Chair Information Management in Mechanical Engineering

Artificial Intelligence in Automotive Production

3. Fachkonferenz: Roboter in der Automobilindustrie
Stuttgart, Germany, 29th November 2017

IfU IMA ZLW RWTH AACHEN UNIVERSITY

Human-like Abilities: What‘s new, Atlas?

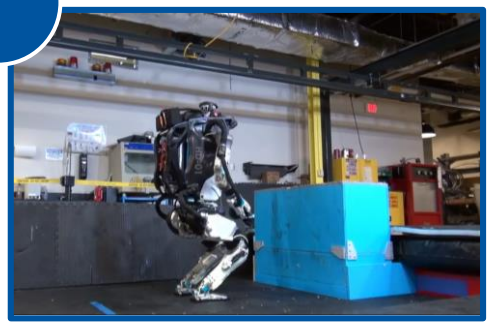
New Evolution of Robotic Systems: The Atlas-”Acrobat”

Atlas in a nutshell:

- **Mass** of 75 kg and 1.5 m **height**,
- enabling a **payload** of 11 kg

His parts:

- Battery-driven **hydraulics** of 28 joints
- LiDAR and Stereo **Vision**
- Based on 3D printing



His abilities:

- Athletic capabilities
- Logistic works
- Construction works
- Vehicle driving

Automation vs Flexibilization

“How to Survive a Robot Apocalypse: Just Close the Door”

Wall Street Journal on Nov, 10th 2017

- The systems are based on complex but static automation technology
- Human-enabled evolution of the robotic system

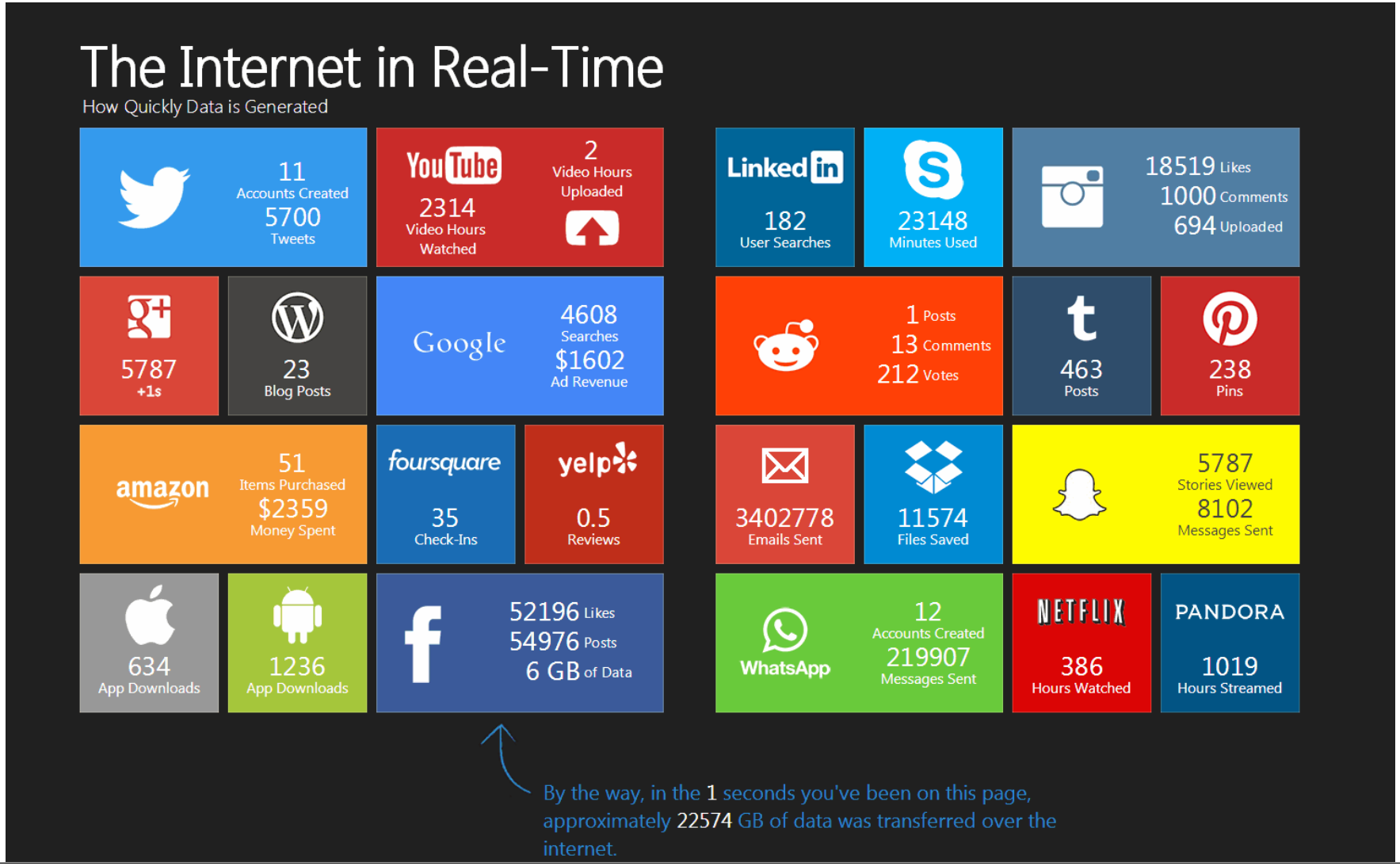
To be honest: Atlas Main Purpose lies in Search and Rescue …and in Industrial Environments e.g. in Automotive?

- High variety of final products: approx. 3-4 of the same car variant p.a.
- …leading to an even bigger number of assembly groups in production

→ **Learning and data-driven approaches**

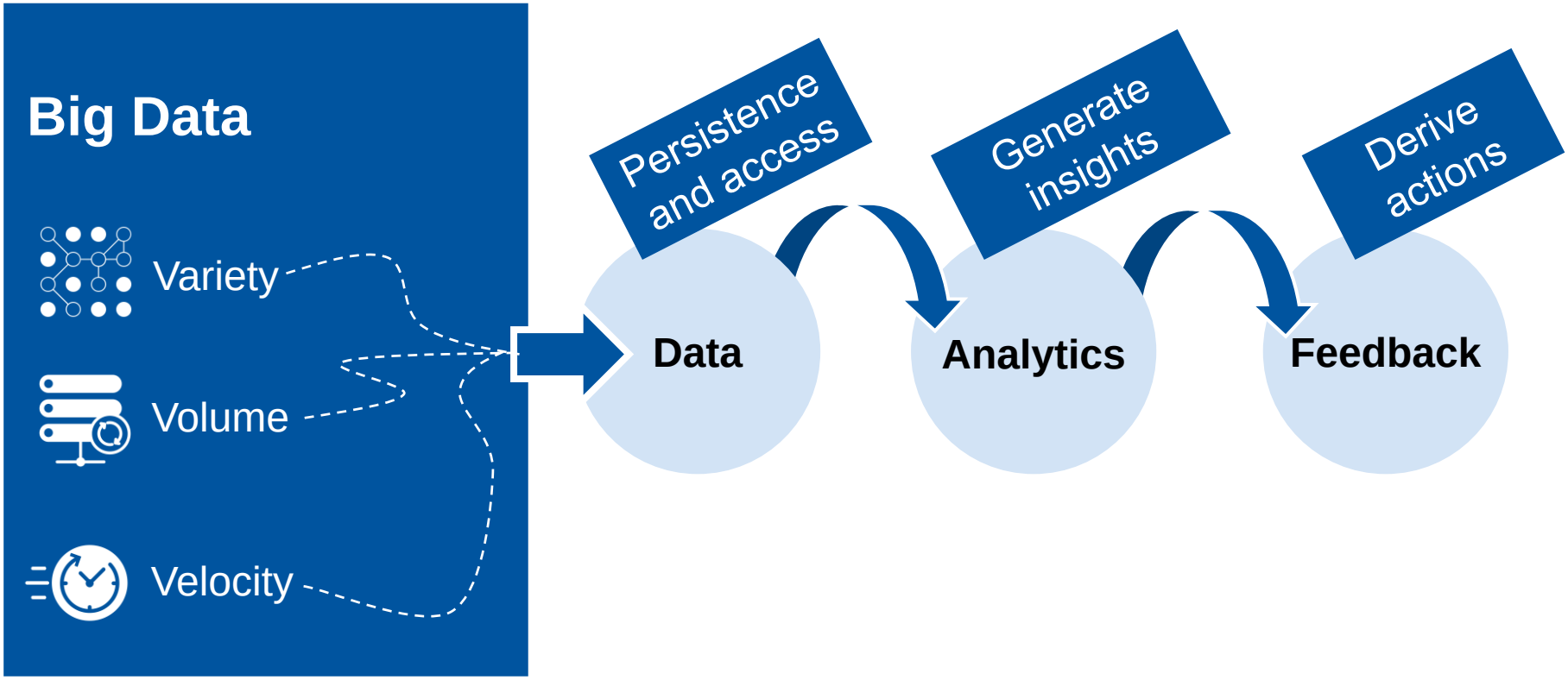
I. From Data Generation and Data Lakes…

From Data Generation and Data Lakes…
The Digital Age: Big Data Human-made…

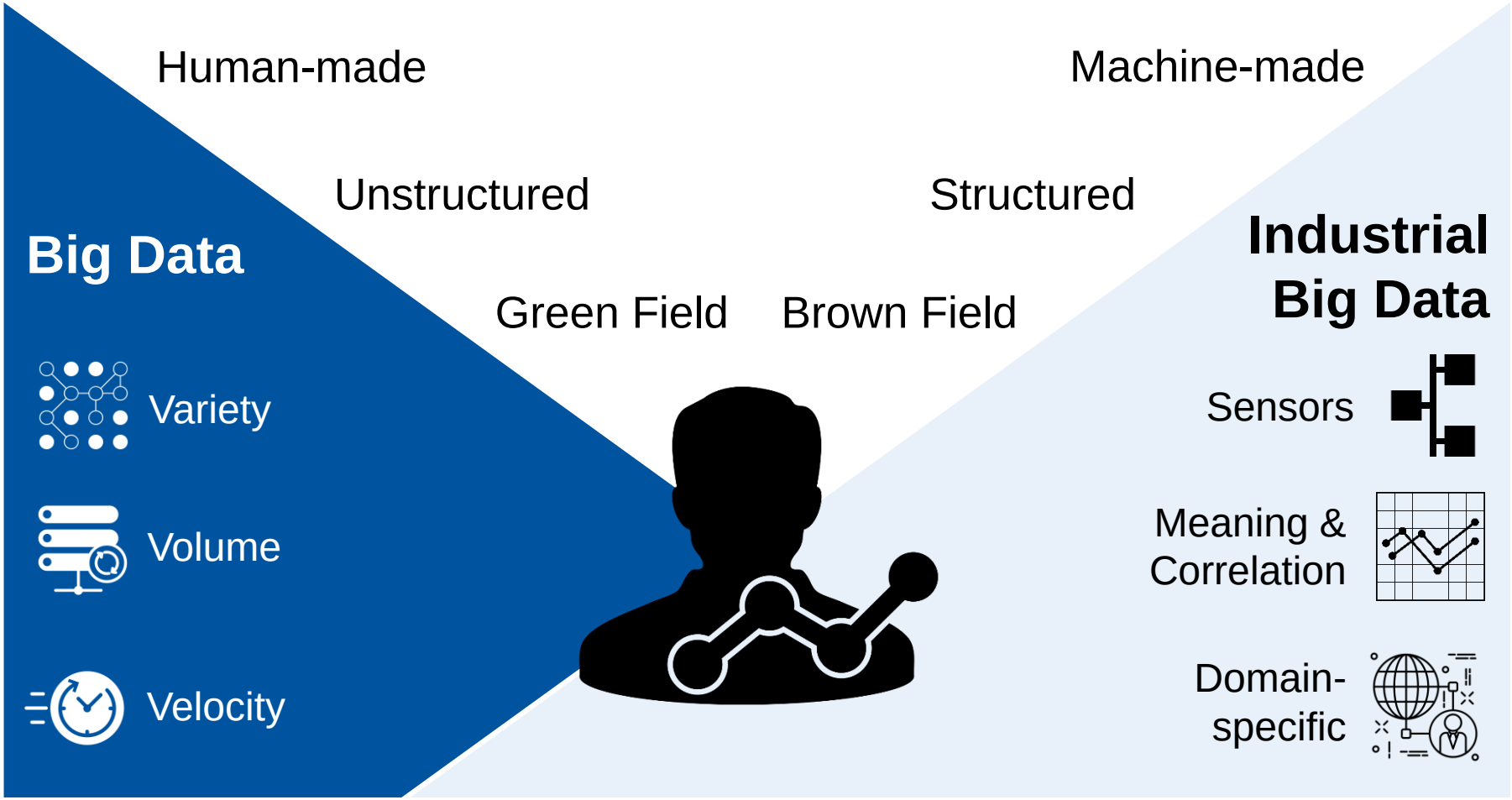


From Big Data to Insights

Key Elements of ‘Big Data‘?



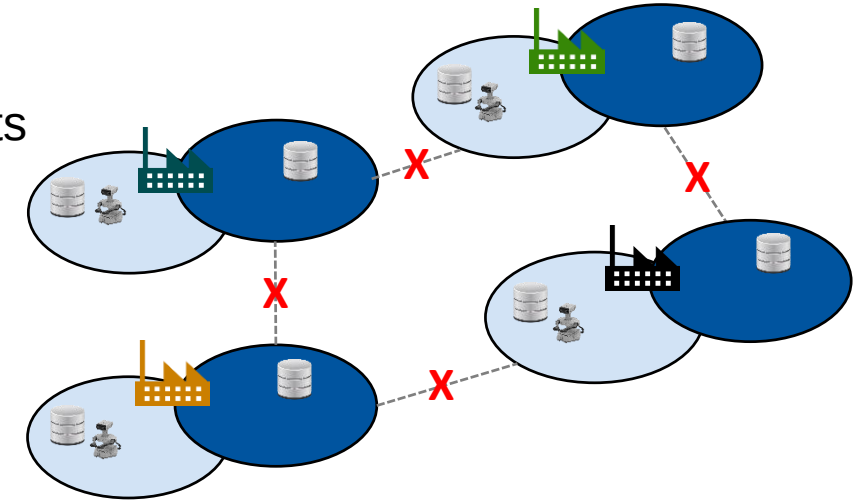
Big Data in an Industrial Scope



Initial situation and objective for a so-called Data Lake

Initial Situation:

- Many different data systems in different nets and positions
- Isolated stand-alone solutions enable only specific local data access
- No transparency over locations
- Optimization potential of an integrated perspective



No integral data view possible!

- Necessity of creating a cross-plant, continuous data storage for usage in a downstream process optimization and further analyses.
- Continuous data-driven process through self-learning optimization methods

Modular, schema-based Big Data integration pipeline

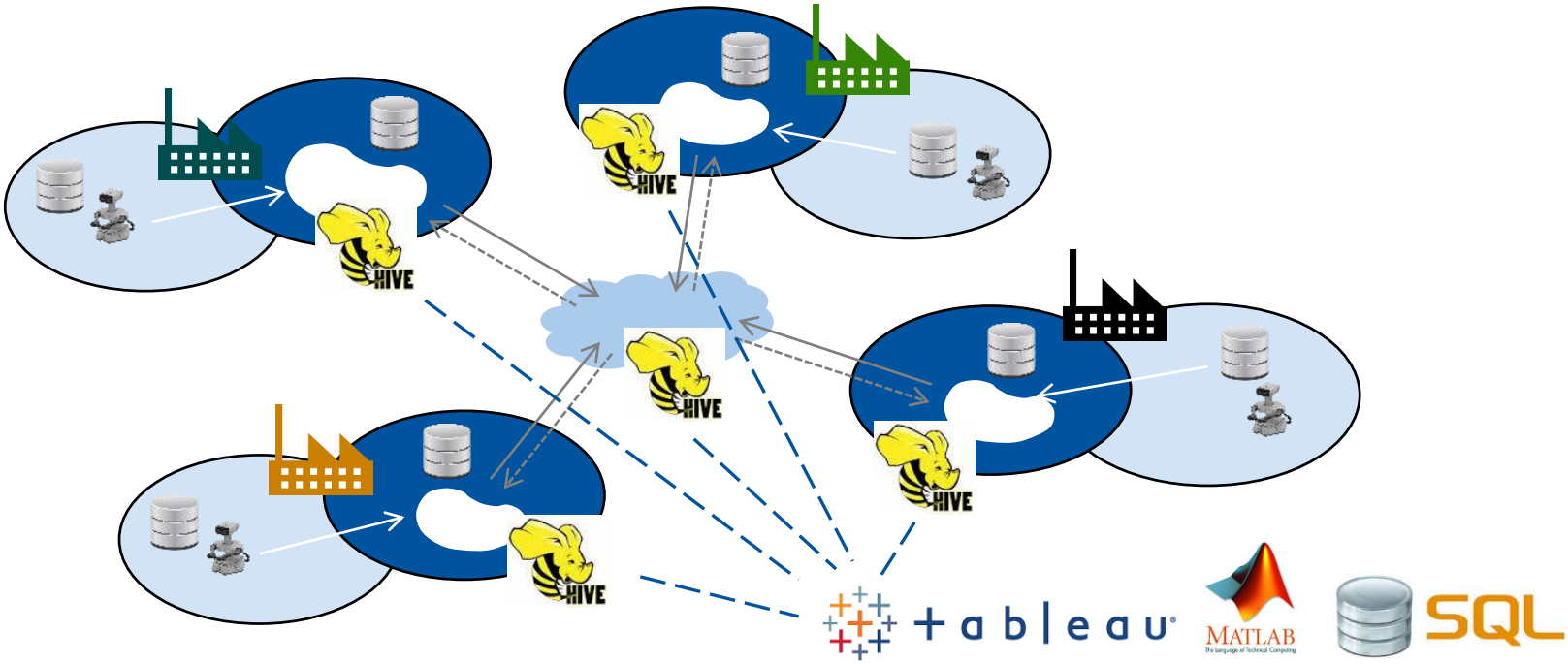
Results

- **Live operation** since more than **twelf months**
- Successful connection of **four plants** and **30 data sources** (increasing)
- **Configurable Connector-Modules** allow a connection of different data sources:
- **Batch-** as well as **streambased data integration** possible
- **Automatic metadata enhancement** (schema description) of all incoming data
- Complete **technology-stack** based on **Open-Source Software**

Hybrid Integration

Data Lake

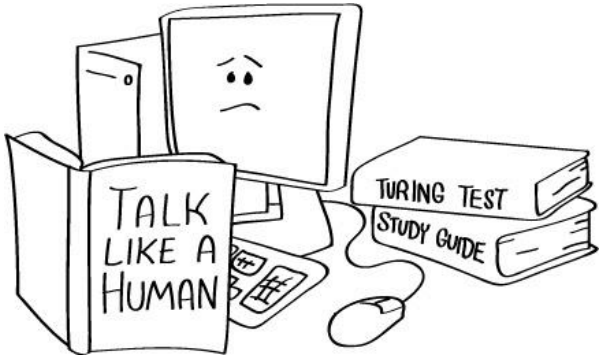
Analytics:
Provision of joined data bases for data analysts. Access through common access methods (SQL) and tools.

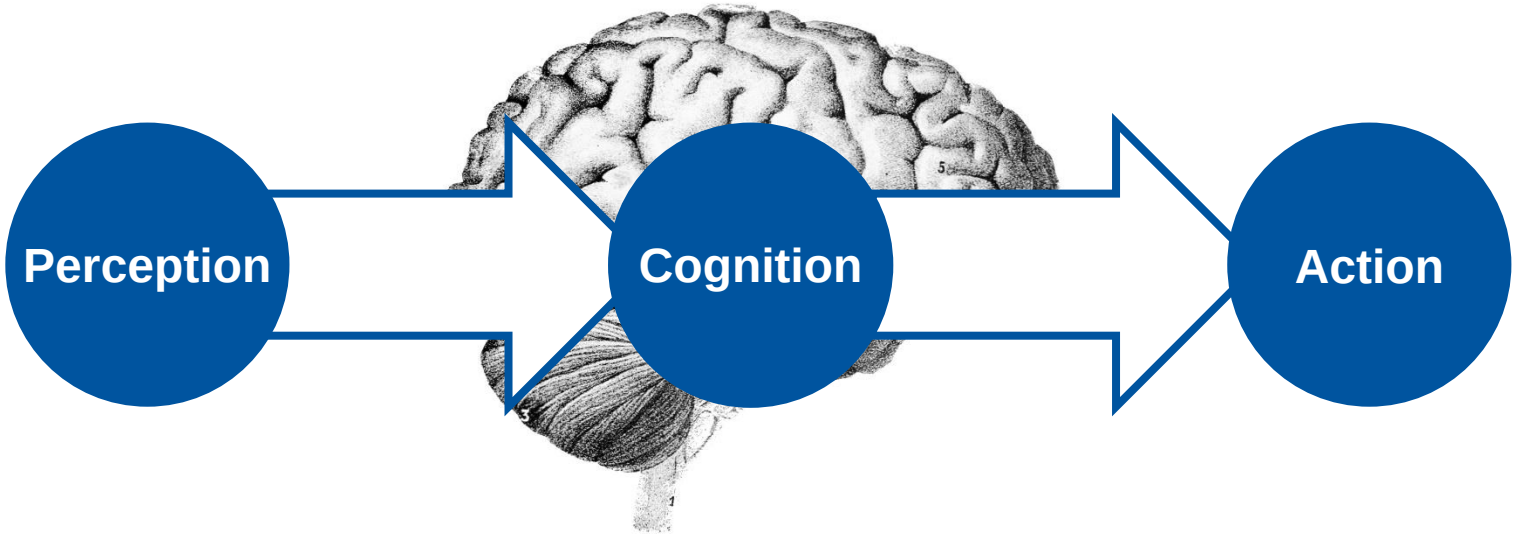


II. …towards Data Analytics and AI.

From stupid to intelligent systems

What is necessary to turn a system into an intelligent one?





What is necessary to turn a system into an intelligent one?

Do you remember space invaders?

1. **Perceive** the current situation, the **state**, of the game.
2. **Analyze** and **evaluate** the current state.
3. **Determine** a suitable **action** to maximize the outcome (by creating a new “better” state).

How do we get artificial intelligences to act in such an intelligent way?

- In the beginning, we gave the system rules to evaluate a current state and decide how to act…
- … and it did not work!

Supervised learning – learning from labelled data

Using labelled data to derive models!

label: **apple**

label: **apple**

label: **pear**

label: **pear**

➔ Training data

➔ Classification model

classified as: **pear (94%)**

classified as: **apple (62%)**

Problem: You need labelled data!

Unsupervised learning – what if we cannot provide labels

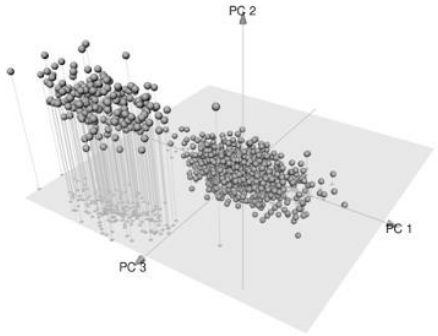
What if we do not know about a categorization or existing structure? Or, if an observation is good or bad?

➔ Finding the hidden structure (patterns) in data.

"Although it may seem somewhat mysterious to imagine what a machine could possibly learn given that it doesn't get any feedback from its environment, it is possible to find patterns in image data using probabilistic techniques."

Zoubin Ghahramani, Professor of Information Engineering at the University of Cambridge, Machine Learning

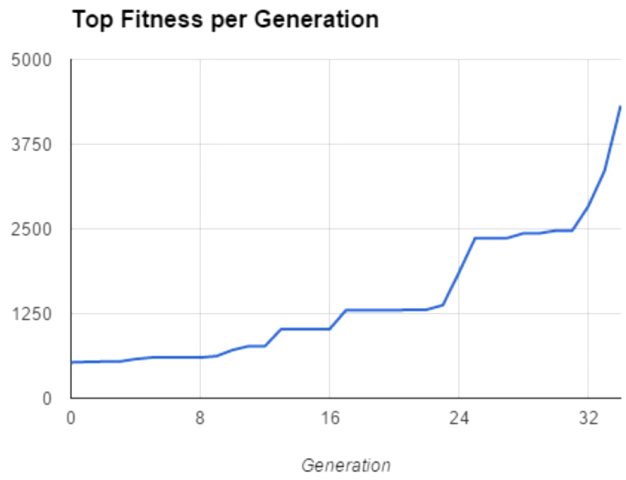
Batch of unlabeled pictures



Cleansing, preprocessing
and
hierarchical clustering

From data to reinforcement: Using rewards to learn good actions

Remember your childhood hero Mario: What if the machine could learn, how to solve a level? Why not use a some kind of intelligent trial-and-error?



Neuroevolution of augmenting topologies (NEAT) [Stanley, 2002]

- **Genetic algorithms on top of neural networks.**
- At each **state** the system decides what **action** to perform.
- Actions are **rewarded** if Mario does not die in return.
- Level progress by **evolving** neural networks.

➔ Reinforcement learning is inspired by behaviorist psychology – maximizing the expected return by applying a sequence of actions at a current state.

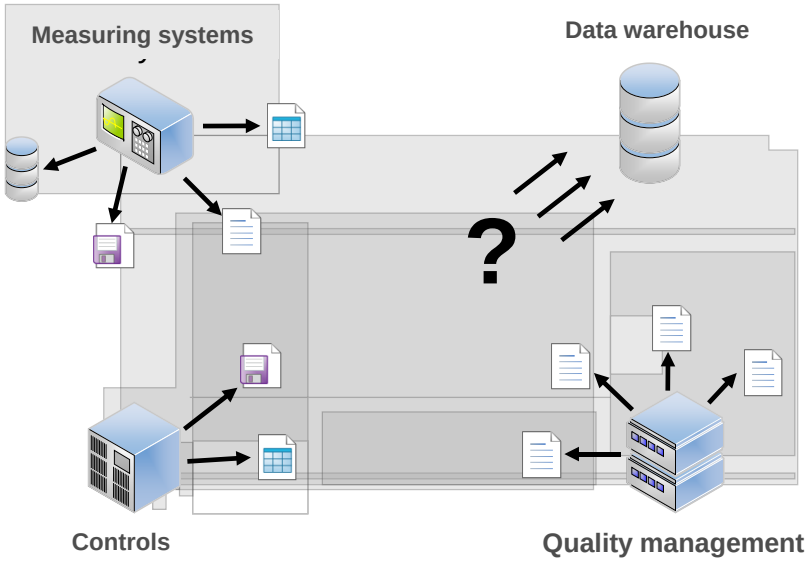
III. Artificial Intelligence in Production Technology by Example

Supervised learning in HPDC

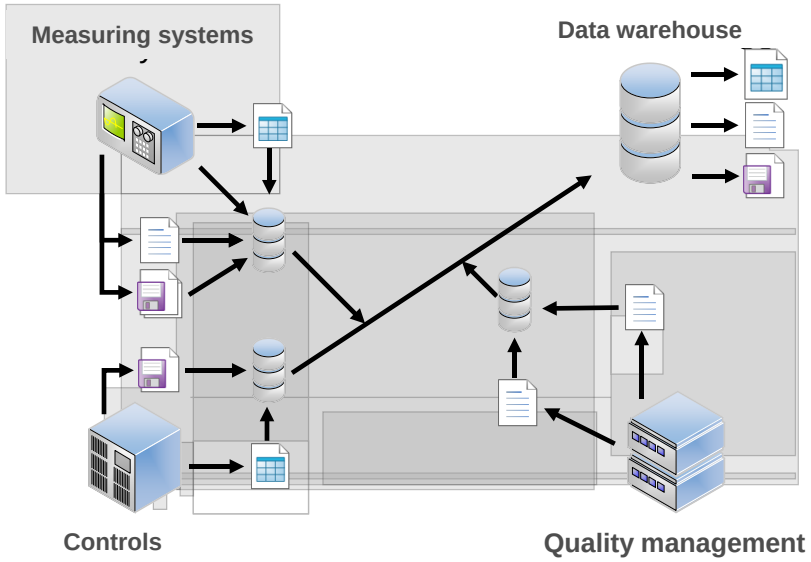
Using data mining and machine learning to improve prediction

First step

Gather, consolidate and store data for analysis and training – but this is a different talk ☺, but also a challenge.



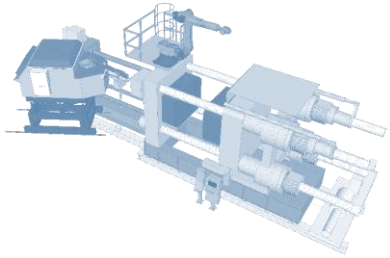
» Heterogeneous system architecture



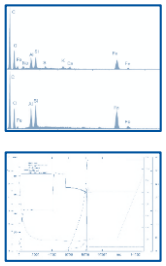
» Consolidated system architecture

Second step

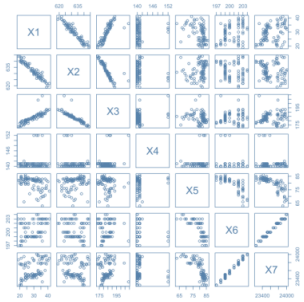
Analyse data and train suitable models to provide in-process decision support.



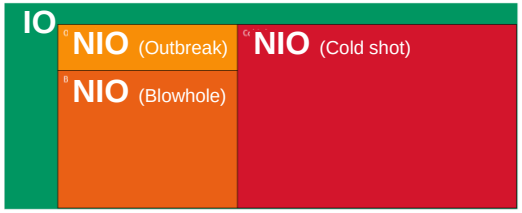
HPDC process measurements



Historical data
Process and quality data



Prediction model
Modelling and training



Visualization of predicted categories
Inline and web-based

Extension of the prediction model with additional data sources:

Acoustic Sensors
Fourier-Transformation & Feature Extraction

Extended Model
k-nearest and random forest tree

Weather Data
Temporal correlation

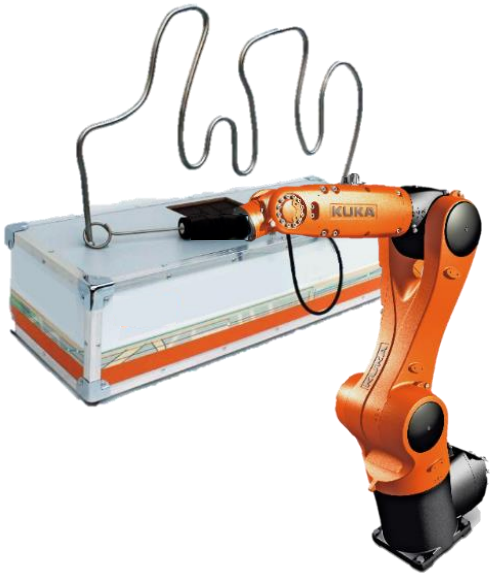
Cognition Enhanced Self-Optimization

in cooperation with

Reinforcement learning in robotics and production

Building an understanding of the potentials and difficulties of reinforcement learning algorithms for self-optimizing productions systems.

Working out the benefit of such a cognition enhanced robot in comparison to classical control engineering solutions.

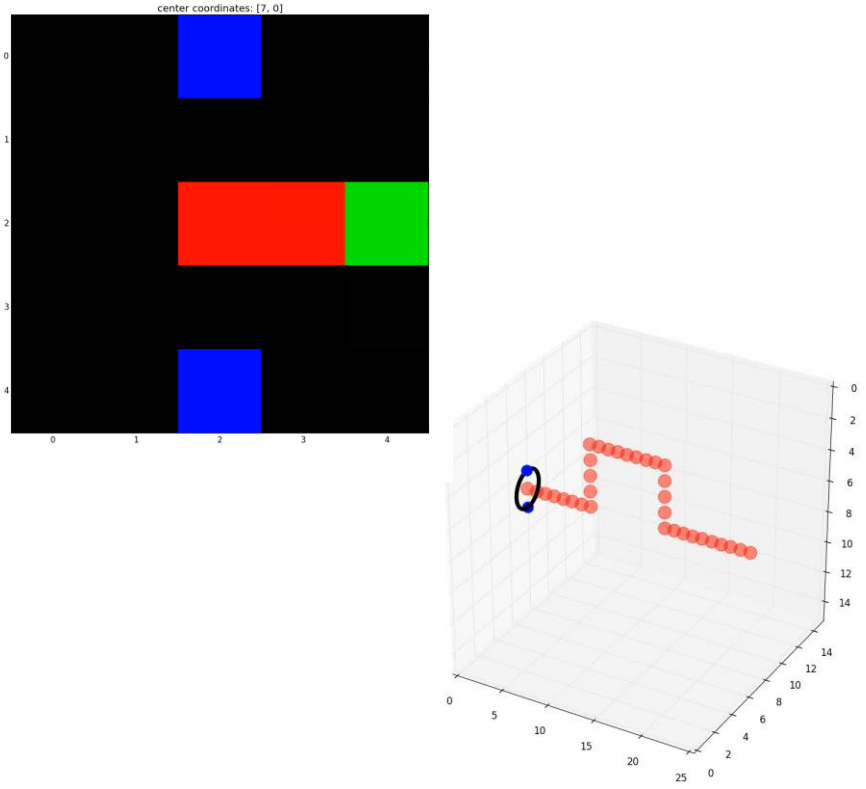


Transfer to production- and assembly processes

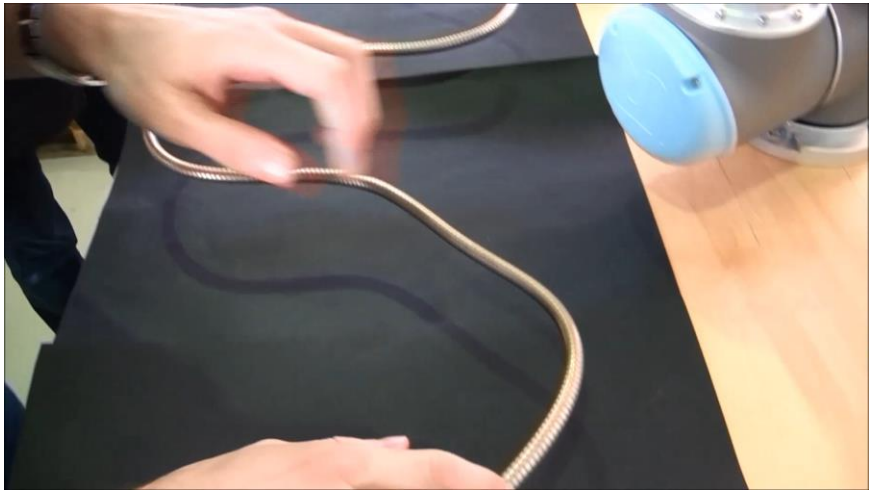
- Planning of fusion lines.
- Application of adhesive bonding compounds.
- Assembly of flexible components.

The hot wire game: Visualize the intention

Internal representation of the environment of the neural network…



…and real experiment setup

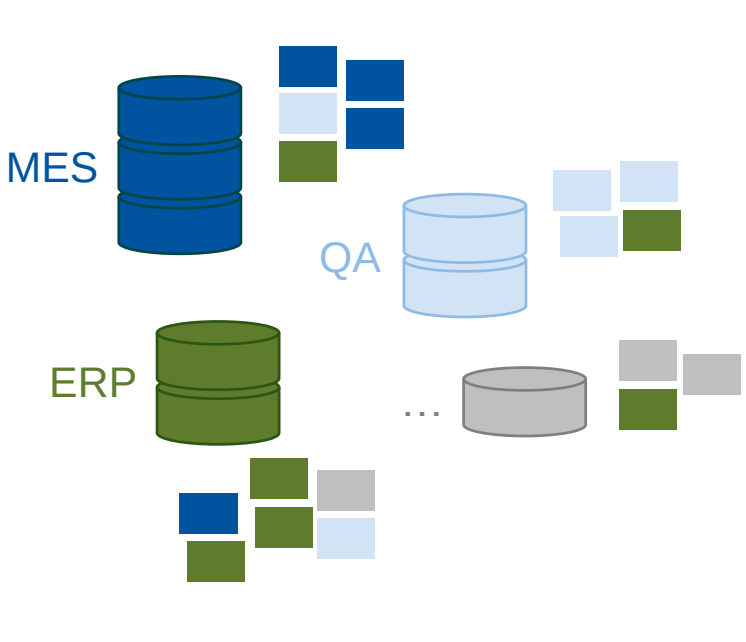


IV. Summary

Summary
The truth about production data

It is not only a problem of artificial intelligence!

Most of the time the first challenge is to realize the data availability and the IT-infrastructures.



Data is **distributed**, **heterogeneous** and **not available in general**

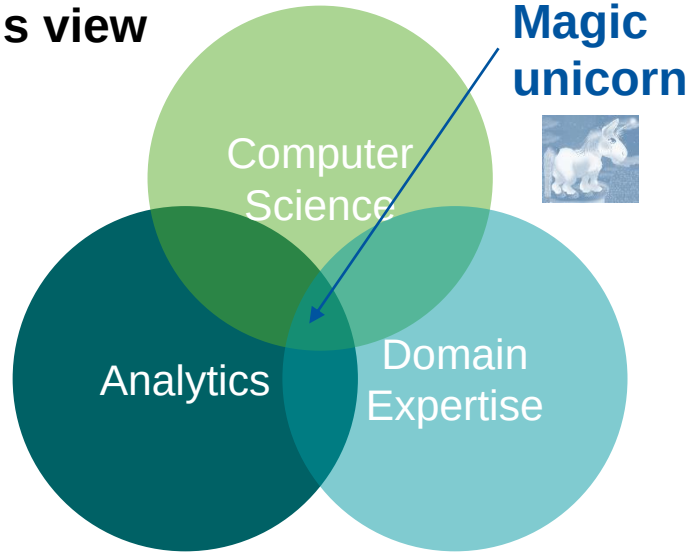
- **Supervised** and **unsupervised learning** require data to learn.
- **IT-infrastructure** or **cloud-based systems** providing the necessary **space** and **processing power**.
- **Most algorithms** are **hybrids** that **do not only rely** on **reinforcement learning strategies**.

The truth about data science and scientists

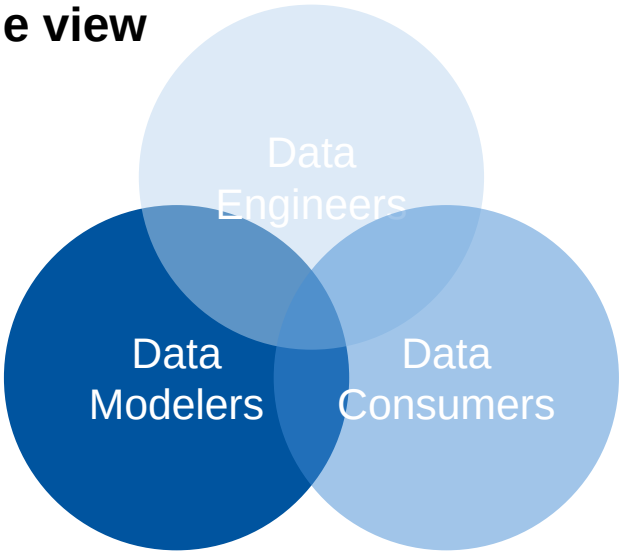
Data science cannot be done by one person!

Data science is an interdisciplinary science that requires experts working together - not on their own.

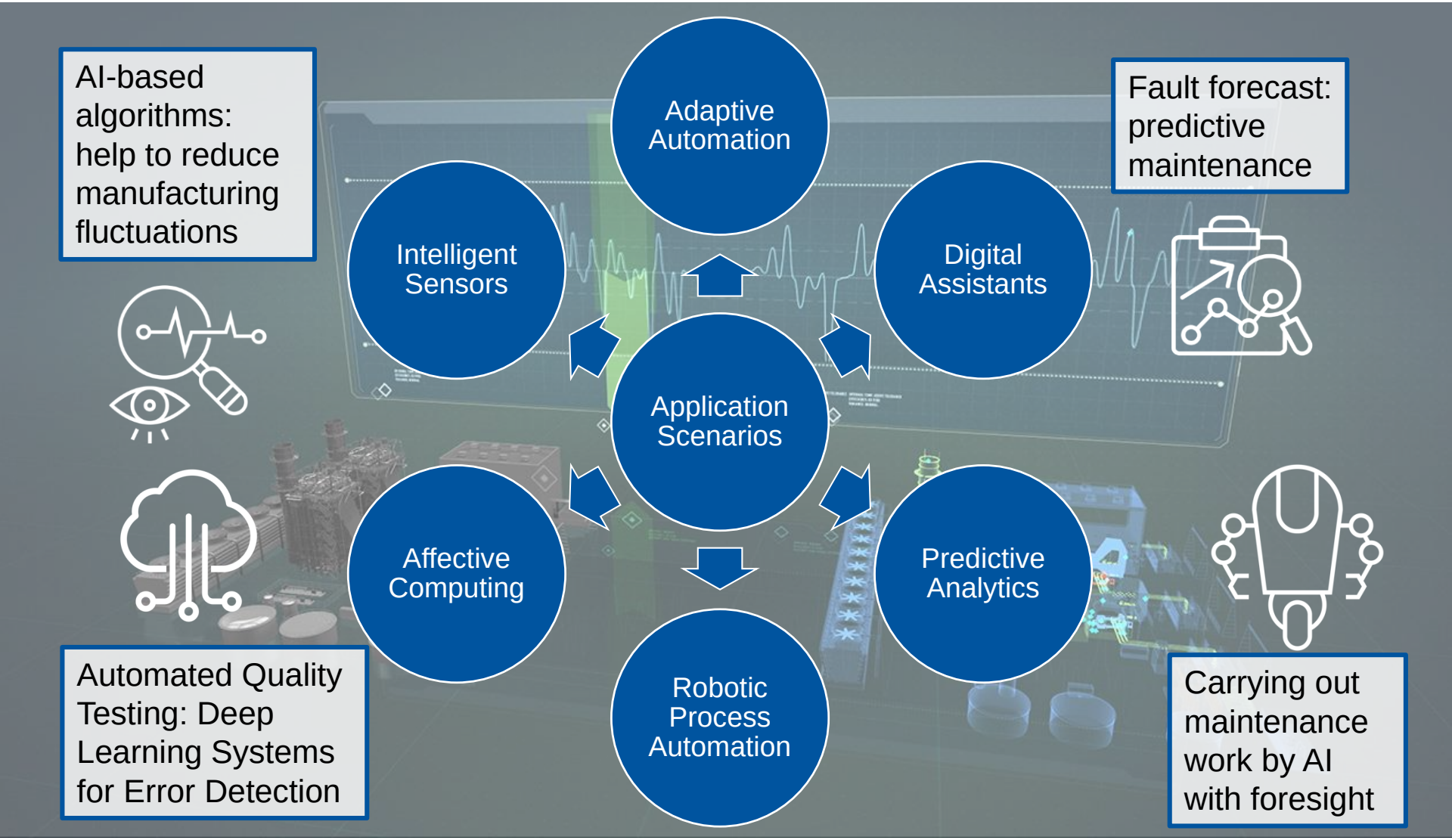
Skills view



People view



Summary
Future Fields of Application



Thank you for your attention!

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