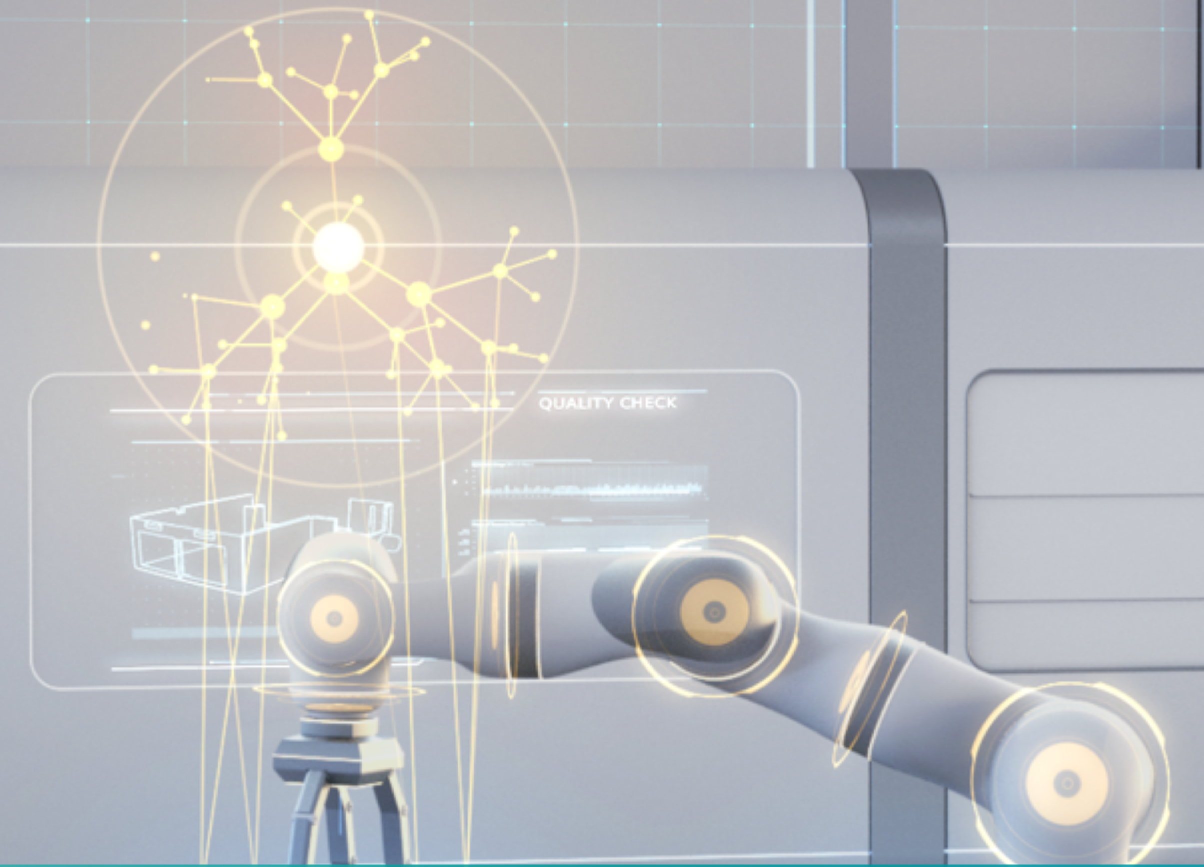

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AI on the machine level in industrial automation

Dr. Ingo Thon

Many major breakthroughs in Artificial Intelligence (AI) have occurred since 2011, and will have significant impact on our business

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Definition of AI | **Creating machines that perform functions that require intelligence when performed by people (Kurzweil, 1990)**

Before 2011

1946: Zuse's *Z3*, first programmable electronic computer

1997: IBM Deep Blue defeats world's chess champion Kasparov

2005: Honda's humanoid robot *Asimo* comes to life

2011 – 2017

2011: Watson wins *Jeopardy!* against most successful contestants

2014: Alexa, Amazon's intelligent assistant debuts

2016: AlphaGo beats Lee Sedol in a Go match

Expected by 2030+

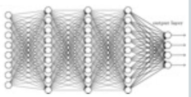
~2020: All-over virtual personal assistants as interface for consumers

~2030: Fully autonomously driving cars become market-ready

20xx: Robots may build robot "children" on their own

Significant activities

- Technological break-throughs, esp. **deep learning and NLP**



- **Competitors invest** strategically into AI
- IT players start to **move into industrial areas**
- **Open platforms** and data bases

Industrial automation and how it changes towards enabling AI

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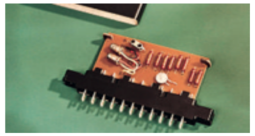
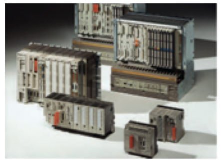
Definition of Industrial Automation | **Industrial automation is the use of control systems, for handling different processes and machineries in an industry to replace a human being**

History



1958: SIEMENS replaces simple switches and relays by transistors

1973: SPS S3 Programmingd evice, punched tape



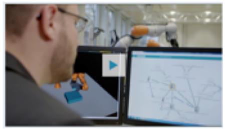
1979: Programming with screens and graphical programming

Current

2017: Freely programmable cores

2018: release of TM NPU

Expected by 2018+

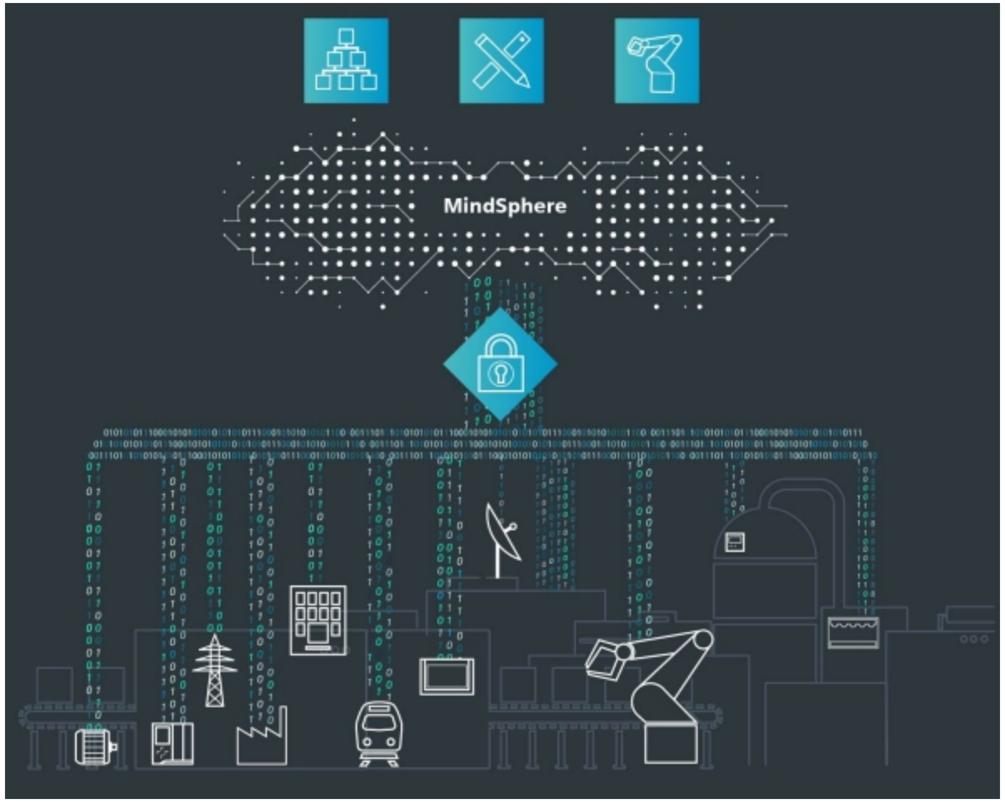


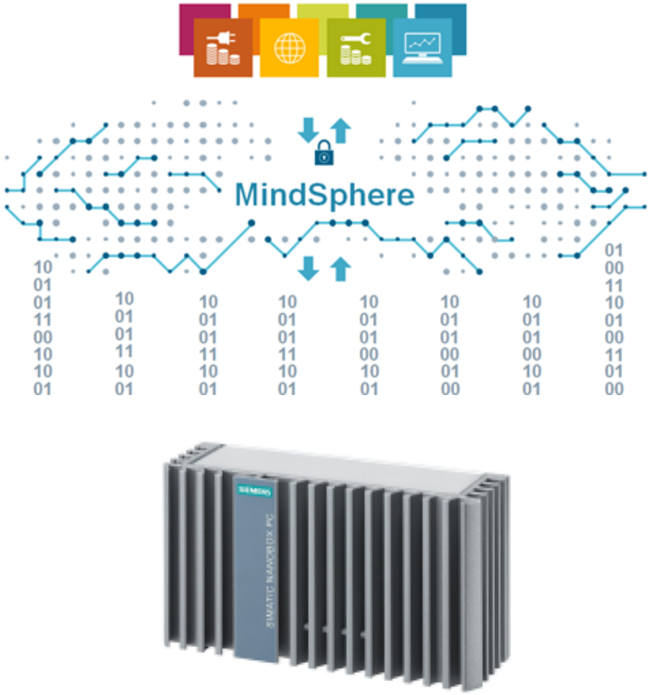
~2025: Robots which do not need to be programmed

~ 2025: Flexible lot size one production

Internet of Things – Today

Today's IoT approaches largely offload compute-intensive work to the cloud, which is hardly feasible for intelligent things.





NanoBox can only send data with approx. 1Hz frequency
⇨ High roundtrip latencies, not suitable for control or safety-critical applications

Data and Services Move from the Cloud to the Edge

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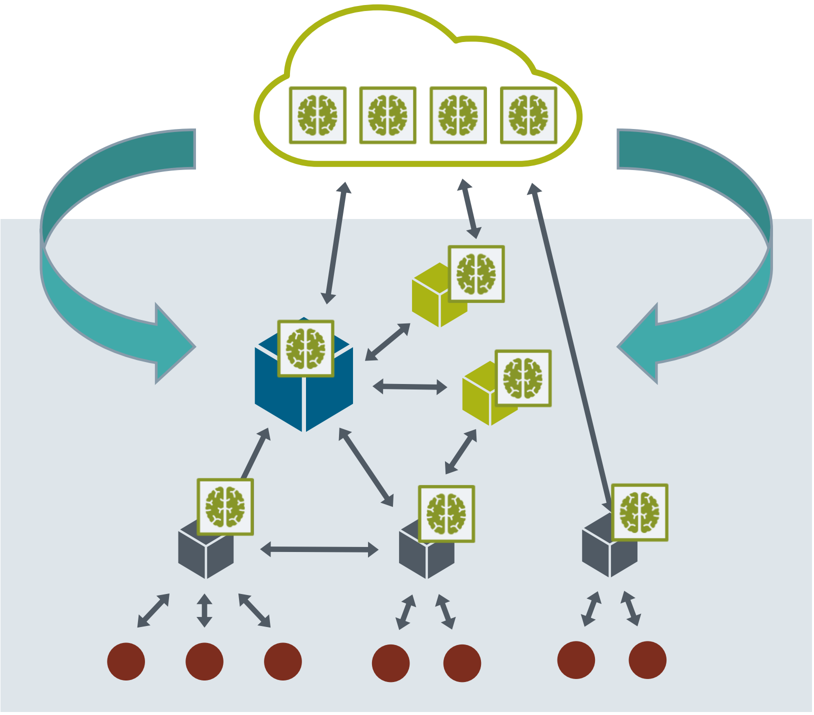
The large amount of data generated by intelligent things requires to process the data at the edge (devices, gateways, etc.).



Fast response
- Work directly on **local streams of data**.
- **Real time**, **low latency** required for control applications.

Offline operation
- **Independence** from cloud backend (network bandwidth / connectivity).
- Reduce of **network traffic** / bandwidth requirements

Low cost
- Leverage **existing hardware** for compute-intensive applications.
- Avoid / minimize cloud **usage fees**

Security / privacy
- Keep **sensitive data** on device.
- **Ensure privacy** by sending only non-confidential data to the cloud.

AI on the Edge and Distributed AI
Motivation

Enabling Industrial Edge & Field Devices with Artificial Intelligence and Data Analytics Capabilities

The need for local Intelligence on Devices

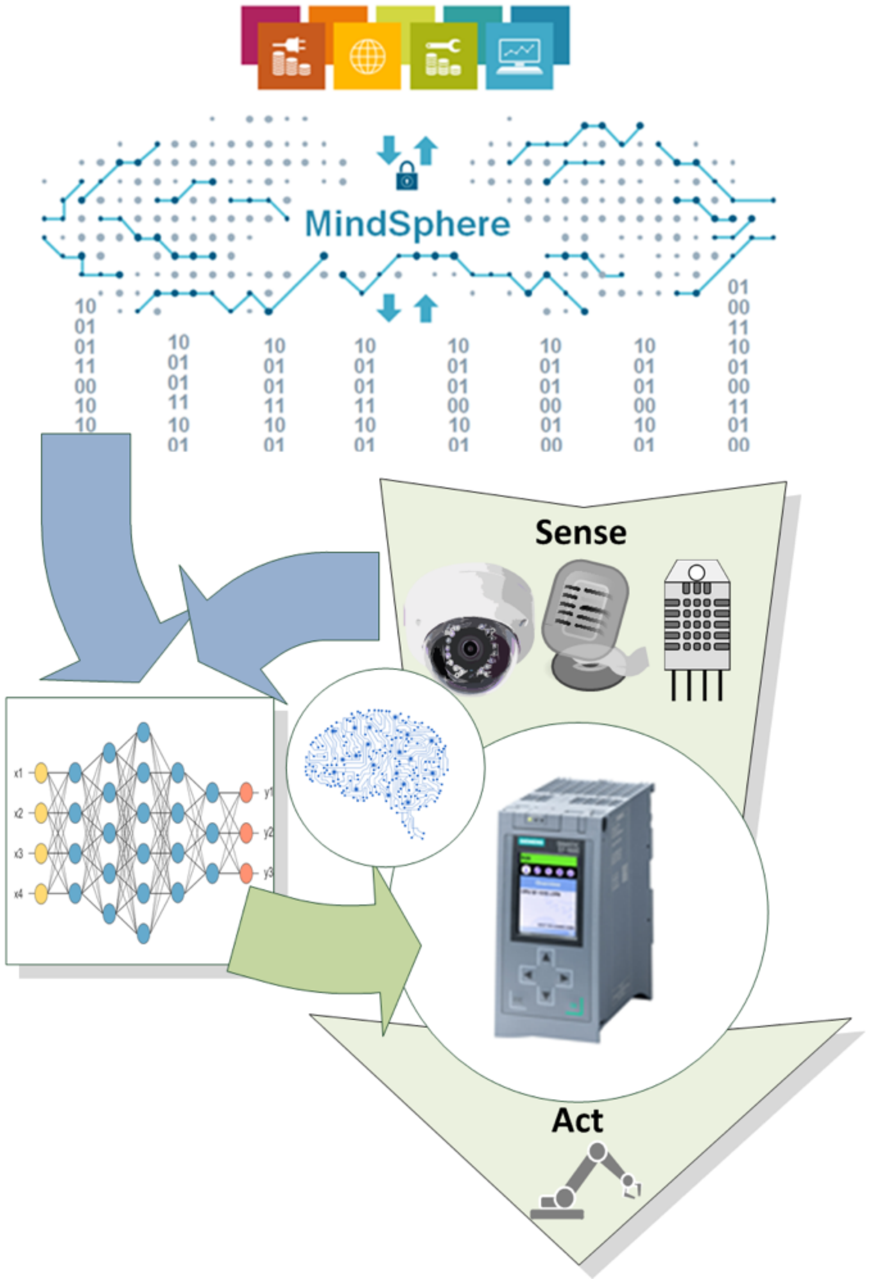
Responsiveness
Work on local data, perform low-latency decision making.

Contextualized Intelligence
Learn from the local environment and adapt to it in real-time.

Security and Privacy
No need to extract sensitive data from the field, or expose IP.

Autonomy and efficiency
No dependency on cloud, no transfer of large amounts of raw data.

Reduced costs
Resource sharing, leverage existing computing devices and platforms.



Real-Time Video Analytics for Intelligent Traffic Systems

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Use Case 1

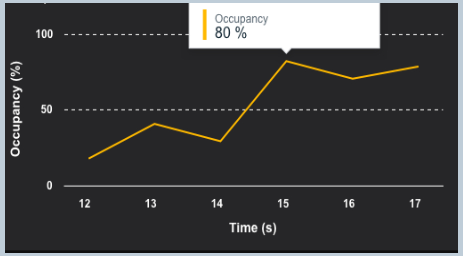
Vehicle detection, Tracking & Counting *[July'18]*

- Detect vehicles and pedestrians in the field of view of the camera
- Track vehicles for accurate counting and speed estimation
- Improve turning movement count based on type

Use Case 2

Density Estimation & Statistics *[July'18]*

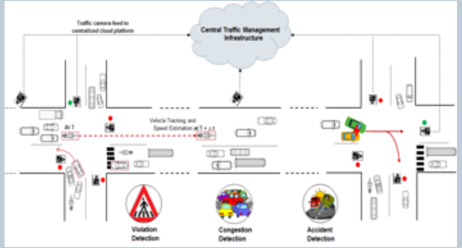
- Real-time estimation of road occupancy (density)
- Statistical reports with time graphs of hourly, daily, weekly and monthly variation of traffic density



Use Case 3

Anomaly detection *[Sept'18]*

- Detection of traffic violation (e.g: helmet detection)
- Accident detection & localization. Notify medical and law-enforcement authorities



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Deployment of Machine Learning models to Protection Relays

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Siemens Innovation

Machine learning & distributed analytics – intelligent grid controllers

Challenge
– Reliably classifying and locating faults in power grids
– Conventional methods at ~80% reliability

Solution
– Machine learning applied to ~70,000 fault events
– Resulting optimized algorithms embedded in SIPROTEC™ protection relays
– Real-time streaming and interpretation of grid data

Outcome
– Considerably improved reliability of locating faults
– Faster recovery times, reduced maintenance cost
– Enabling large-scale integration of solar & wind

Benefit for Siemens
– **Enhancing the electrification & automation portfolio – expanding leadership**

Artificial Intelligence in Factory Automation
Machine Learning on PLCs

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Motivation
- Todays control code on PLCs does not adapt during run time.

Key questions
- Can control programs adapt to changes in the environment automatically?
- Can Machine Learning algorithms run on PLCs?

?!

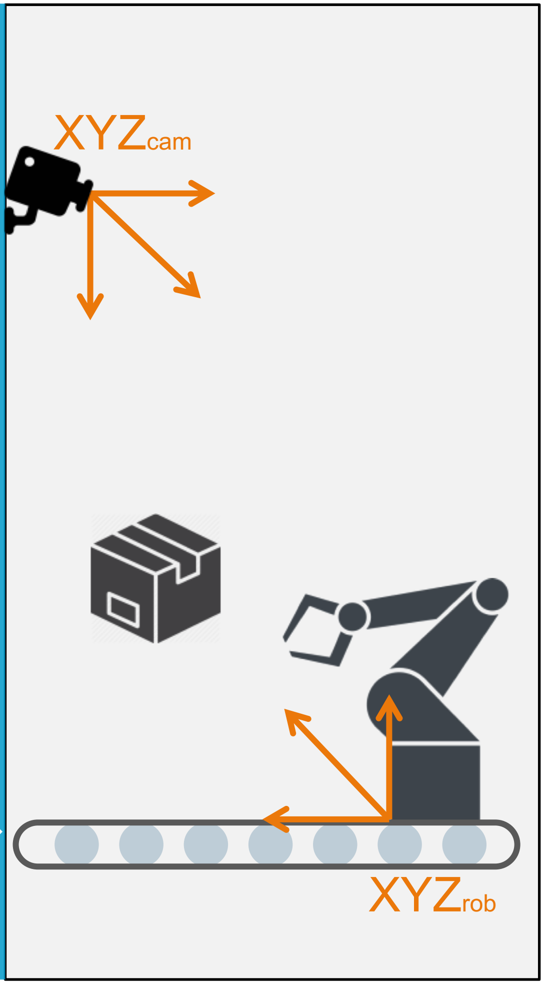
Proof of concept
AI Approach:
- Online Learning on the PLC to auto-calibrate a robot-camera system

AI Training:
- Constantly updating the parameters of a control program on PLCs

AI Execution:
- Run the program on a PLC

Results
- Yes it worked!
- PLC code can adapt, for example, to camera position changes

Future Potential
- Reducing programming efforts and making control logic more robust towards changes in the environment



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Artificial Intelligence in Factory Automation
Executing AI on PLCs

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Motivation

- Today control code on automation controllers is programmed manually

Key questions

Is it possible to:

- Generate control logic w/o human input just via high end Machine Learning?
- Deploy that on a standard PLC?

Proof of concept

AI Approach:

- Learn from simulation (Pong computer game)

AI Training:

- Developing of Deep Learning Network w/o any pre-knowledge or engineering

AI Execution:

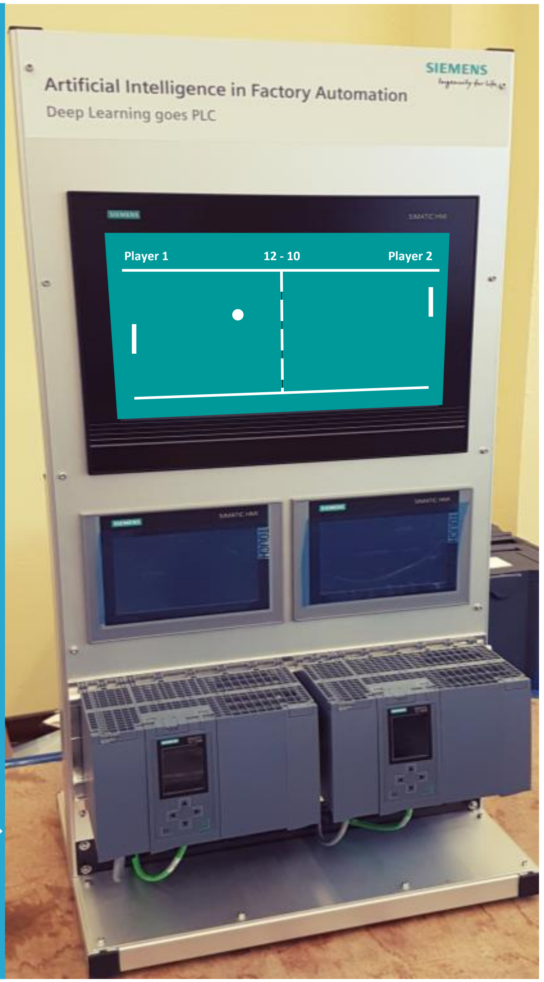
- Deploy Deep Learning model to a S7-1518

Results

- Yes it worked!
- PLC Code created from observations w/o any programming
- Two S7 PLCs play against each other

Future Potential

- Reducing programming efforts towards zero engineering



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Artificial Intelligence in SIMATIC

Benefits of AI using an example

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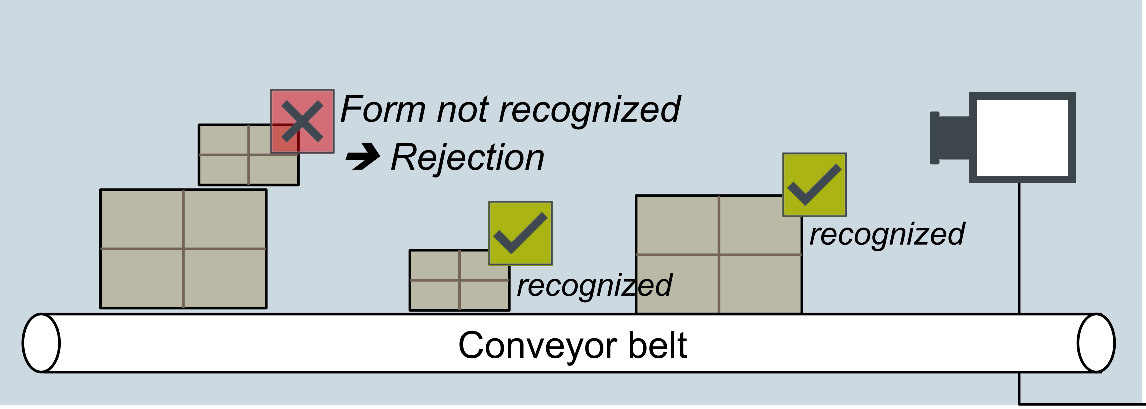
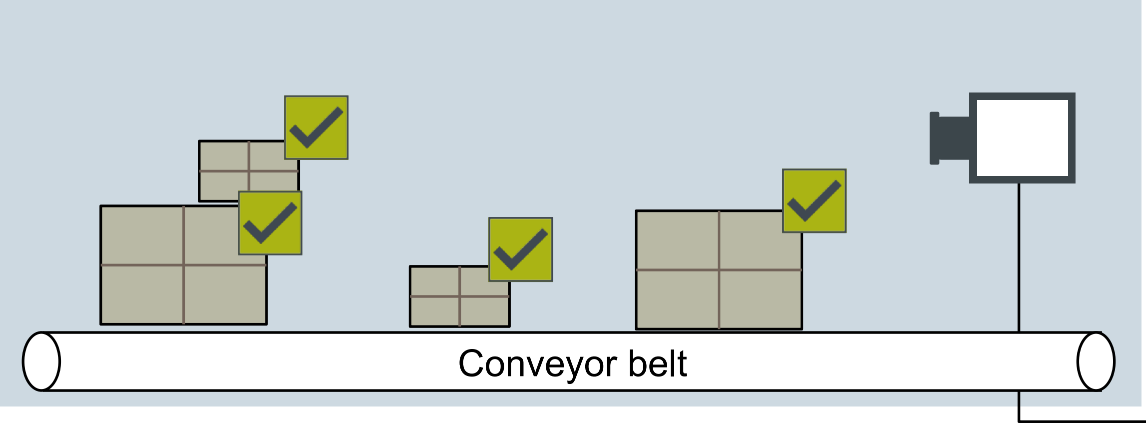
Conventional object recognition

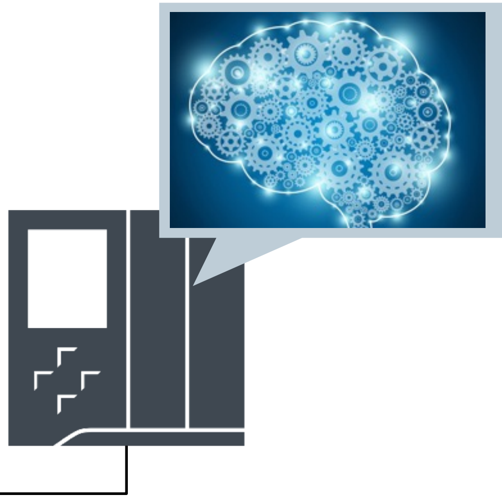


Properties

- Processing of data via programmed image capture system
- Each object to be recognized has to be precisely defined (deviations = rejection)
- Time-consuming programming for new objects

In the future (with Artificial Intelligence)





Properties

- Processing of input data via neural networks
- Higher availability through detection of **complex patterns**
- Easier handling also of unknown objects

Industrial Edge

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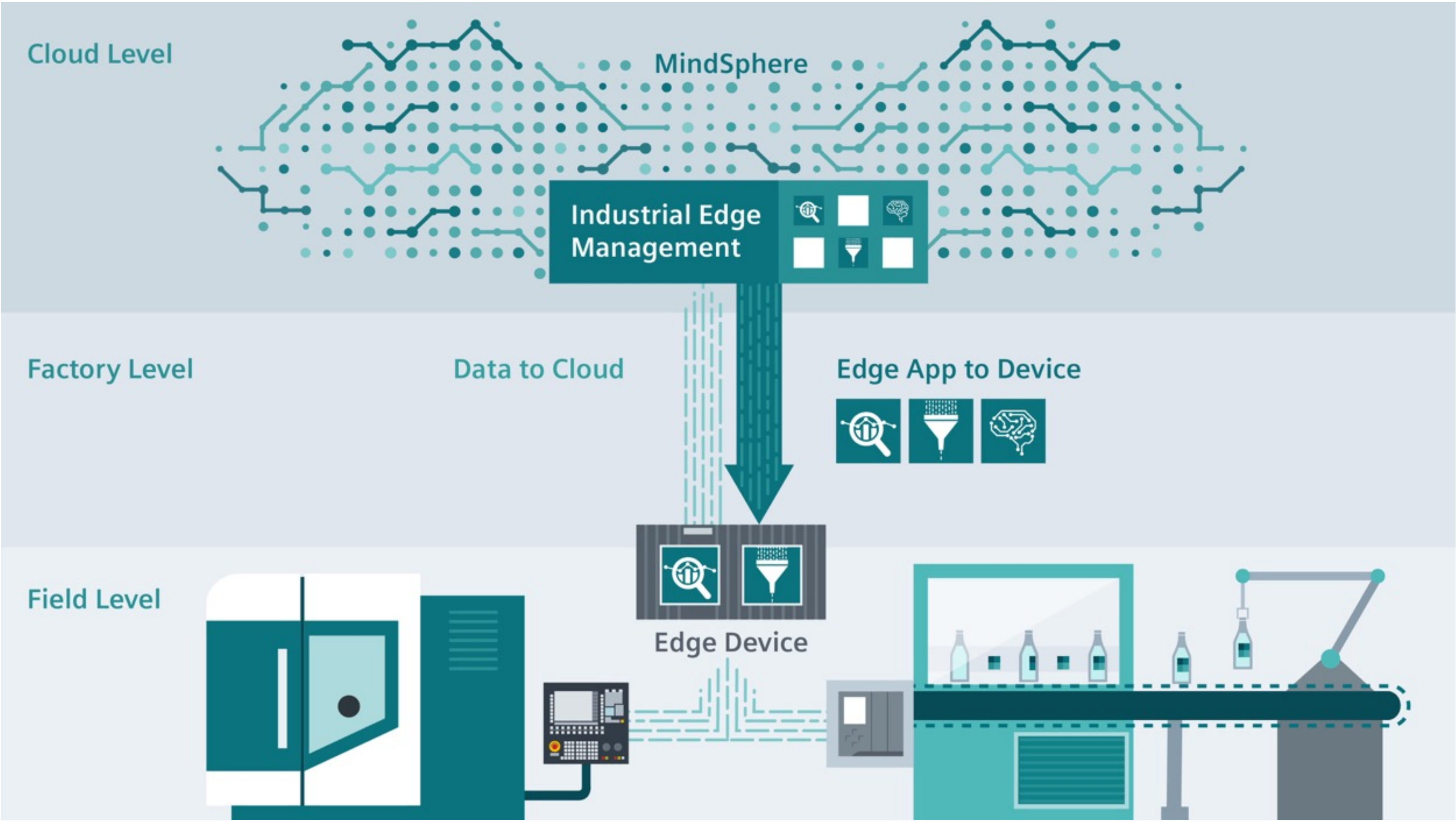
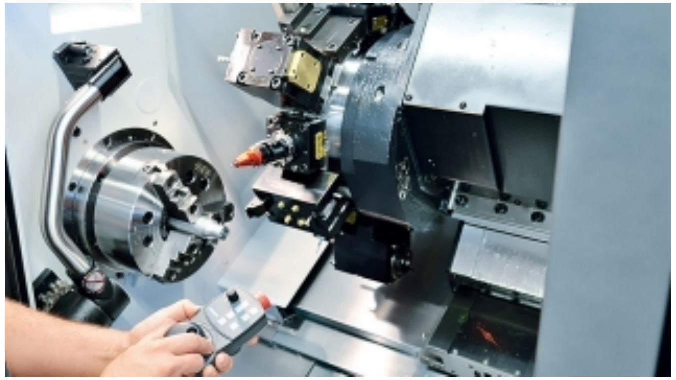
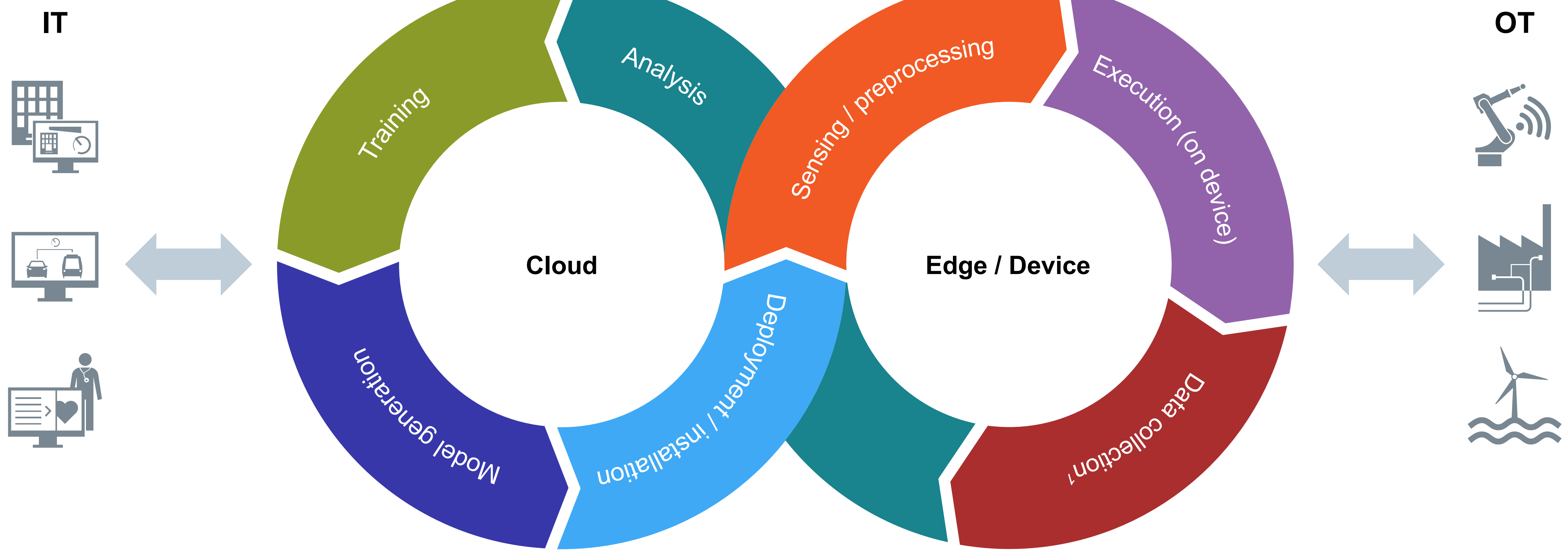
Industrial Edge combines local and high-performance data processing directly within the automation system





Machine Learning Lifecycle

Feedback loop allows model deployment on the devices and continuous refinement to bridge the gap between IT and OT.



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Our future portfolio will enable AI across all levels of Totally Integrated Automation - Best fit to customers needs

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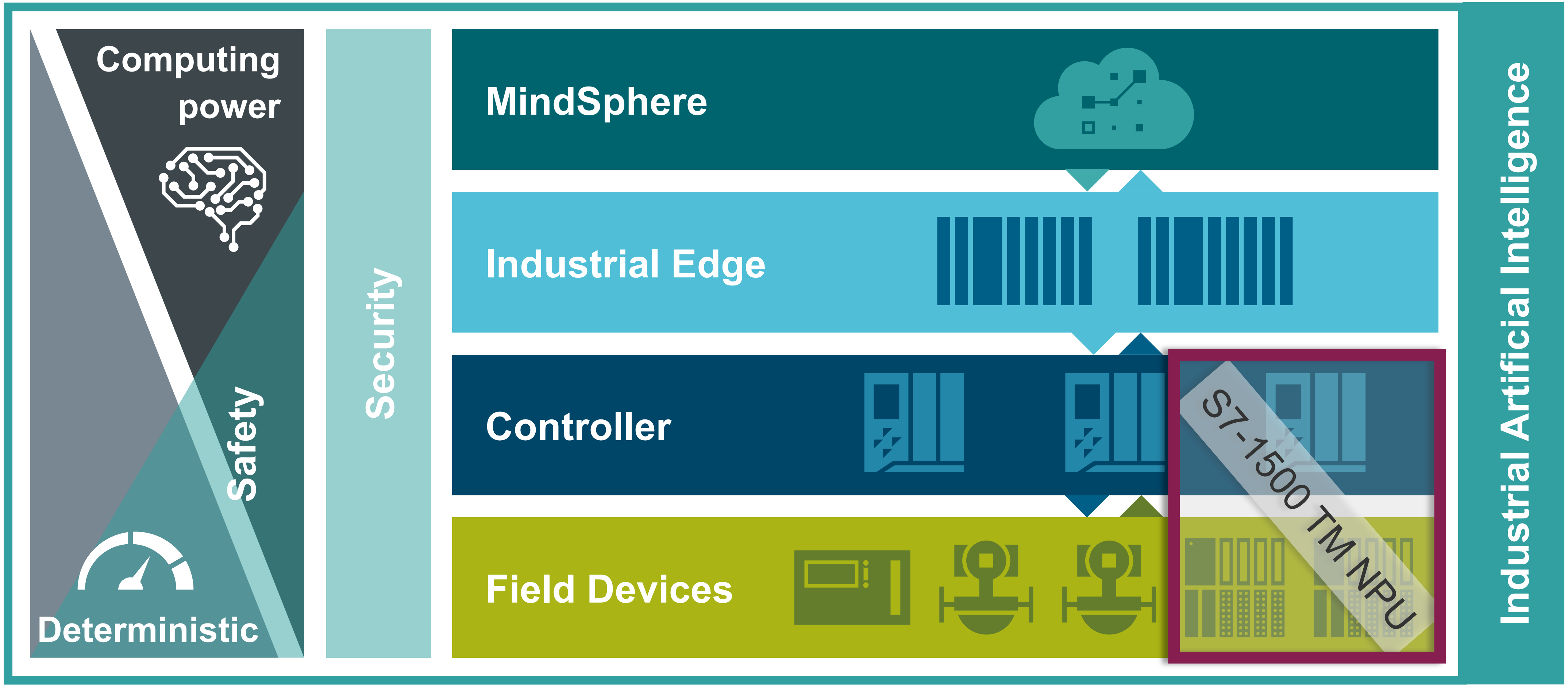

Artificial Intelligence in SIMATIC…

… realized via a new module for the S7-1500 / ET 200MP

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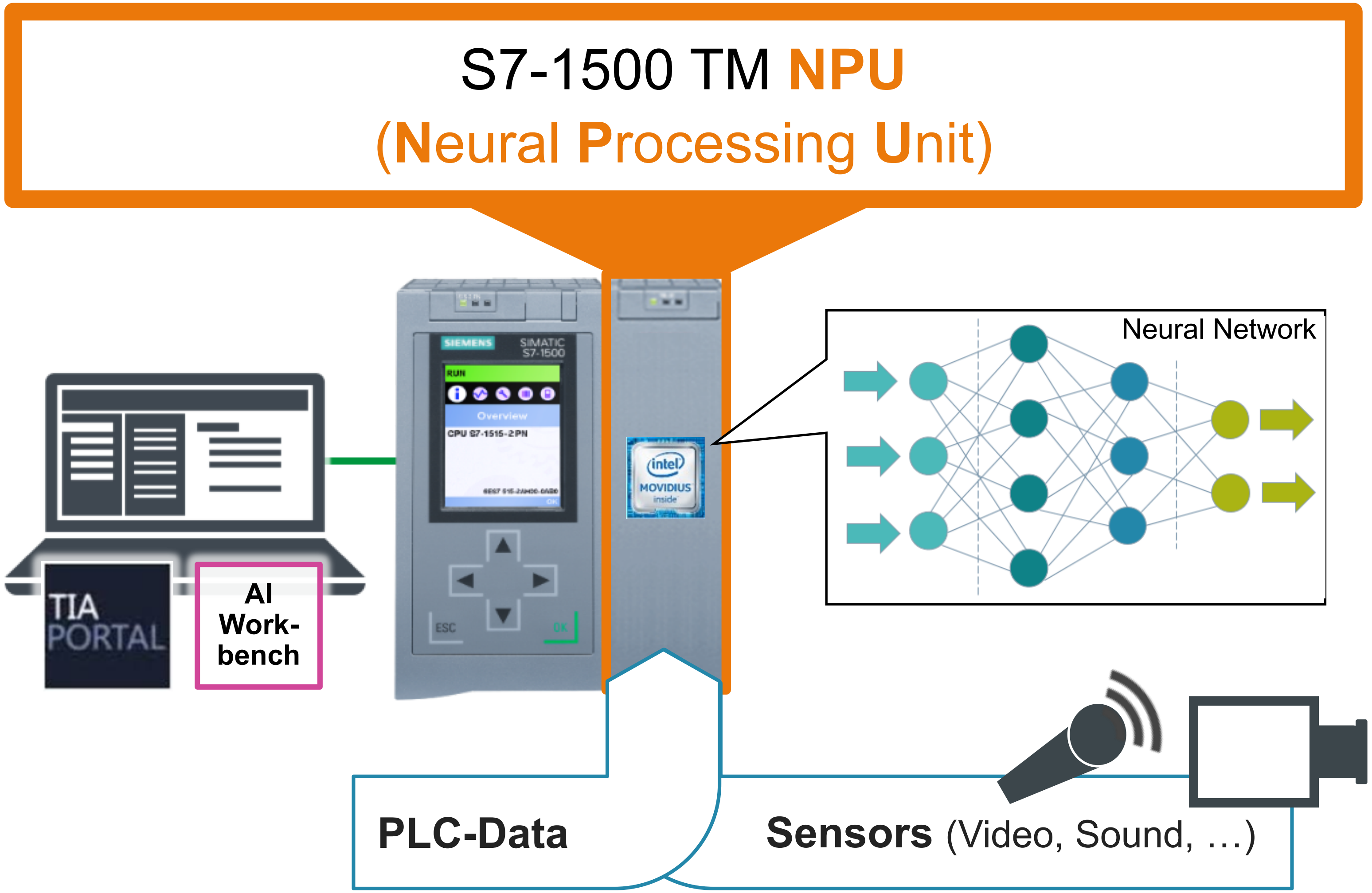

Features / Functions

- Integrated high performance AI-Chip
- Processing of input data (camera, sound, CPU) via trained neural networks
- Connection of sensors via USB and Ethernet interface
- Engineering and handling via TIA Portal and AI Workbench

Artificial Intelligence in SIMATIC S7-1500/ET 200MP
Application examples

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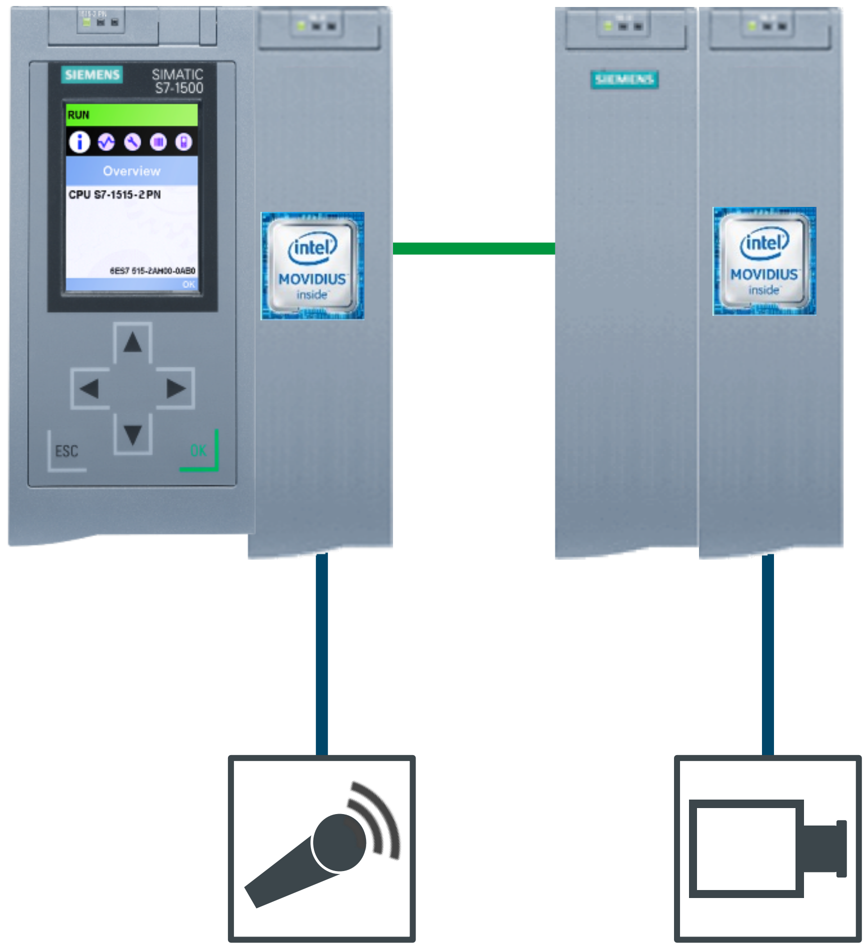
Robotics:
Handling of **arbitrary and unknown** workpieces/ objects recorded via camera

(Visual) quality control:
Application of human “**expert knowledge**” about the perfect consistence, color, texture etc.

- of a product (chocolate mass, metal, …)
- a process (flame color in a furnace)

Detection of process anomalies

Condition monitoring
(e.g. recording the sound profiles in paper plants)



Functionality using the example of the SPS fair model

Step 1: Object recognition & determination of possible grip points

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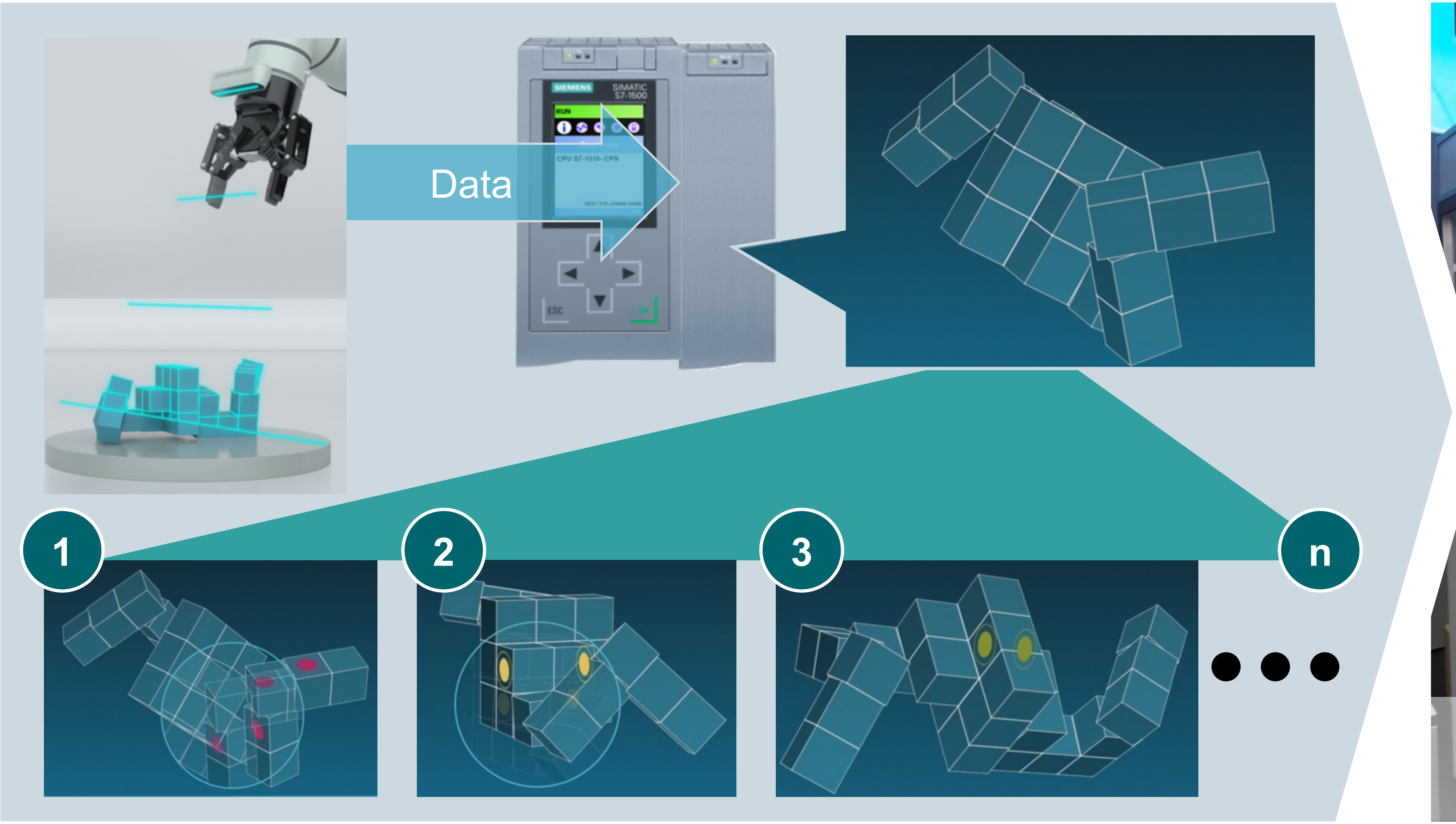
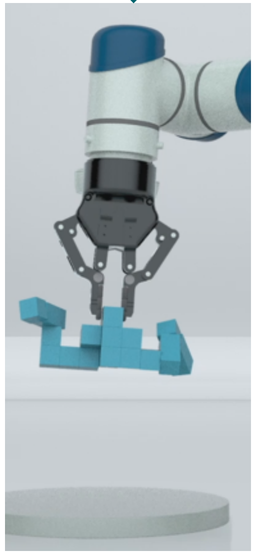
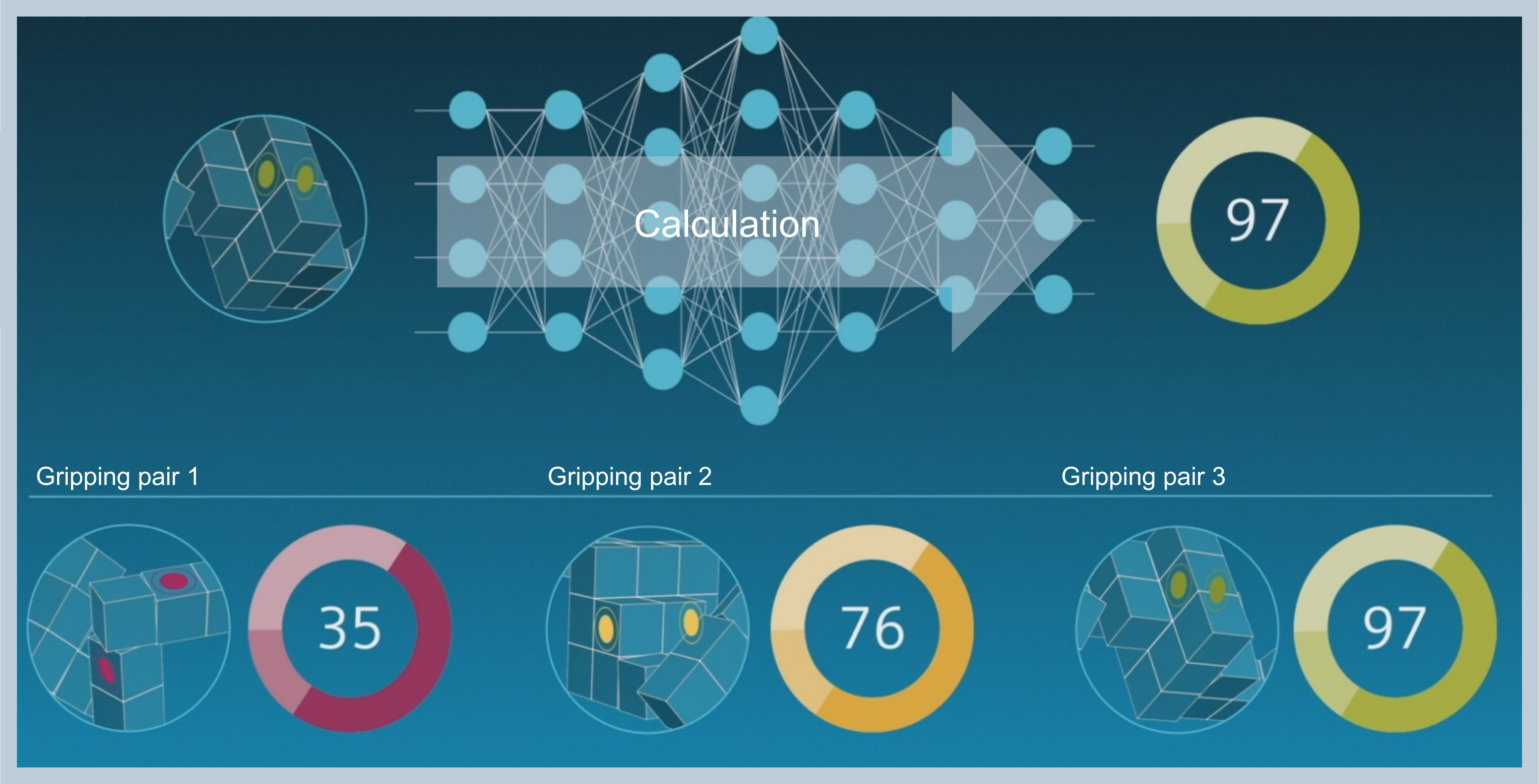


Functionality using the example of the SPS fair model

Step 2: Calculation of the best grip variant





Thank you for your attention

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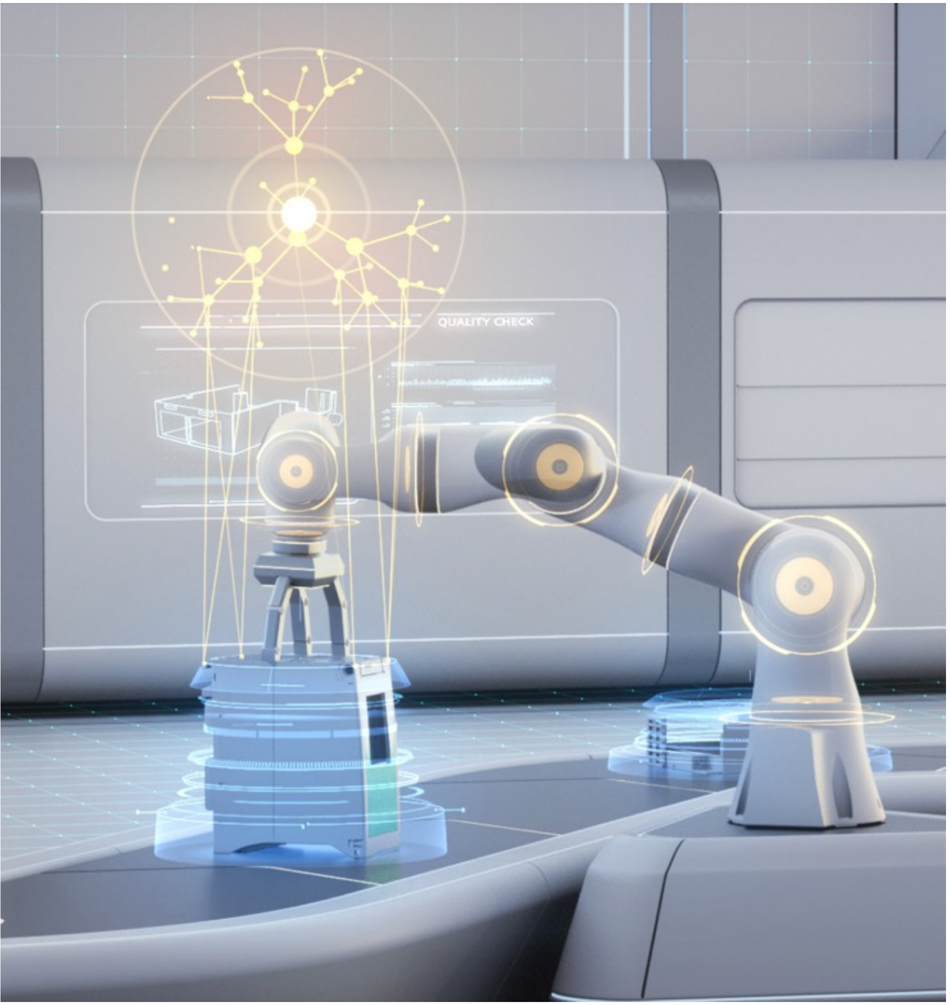

Ingo Thon
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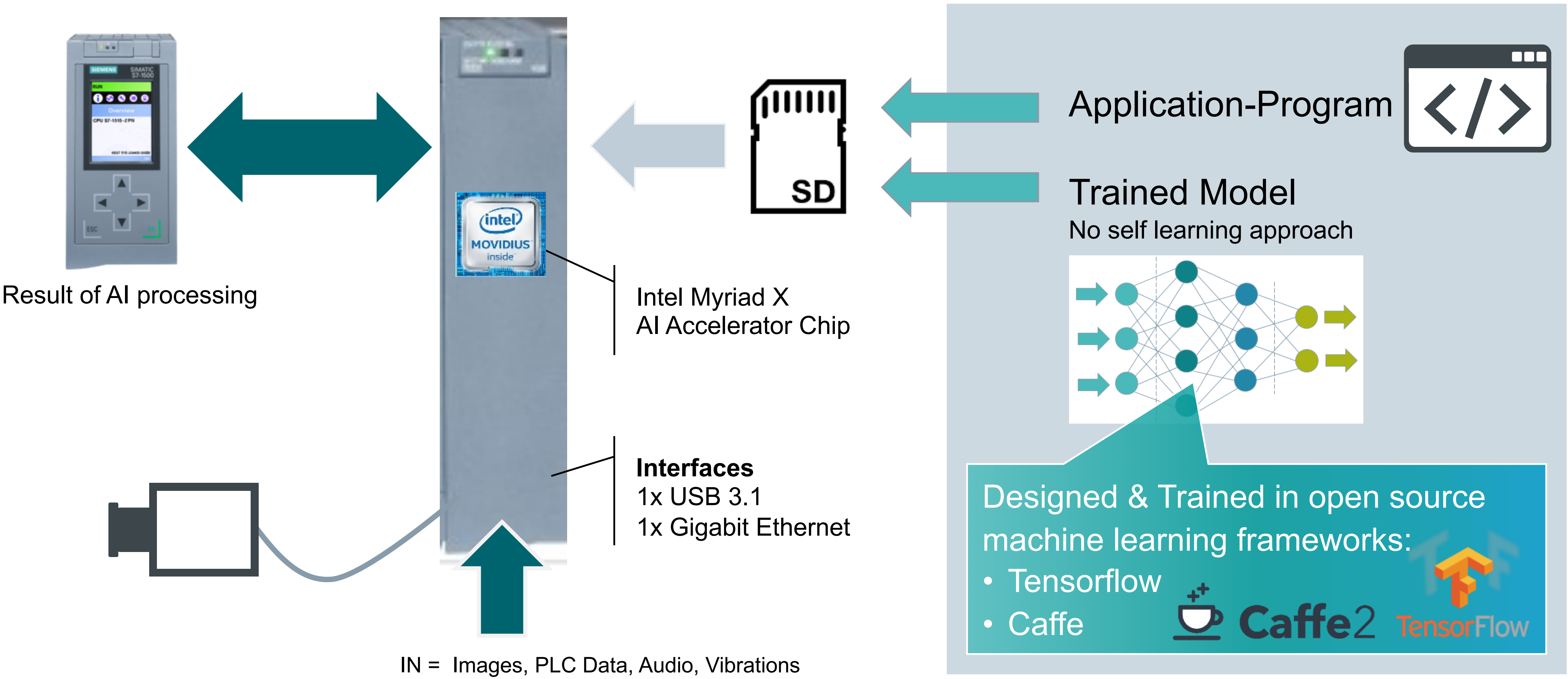
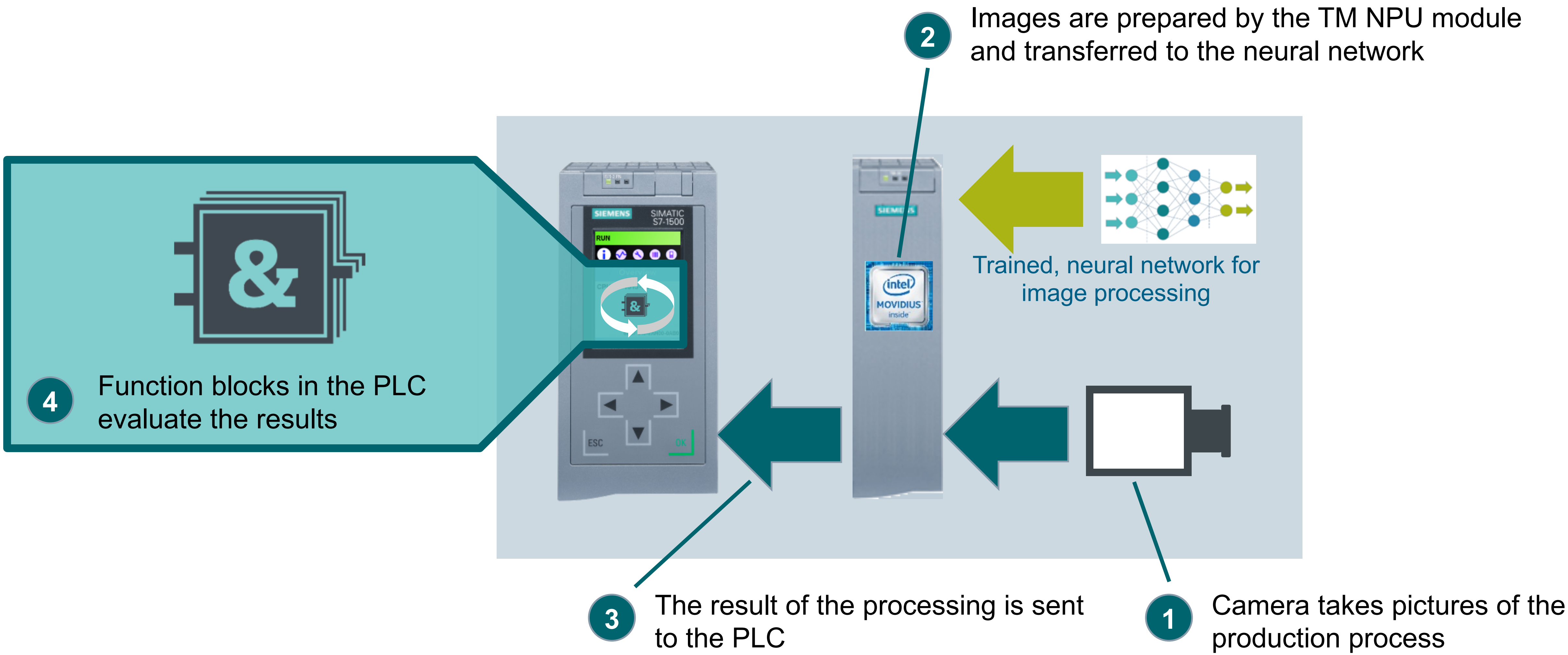
Senior Key Expert Machine Learning

Artificial Intelligence in SIMATIC
Technical concept



Artificial Intelligence in SIMATIC

Applicability: Image processing



Artificial Intelligence in SIMATIC

Applicability: PLC data analysis

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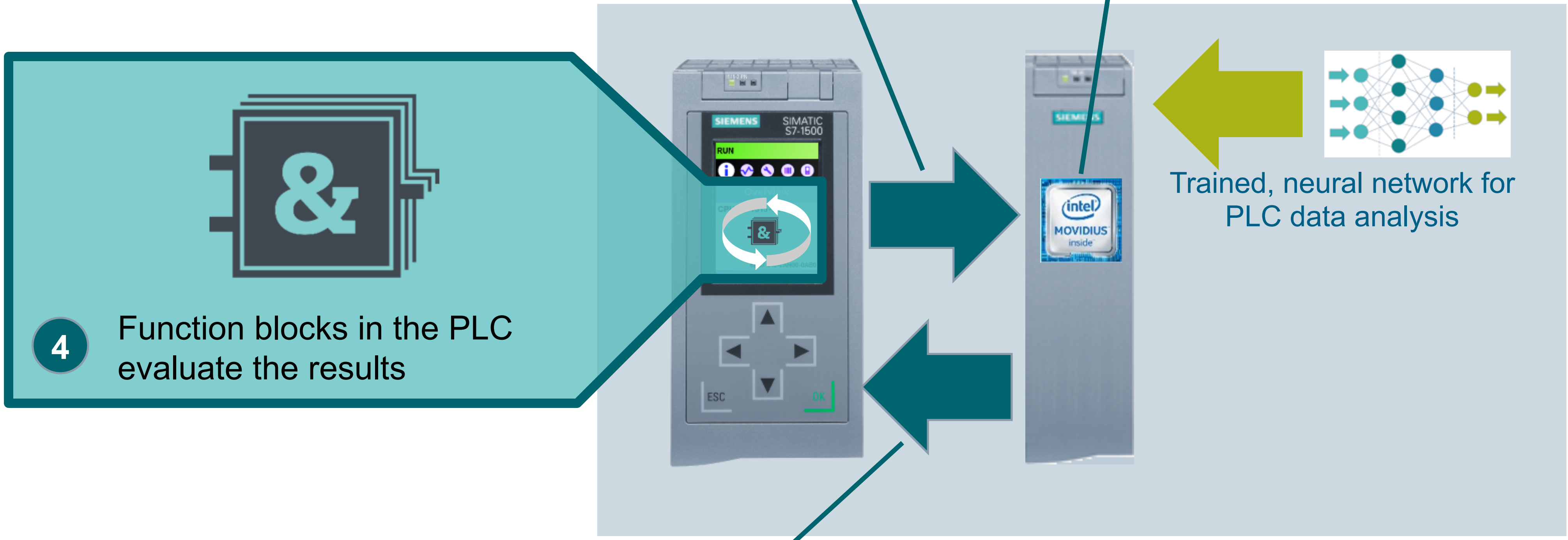
1 Data of the PLC (sensors, drives, …) are sent to the module

2 PLC data is transferred from the TM NPU module to the neural network



3 The results of the processing is sent to the PLC