Challenges that are specific to AI and ML in the Manufacturing Industry

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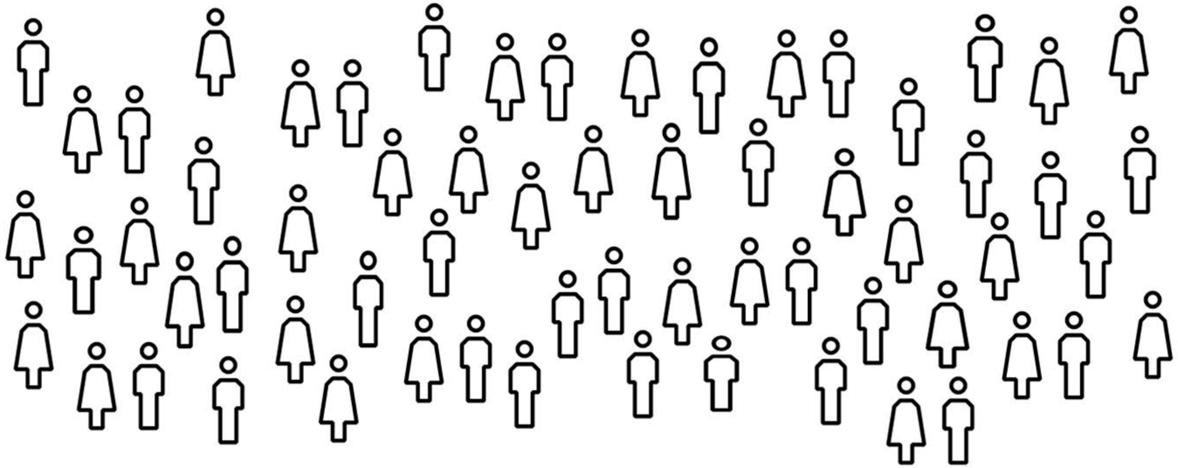
04.04.2019

Data from diverse industrial individuals
Industry is a zoo

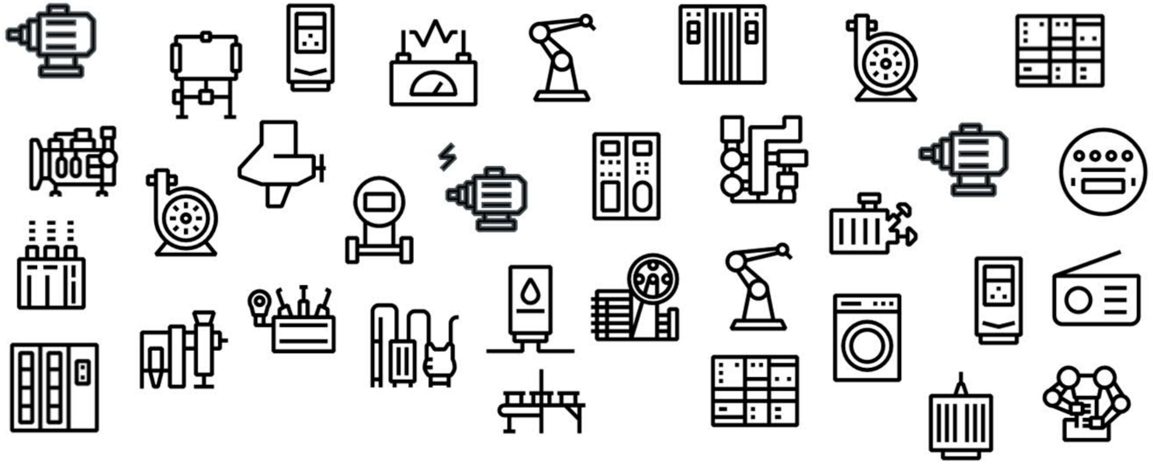
Consumer use cases: comparable individuals



Large number of individuals with similar profiles (consumers)

Mostly behave erratic (unknown), following psychology

Industrial use cases: many, but diverse objects



Large number of highly diverse devices and systems

Mostly behave as designed (known), following laws of physics

Large in number, but in small industrial populations – smaller data sets

Information content
Large amounts of data do not contain relevant information

Industrial IoT data

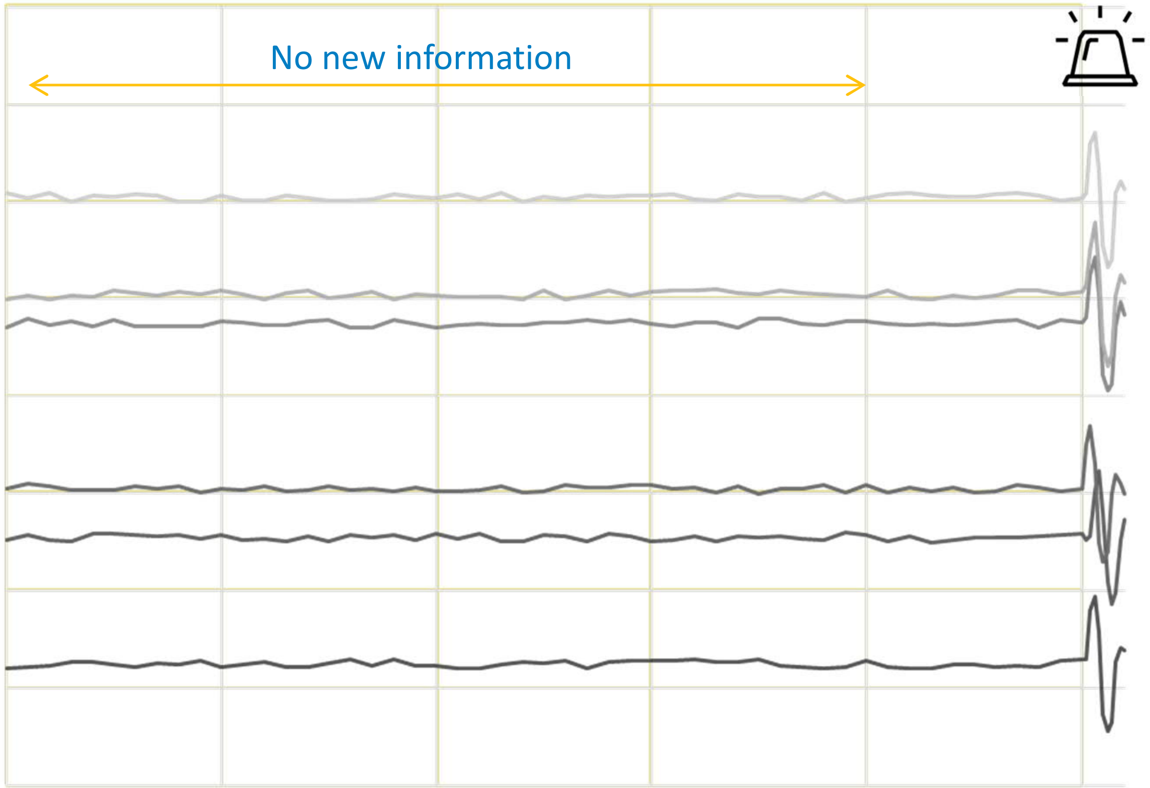
Plants in normal operation produce very similar data sets over a long period of time

Large amounts of data may not contain a lot of useful information

Measure for information content – Information entropy:

- Simplified: 'How surprised are you about a new data set?'

Training AI requires information, not data



Correlation vs. causality
Data does not tell it all

Drawing the right conclusions

- Well-defined: Classification – image / voice / language recognition
  - Input and output are clearly defined, causality is a given
- Complex: cause and effect are not known (e.g. physical systems)
  - Data shows correlation, but does not reveal causality
- Desired: Influence the cause to achieve an effect
  - Requires clear identification of causality
  - Improper identification of causality results in wrong decisions

AI shows that A and B are correlated, but:

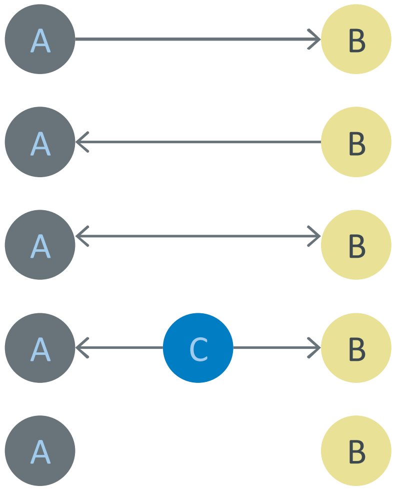
A may cause B

B may cause A

A and B may reinforce each other

There may be a common cause

Pure chance



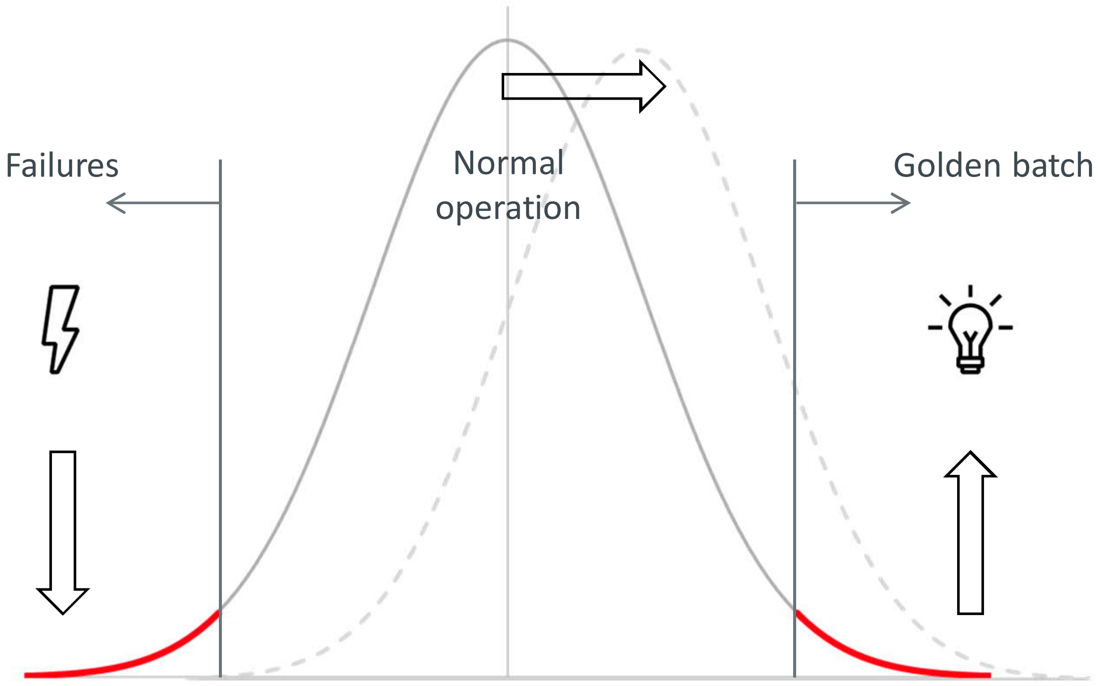
Example: The more power a motor produces, the warmer it gets. Heating the motor will not make it deliver more power

Discovering causality requires domain knowledge

Industrial interest in outliers
Differentiate from the average

Low end outliers:
Avoid downtime

- Reduce failures with predictive maintenance
- Train prediction models using rare data from failures



High end outliers:
Improve production

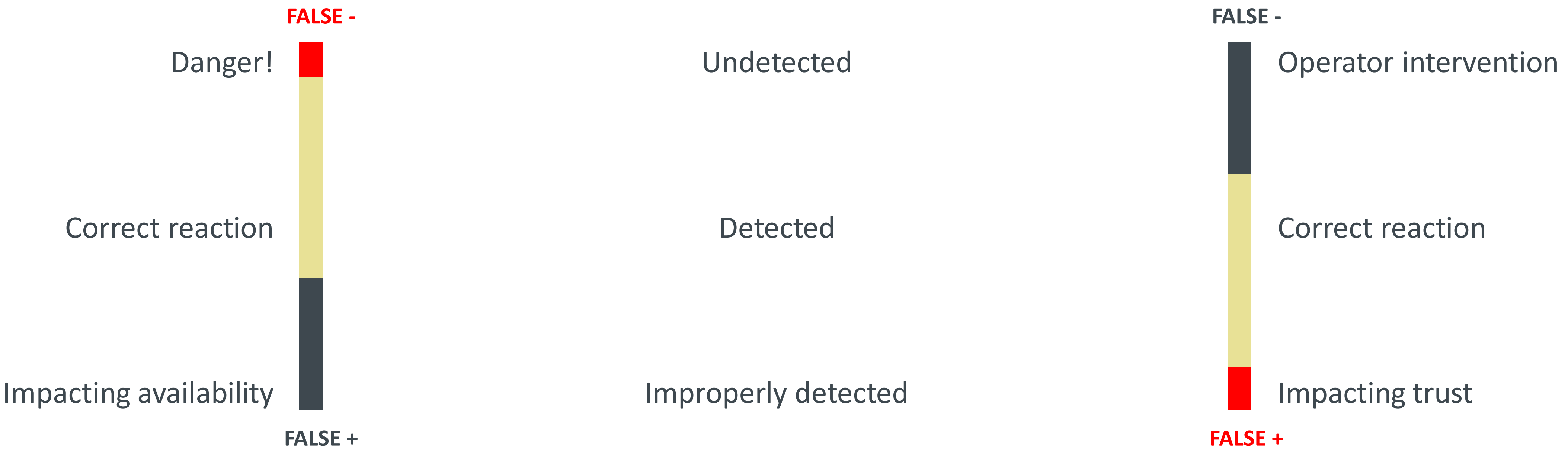
- Catch rare cases of best production (golden batch) and learn from that
- Improve production based on the learning

Addressing the outliers shifts average operation

Trust in autonomous systems
Different roles for automation and AI

Critical situation (safety relevant)

Non-critical situation (improving effectiveness)



“better safe than sorry”

“nobody is perfect”

Complexity of the industrial reality
Life isn't playing a game

Well defined rules and limited states in games

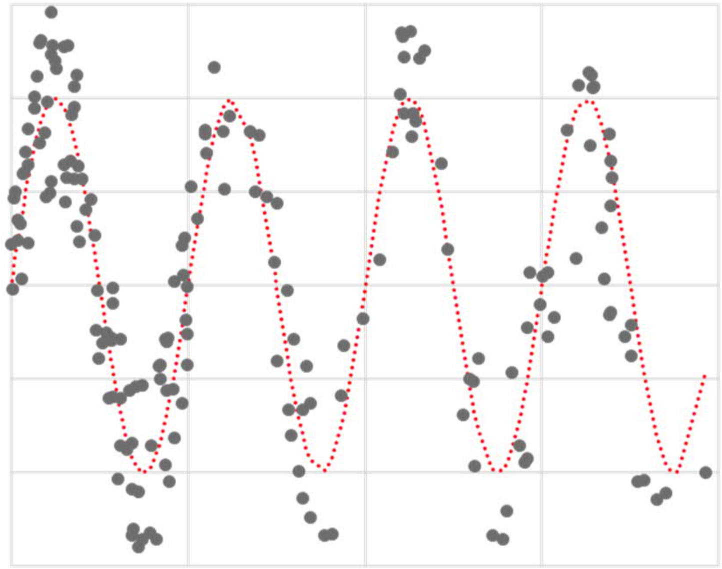
Unlimited states in reality[1]

Moving from a closed world to reality requires Industrial AI

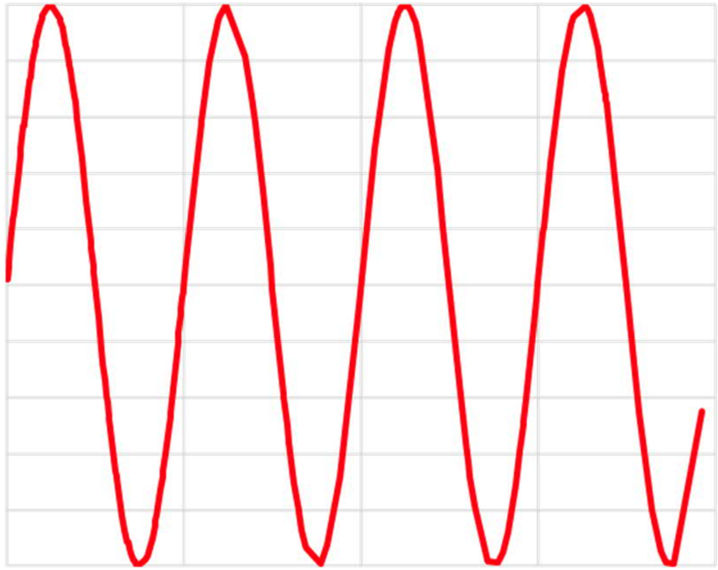
[1]Visual by William Sadler - Napoleon.org.pl, public domain, https://commons.wikimedia.org/w/index.php?curid=15176449

Model – data hybrid algorithms
Use what you know

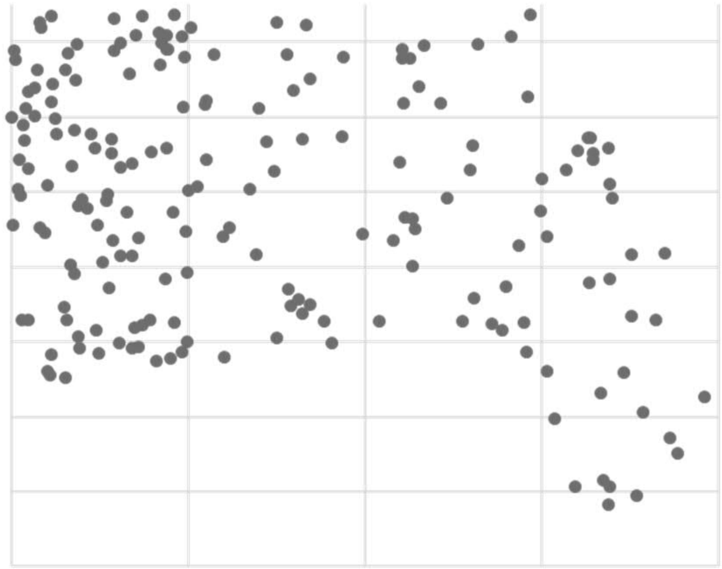
Measurements



Modeled component



Remaining stochastic part



Removing the known from the data reveals the unknown

Intelligent systems: confined AI
AI in safety critical environment

Defense in depth

Normal operation: AI operates optimally

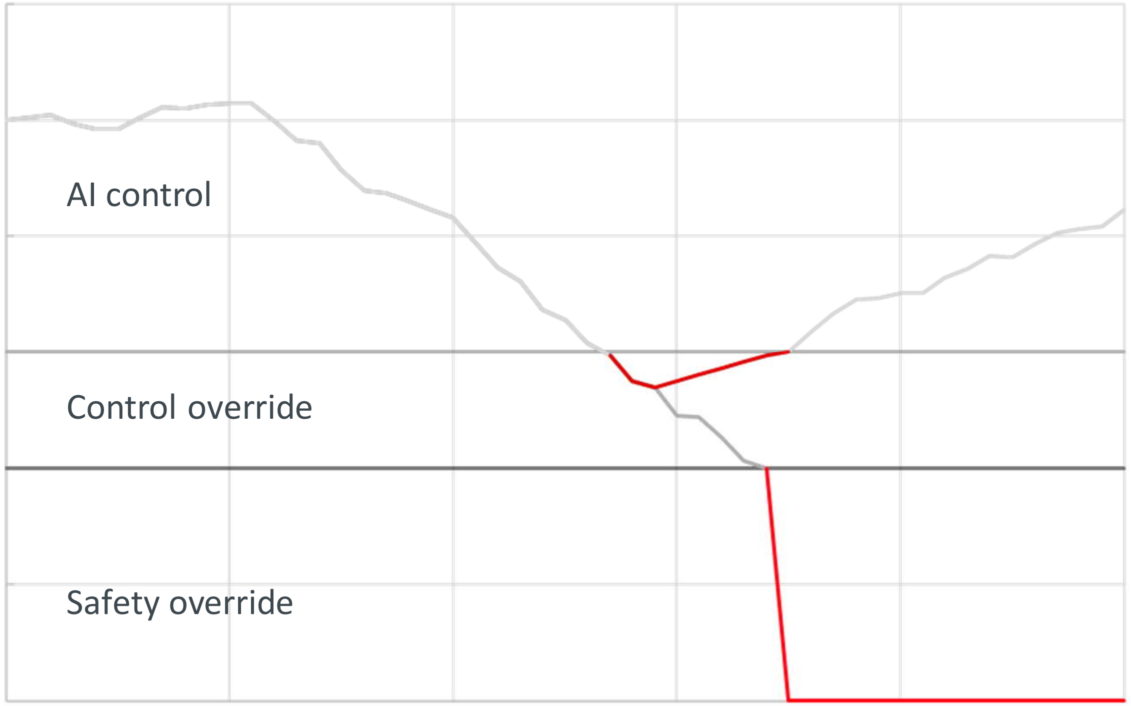
- Plant runs in a safe state, far away from a dangerous situation, with sufficient time to react

Deteriorating situation: Control overrides safely

- State where a dangerous incident may be caused by a wrong reaction of the AI system

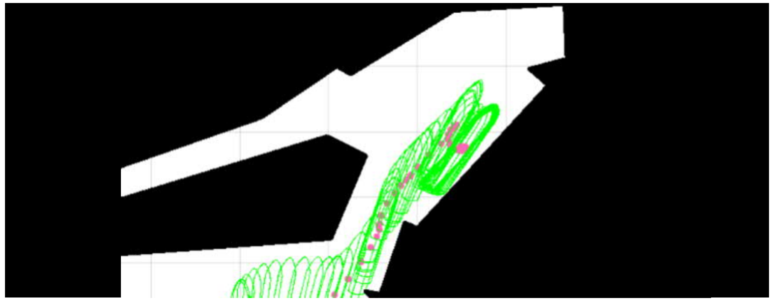
Dangerous situation: Safety interrupts

- A situation that if sustained over a period of time will lead to an incident (destruction or causalities)



Industrial AI addressing the complexity in industrial reality
Combining domain knowledge with data

Know (foresight)



Domain knowledge

First principles models and simulation

– Described, but not yet observed

Safety, control and optimization

– Engineered well-defined solutions

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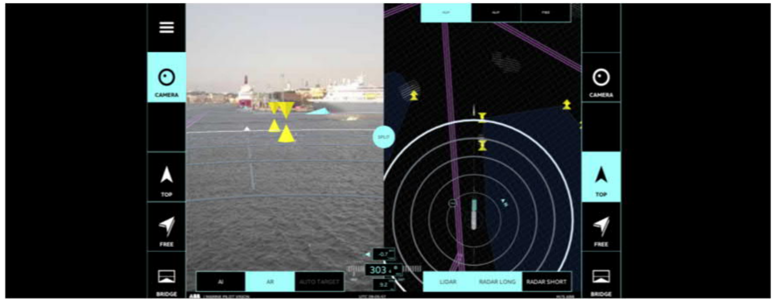
Observe (hindsight)



Data science

Data driven models

– Observed, but not a priori described

Industrial AI

– Complex scenarios

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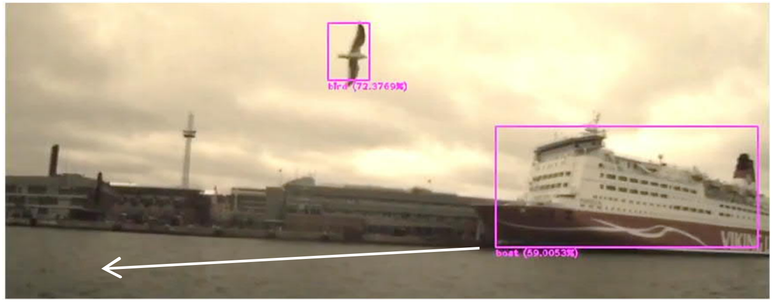
Combined approach



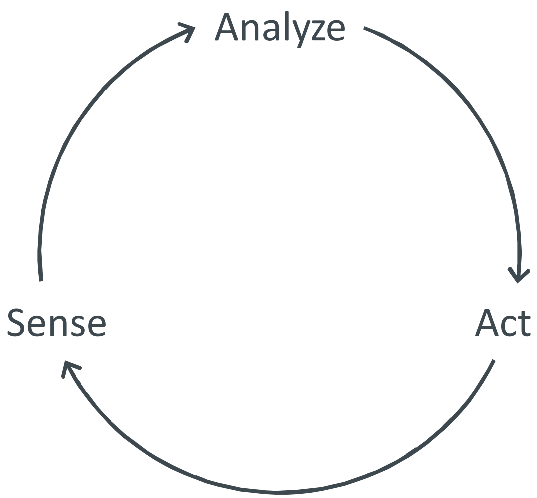
Build on what is known

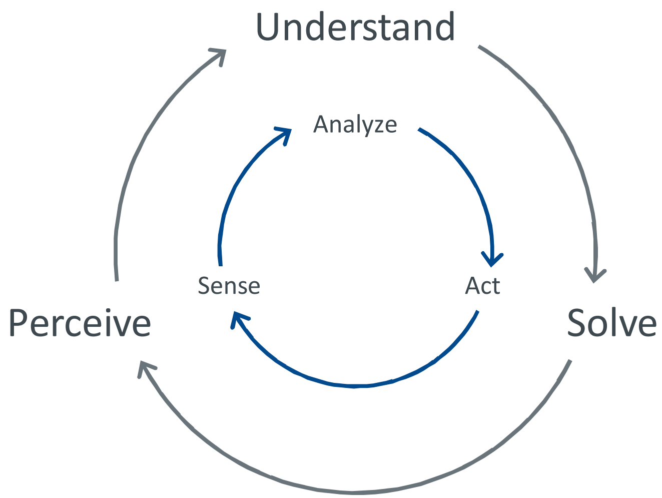
Safely avoid known dangers

Explore the unknown through data analysis and simulation to increase flexibility

Industrial AI needs a combination of domain and data expertise to be successful

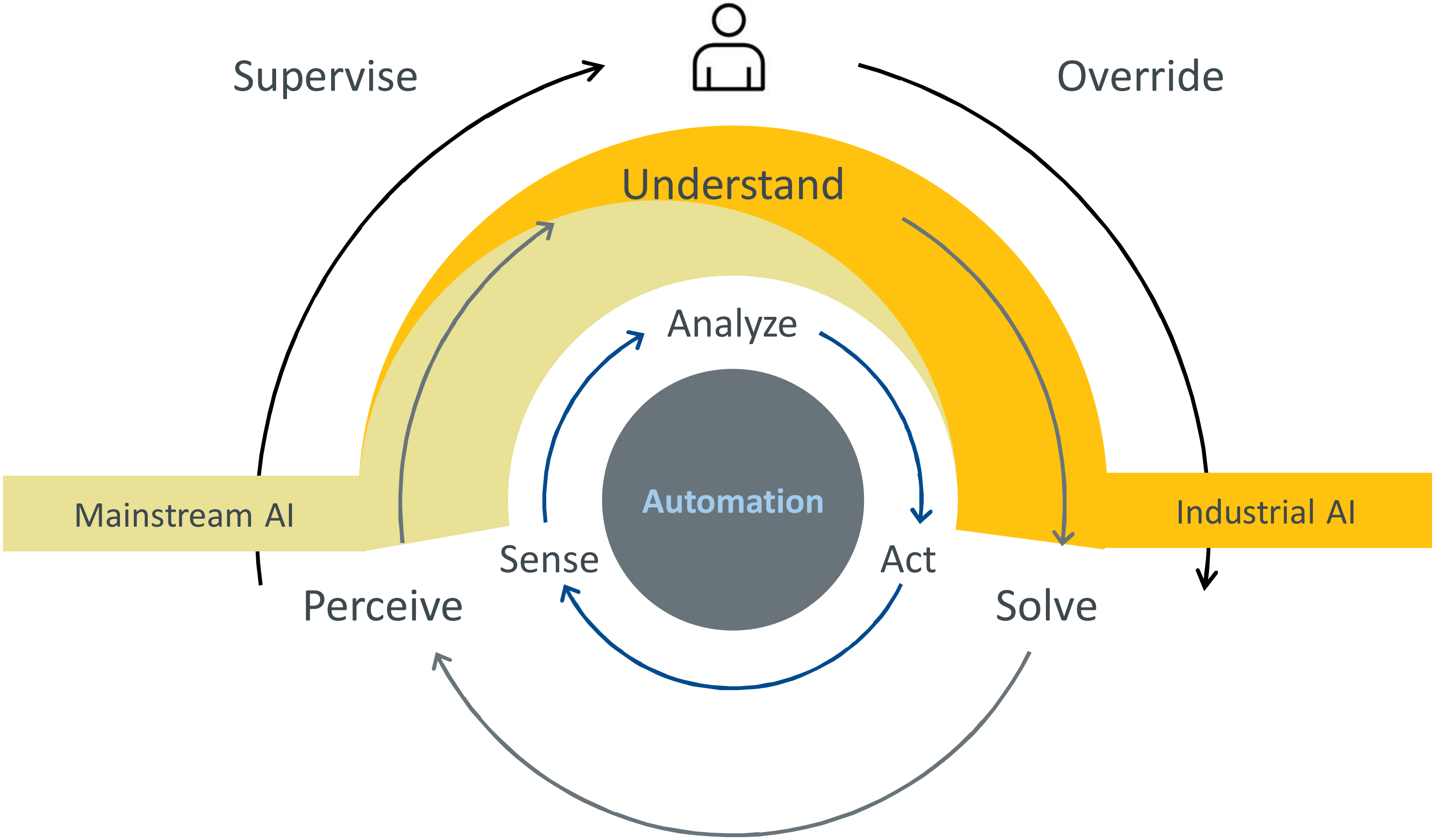
Automated	Autonomous





Steady state control → Normal operation – Start, transients, stop → Complete plant lifecycle →

Moving towards autonomous industries
AI is the enabling technology



Artificial Intelligence is key technology for the next level of industrial progress

Human

Systems designed by experts

+ Intuition
+ Creativity
+ Expertise

– Computation

Augmented

Experts supported by algorithms

Amplifying human potential

Artificial

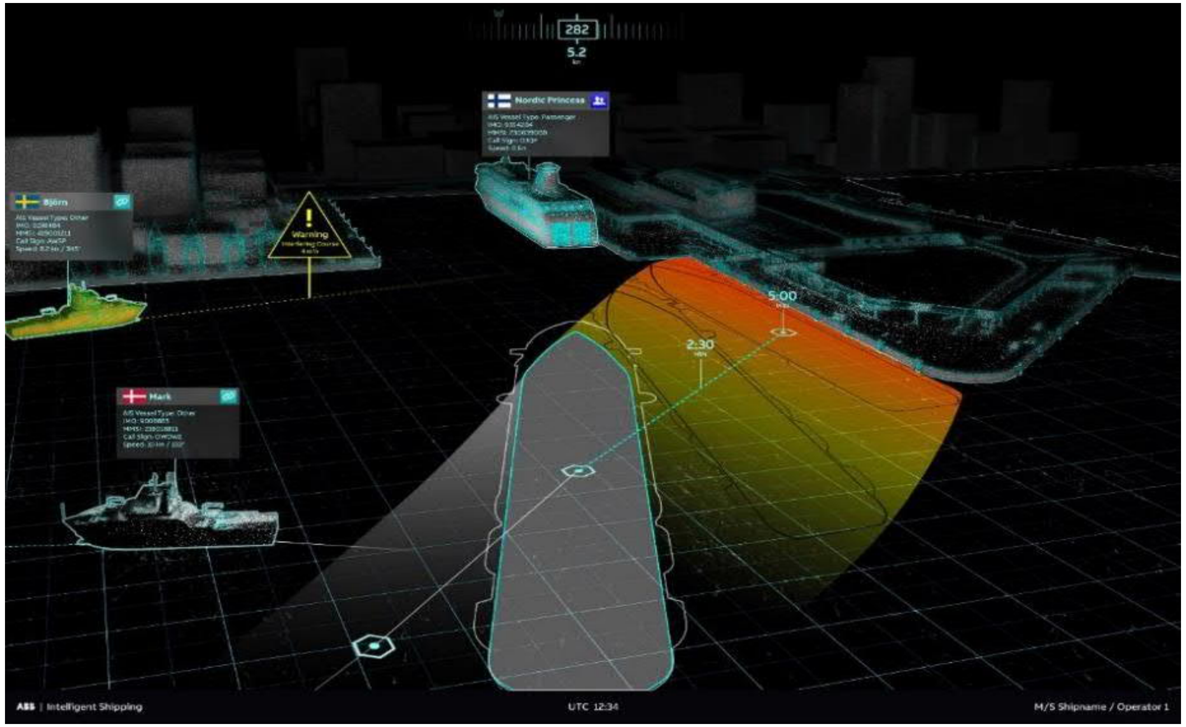
Knowledge learned from data

– Intuition

– Creativity

+ Expertise
+ Computation

Steering towards autonomous ships
Transforming the way ships are operated



Changing the view of the captain

Artificial intelligence from ABB
Wind production forecast for renewables

Challenge

How can I better participate in the energy market given the production uncertainties due to weather that make scheduling difficult?

ABB Solution

ABB together with IBM is applying IBM's Watson AI solutions to more accurately predict weather effects relevant to renewables production.

In addition, IBM's weather data provides the data sets required to feed the machine learning algorithms

Creating Value

Better production prediction leads to:

- Increased revenues offering more services to energy market e.g. day ahead or ancillary services for grid operations
- Reduced trading risks

Conclusions

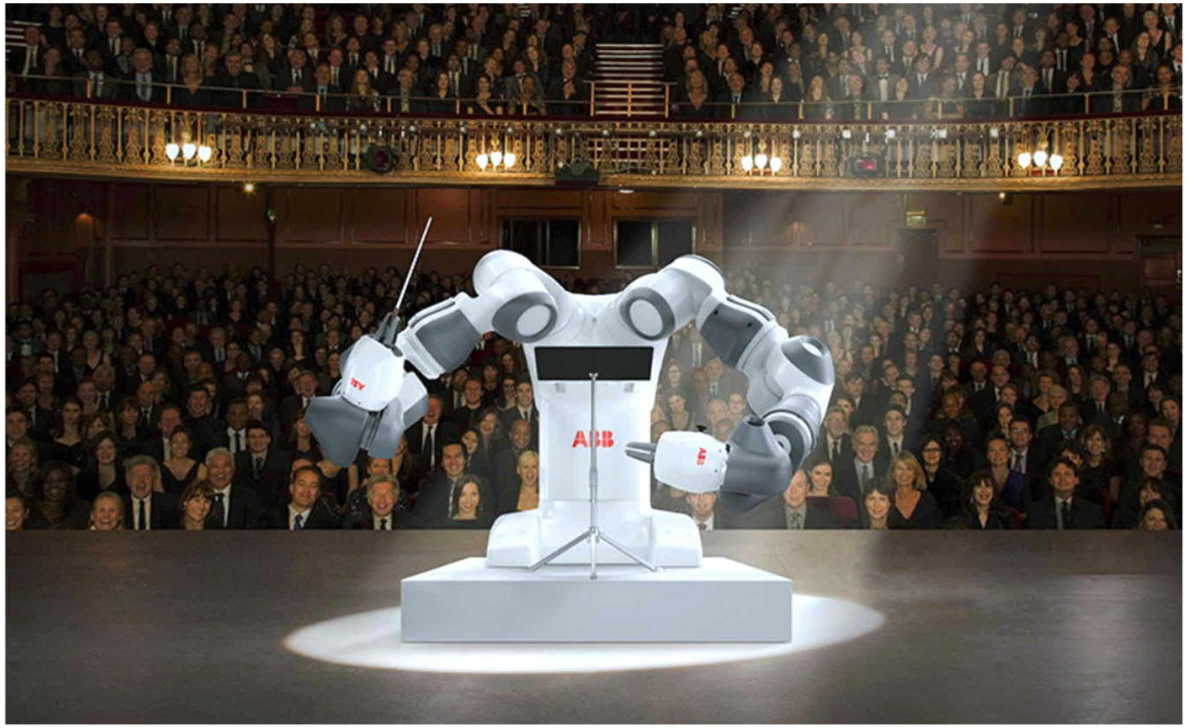
Autonomy: AI helps expanding automation systems' capabilities towards handling more unplanned situations

Safety: The behavior of AI is not consistent. Seamless interaction between deterministic, reliable control algorithms and AI solutions are key to success

Knowledge: Most behavior of industrial equipment can be explained by physics. Combining 1st principles know-how with data driven algorithms creates most insight

Data: The availability of complete, correct, and consistent data to train AI algorithms is essential. Industrial data is significantly different from the data normally used in ML

Humans: Interaction between humans and AI systems lead to the creation of the augmented expert, combining best of both worlds



The key focus shall always be the customer's challenge, AI is just one of the tools to be applied

ABB is building a bridge to the future