IoT in Manufacturing

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Agenda for Part 2: IoT in Manufacturing

- My background in the industry
- Industrial IoT and Smart Manufacturing
- Digital Twins and their usage in Smart Manufacturing
- Real-life examples
- What skills are required

My background

- Working in the manufacturing and automation industry for ~15 years

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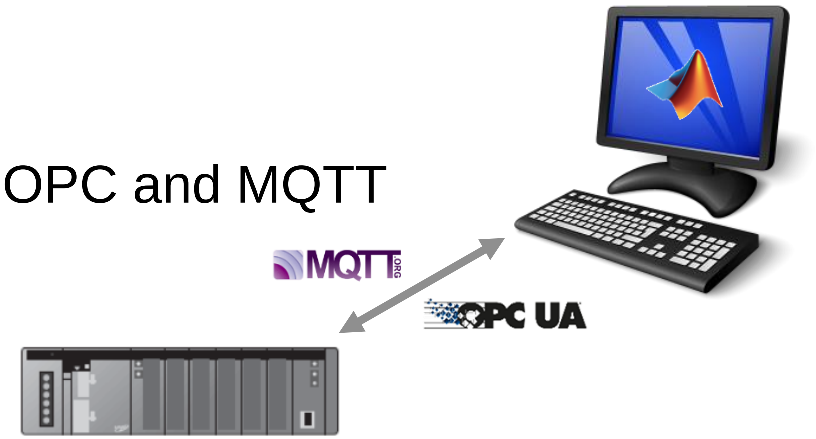
- Working in the worldwide Industrial Automation & Machinery team
  - Business development with local offices
  - Technical partnership with lead customers
  - New products and workflows (e.g. for industrial connectivity)

Machine Builders | Industrial Robotics | Semiconductor Production | Oil & Gas | Building Automation | Wind Energy | Power Gen. & Transmission | Electric Drives

Who do I typically talk to?

- Connectivity has been a topic for a while
  - Data exchange through communication protocols like OPC and MQTT



  - Communication between industrial controllers (e.g. PLCs, industrial PCs, etc.) and automation components (e.g. sensor, electric drives, etc.)

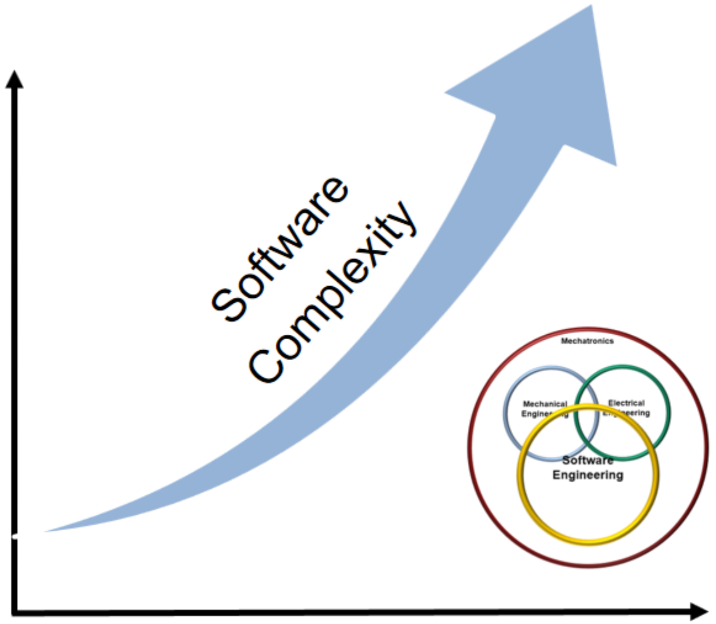
Source: B&R Industrial Automation

- Engineers are interested in connecting data with algorithms and models

What has changed over the past years?

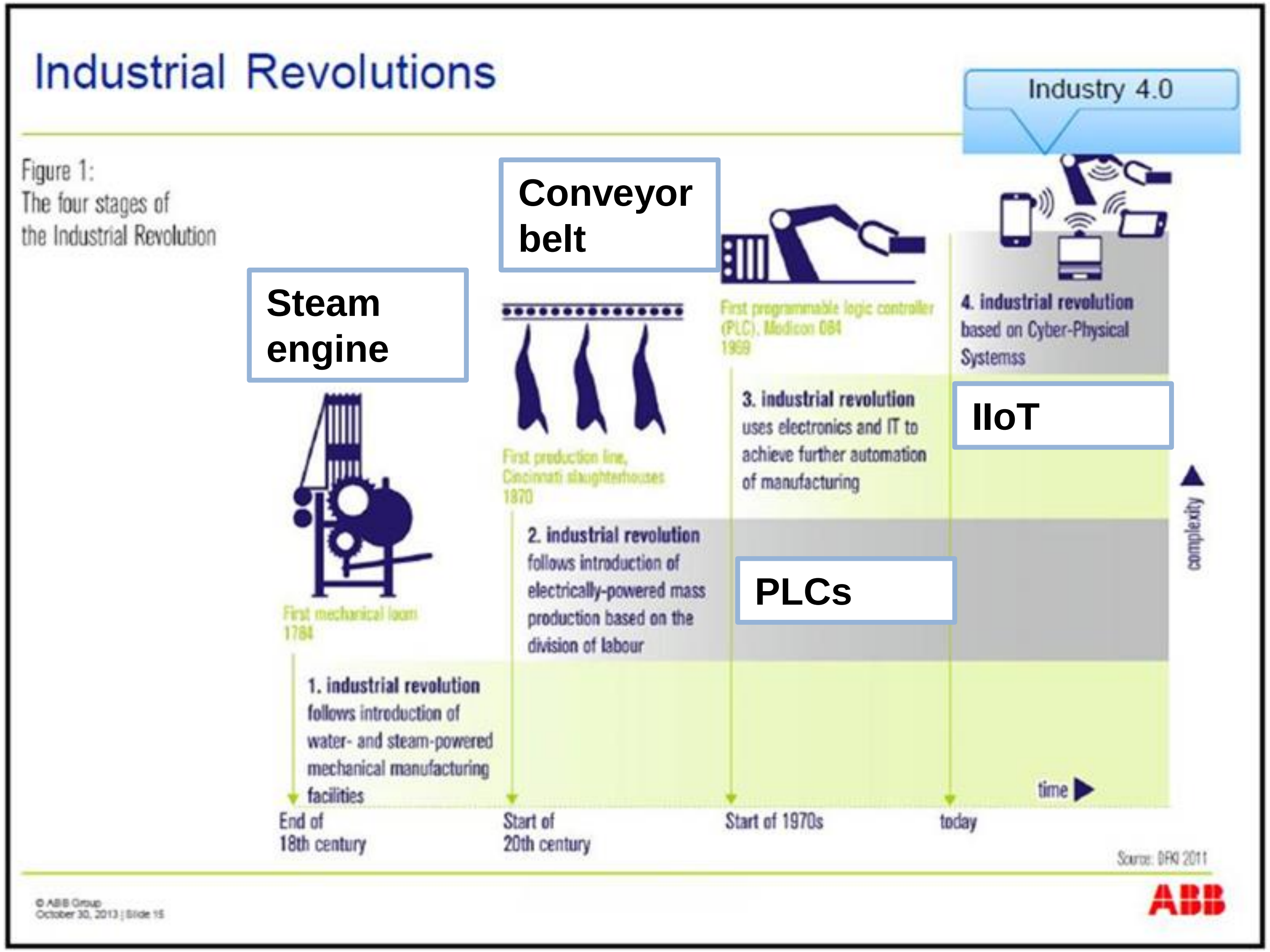
- Rise of the Industrial Internet of Things (IIoT)
  - **Sensors** everywhere
  - Availability of **data storage**
  - **Cloud** computing on the rise
  - More **software** on industrial equipment
    - Using data (from sensors, across industrial equipment, and other sources – e.g. weather forecast) to improve operations
    - Example: Predictive Maintenance (later more…)

Increasing amount of **Data**



Growing complexity of **Software**

Megatrends *Industry 4.0* and *Smart Manufacturing*



Source: ABB

Definition:

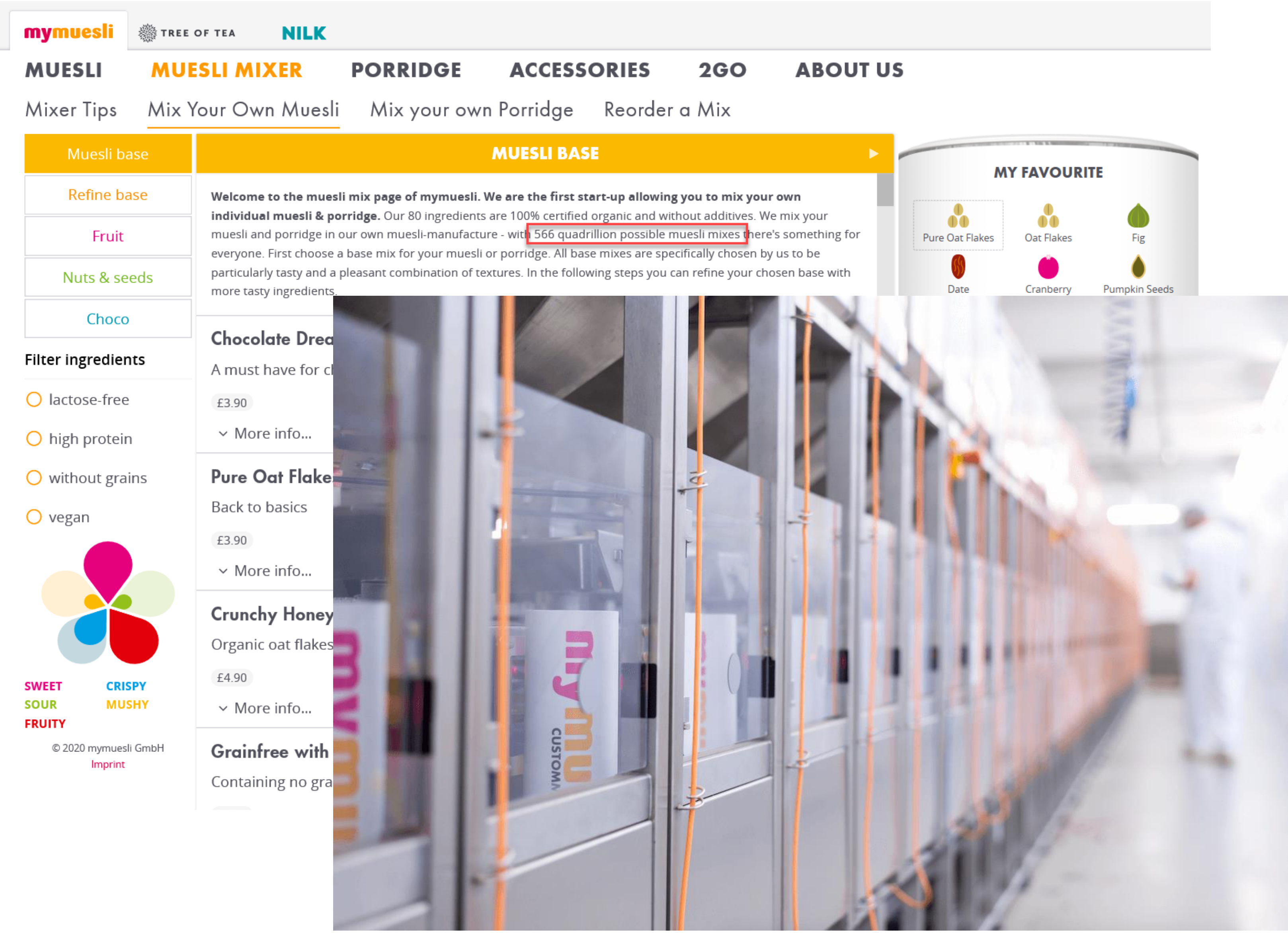
Production equipment, automation components and entire process lines are **connected** with each other and exchange information (= data). They build the "***Industrial Internet-of-Things***".

The goal is to **optimize** the entire process (for minimum energy consumption, maximum throughput, feedstock quality, etc.) and to make the production of small lots **more flexible** ("*mass customization*").

Example: Mass customization at mymuesli

- Mass production of highly individualized goods
  - Ingredients
  - Package
  - Etc.

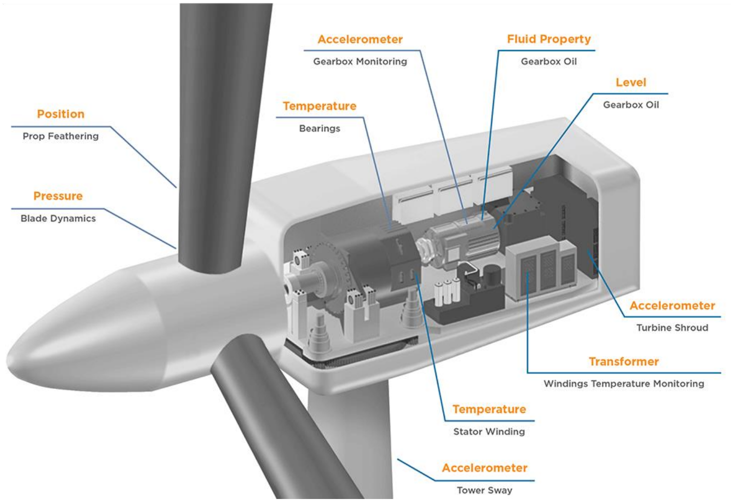
- How can this be produced efficiently?



Source: mymuesli

IIoT as enabler for Industry 4.0

<u>Goal:</u>
By **connecting machines** in operation you can **use data, algorithms, and models** to **make better decisions**, increase flexibility, improve processes, reduce cost, and improve customer experience.



Mondi Implements Statistics-Based Health Monitoring and Predictive Maintenance for Manufacturing Processes with Machine Learning

One of Mondi Gronau's plastic production machines, which deliver about 18 million tons of plastic and thin film products annually.

Challenge

Reduce waste and machine downtime in plastics manufacturing plants

Solution

Use MATLAB to develop and deploy monitoring and **predictive maintenance** software that uses **machine learning algorithms** to predict machine failures

Results

- More than 50,000 euros saved per year
- Prototype completed in six months
- Production software run 24/7

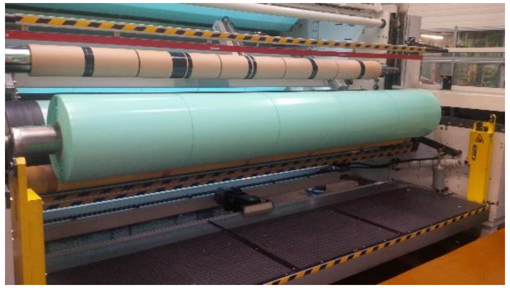
[Link to user story](#)

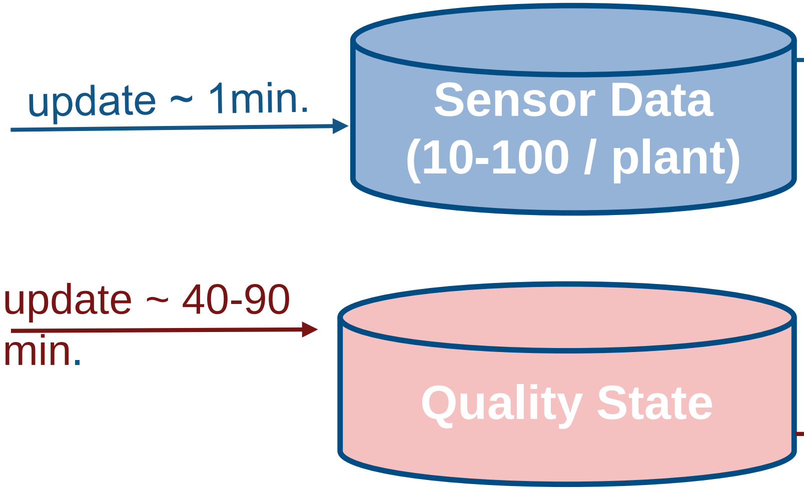
[Link to video](#)

Mondi: Prepare data

- Collect sensor data and quality data
  - 18 machines producing various polymer products
  - 10 to 100 sensors (e.g. temperatures, pressures, etc.) per machine
  - Quality state of machines reported per production cycle (optical monitoring system)

- Aggregate sensor data and quality states (per time stamp)





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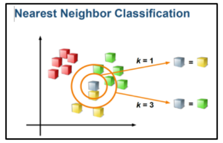
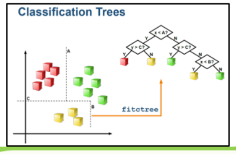
'2015-07-14 00:55:12.0'	160	160	160	160	1000	8	1000	10	33	32	2

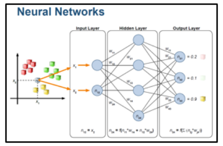
Mondi: Choose algorithm

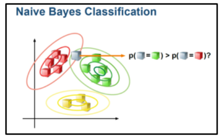
- Select machine learning algorithm based on constraints and priorities (e.g. speed, memory usage, etc.)

Choose model with best misclassification rate

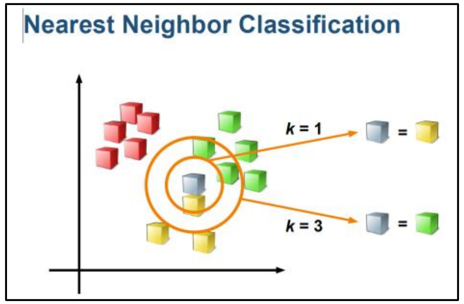


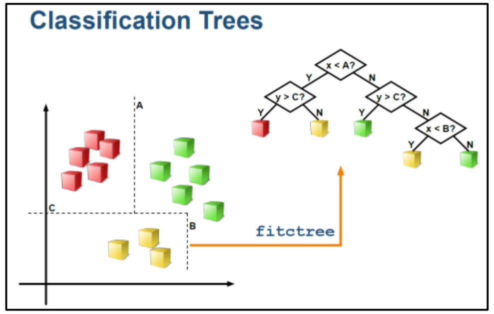


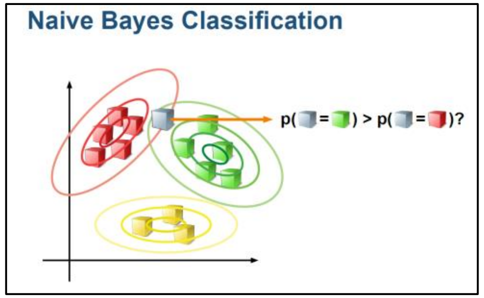


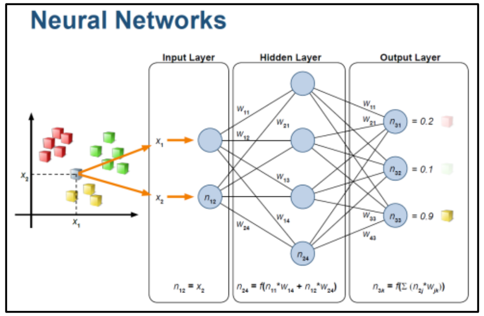


	NearestNeighbour		TreeBagger		NeuralNetwork		NaiveBayes	
	Misclassification % (Mean)	*Misclassification % (std)*	*Misclassification % (Mean)*	*Misclassification % (std)*	*Misclassification % (Mean)*	*Misclassification % (std)*	*Misclassification % (Mean)*	*Misclassification % (std)*
M151	24%	0%	2%	0%	8%	0%	10%	0%
M152	44%	0%	5%	0%	23%	3%	13%	1%
M153	23%	2%	2%	0%	13%	5%	13%	0%
M156	12%	2%	2%	0%	3%	0%	9%	1%
M157	11%	0%	1%	0%	10%	2%	8%	0%
M158	29%	1%	2%	0%	14%	2%	17%	0%
M159	21%	0%	0%	0%	3%	0%	2%	0%
M181	1%	0%	0%	0%	1%	0%	2%	0%
M182	0%	0%	0%	0%	0%	0%	0%	0%
M184	0%	0%	0%	0%	0%	0%	0%	0%
M185	3%	0%	0%	0%	1%	1%	2%	0%
M275	41%	1%	16%	0%	23%	1%	25%	0%
M155	5%	0%	0%	0%	2%	2%	3%	0%
M274	62%	8%	16%	0%	20%	1%	27%	0%



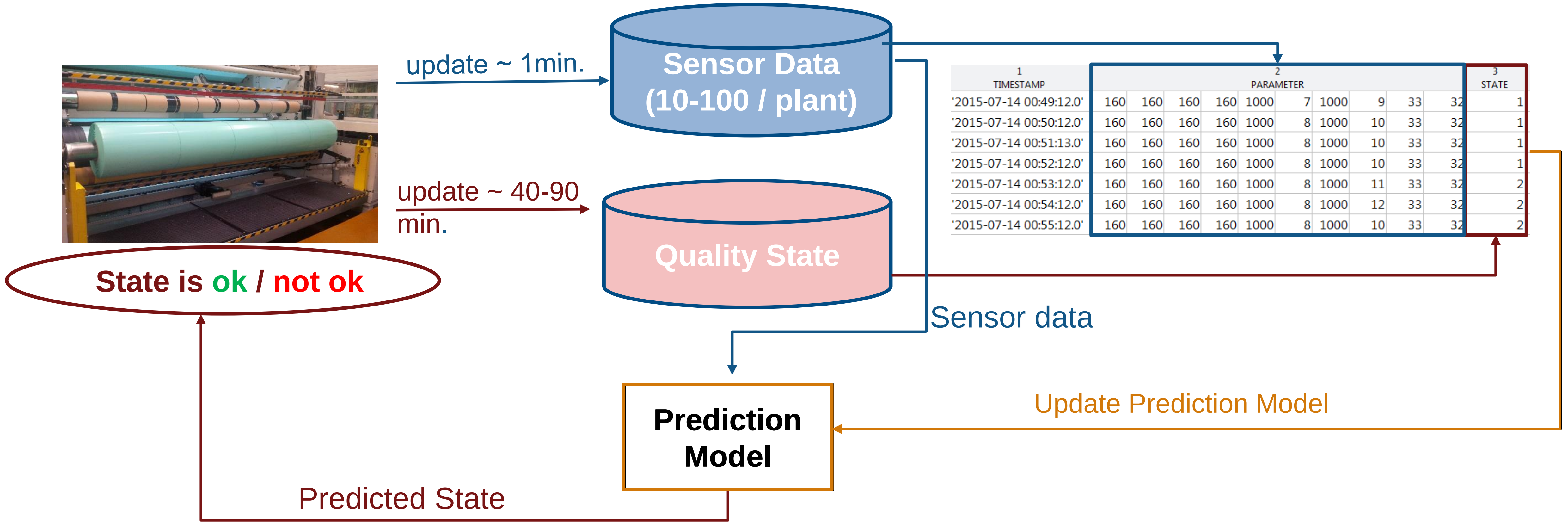






Mondi: Perform Predictive Maintenance

- Predict failures and schedule maintenance intervals based on historical and actual data



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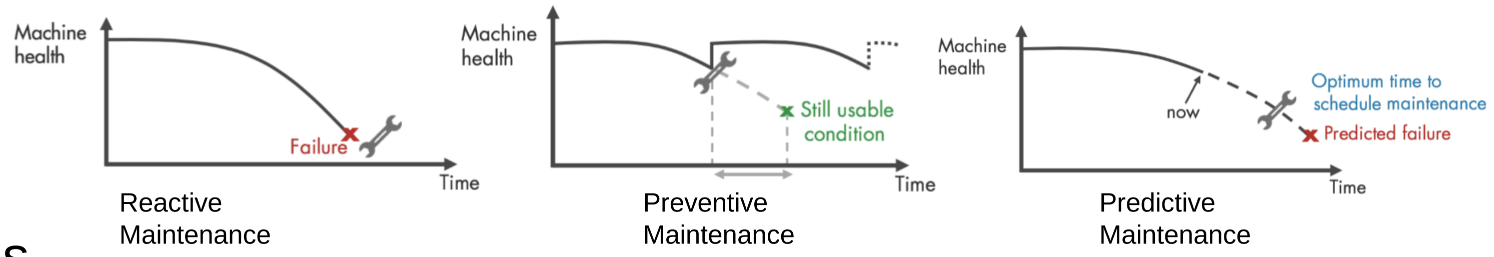
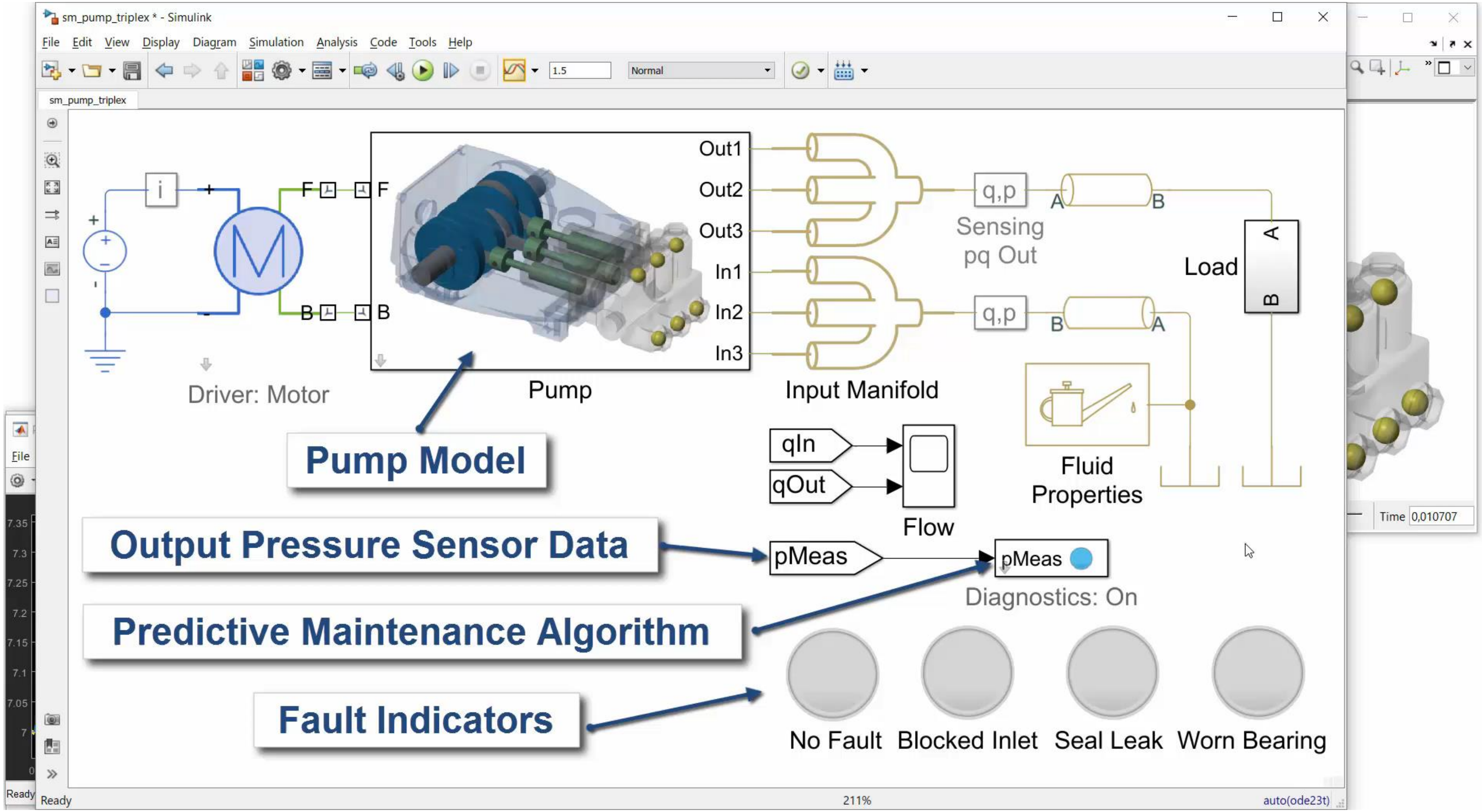
Predictive Maintenance and Digital Twins



- Predictive Maintenance
  - Optimize maintenance schedules
  - Perform remaining useful life estimation (RUL)

- Digital Twin
  - *"Up-to-date representation of an actual physical asset in operation"*
  - Scenarios for maintenance strategy
  - Generate synthetic failure data
    - **Because you don't want to rely on failures in the field to get training data!**

Digital Twin based on simulation models



Summary

- Flexible production requires Smart Manufacturing capabilities
- More data and software enable Industry 4.0 and Smart Manufacturing
- Digital Twins are the basis for Predictive Maintenance and other IIoT applications

What skills are required?

- Domain know-how (how to build a digital representation of the industrial equipment)
- Data analytics (“AI”; how to identify patterns in data recorded by IIoT systems)
- Targeting industrial controllers (e.g. PLCs; using programming languages and Model-Based Design)
- Overview of industrial connectivity (which communication protocols are suited for which application)

Thank you for your attention!

Questions?