Machine learning

Lecture 10

Quality Assurance Legostones

Prof. Dr.-Ing. Jan Schmitt

E-mail: jan.schmitt@fhws.de

FH·W-S

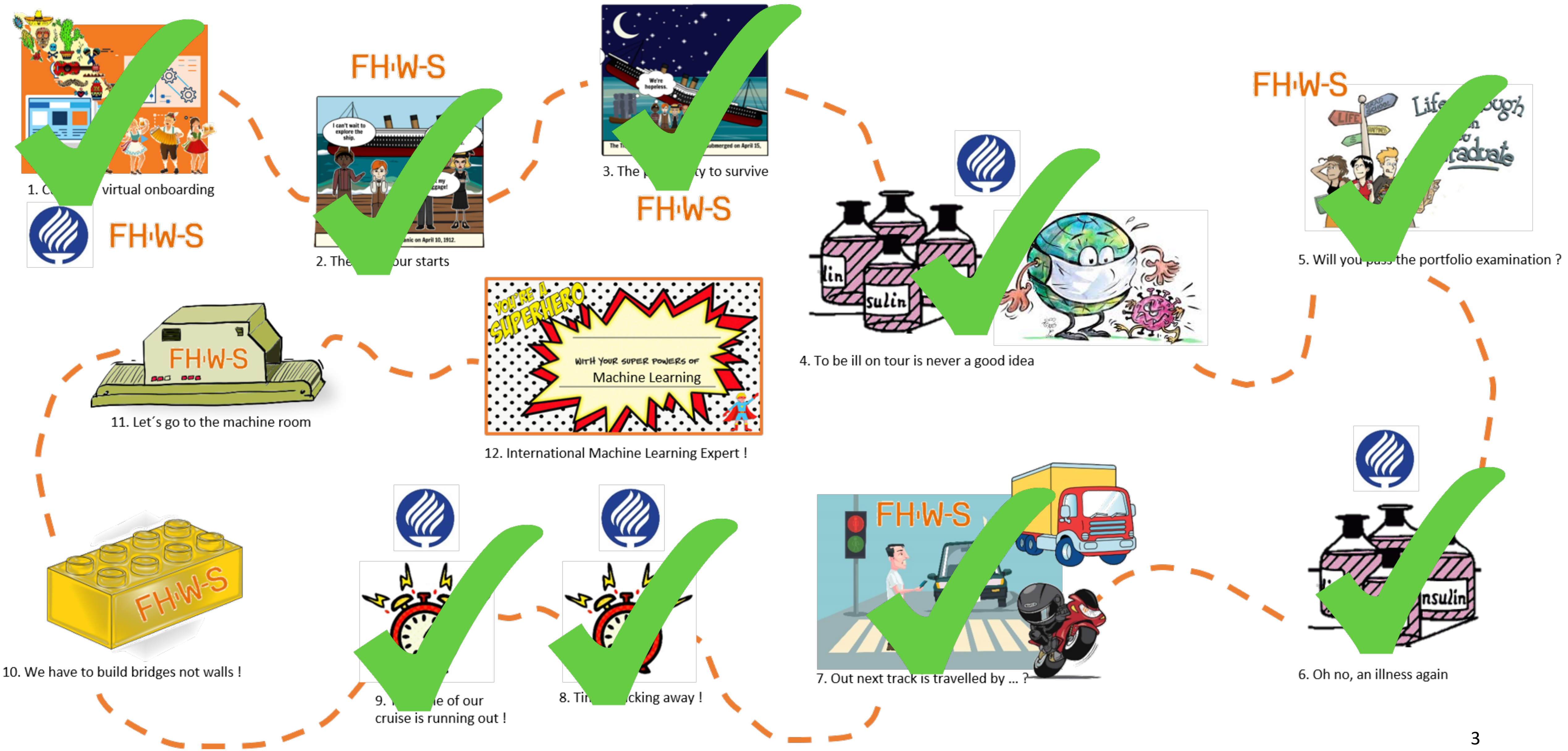
Tecnológico de Monterrey

The course objectives

#	Date	Topic	Lecturer
~~1~~	~~17.03.2021~~	~~Introduction~~	~~All~~
~~2~~	~~24.03.2021~~	~~Data visualization and preprocessing (Titanic)~~	~~Prof. Schmitt~~
~~3~~	~~31.03.2021~~	~~Getting to know Machine Learning~~	~~Prof. Schmitt~~
~~4~~	~~07.04.2021~~	~~Linear / Multiple Regression~~	~~Prof. Ceballos-Cancino~~
~~5~~	~~14.04.2021~~	~~Logistic Regression~~	~~Prof. Engelmann~~
~~6~~	~~21.04.2021~~	~~Decision Trees~~	~~Prof. Ceballos-Cancino~~
~~7~~	~~28.04.2021~~	~~Neural Networks~~	~~Prof. Engelmann~~
~~8~~	~~05.05.2021~~	~~Time Series Forecasting~~	~~Prof. Batres~~
~~9~~	~~12.05.2021~~	~~Time Series Forecasting~~	~~Prof. Ceballos-Cancino~~
10	19.05.2021	Quality Assurance Legostones	Prof. Schmitt
11	26.05.2021	Changeover Prediction	Prof. Schmitt / Engelmann
12	02.06.2021	Poster Session	All

We meet via ZOOM – the link is permanently the same and posted in the eLearning announcement

It´s a Machine Learning Tour



1. C virtual onboarding

2. The our starts

3. The ty to survive

4. To be ill on tour is never a good idea

5. Will you the portfolio examination ?

6. Oh no, an illness again

7. Out next track is travelled by … ?

8. Ti cking away !

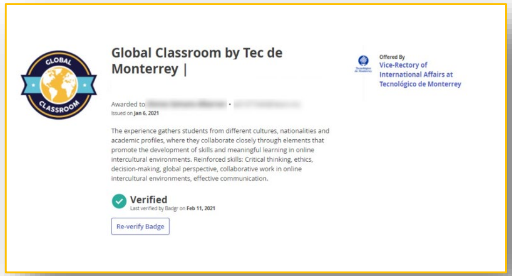
9. e of our cruise is running out !

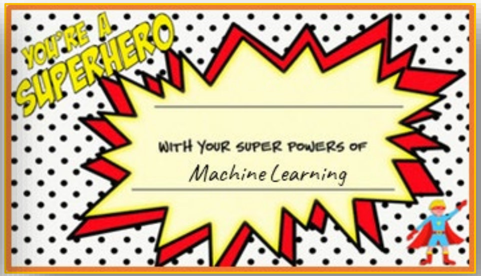
10. We have to build bridges not walls !

11. Let´s go to the machine room

12. International Machine Learning Expert !

Grading





	Digital badge	Course grading
Ice breaker	20	
Quiz 1 – Fundamental understanding		25
Paper – COVID19	30	12,5
Quiz 2 – Deeper understanding		25
Paper – Akahappa	30	12,5
Poster session	20	25
Total	**100**	**100**

Agenda

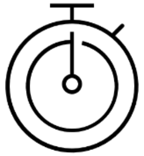
- General course evaluation / vLab performance evaluation
- The CRISP-DM Model again
- Use-Case
  - Fundamentals of production KPIs
  - Interpretation of dataset
- ML-Model
- Practical session
- Results & Discussion

General course evaluation

Link: https://cloud6.evasys.de/fhws/online/
Passwort: WKRAF

- Fill it, please
- 10 min.

vLab performance evaluation

- Please find in CANVAS – Module 10 the vLab performance evaluation
- Fill it, please !
- 5 min. 

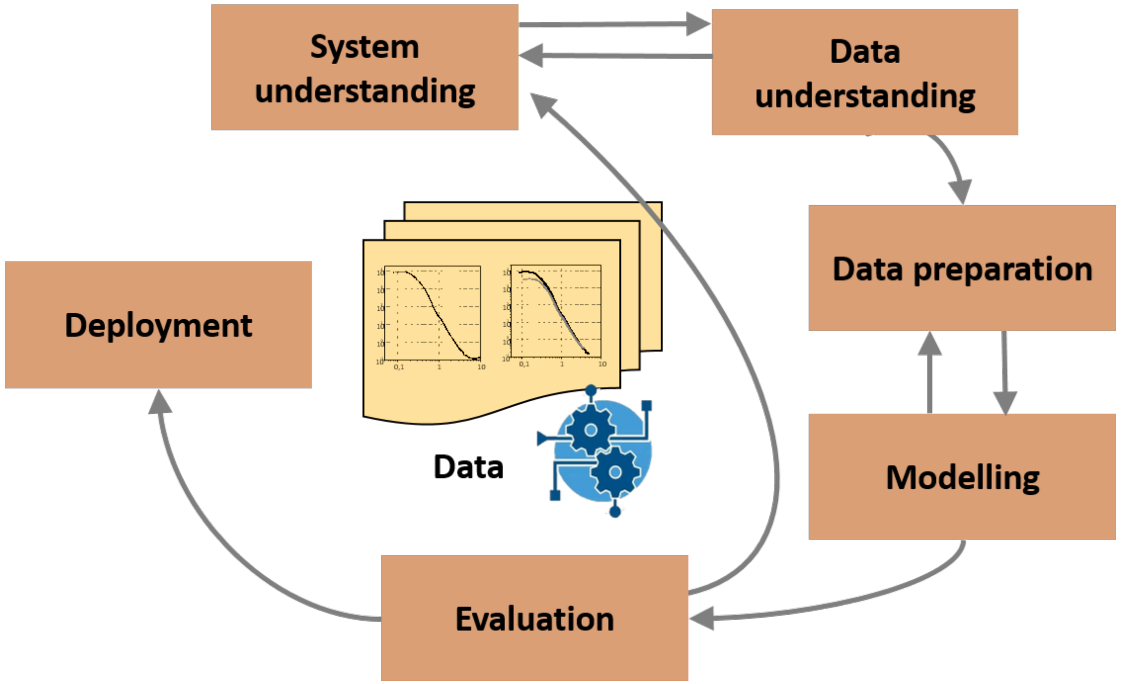
Learning objectives

- In the previous lectures you learn primarily
  - Handling data
  - Single ML techniques and apply them to a dataset
- In the remaining 2 lectures we try to solve an Industry 4.0 issue with real production data
  - Using the CRISP-DM model and discover the task step by step
  - Discuss the relevance of ML in Industry 4.0

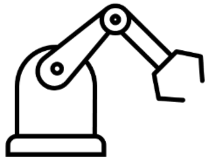
The CRISP-DM Model

Cross Industry Standard Process for Data Mining
CRISP-DM

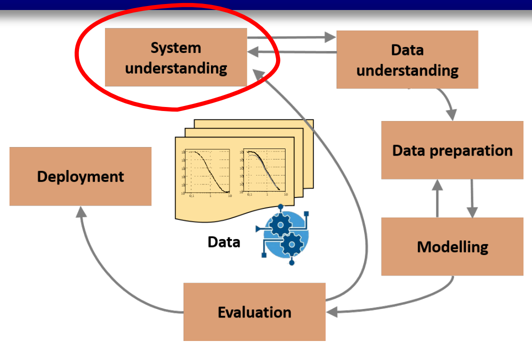
- Standard model for with six different process phases for DM problems
- CRISP-DM is application-neutral and can be used in any areas
- Established worldwide
- One of the most frequently used models in this (data) environment



Our Use Case



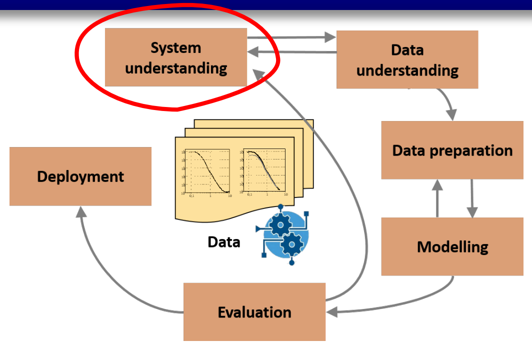
The product - Lego Brickstone



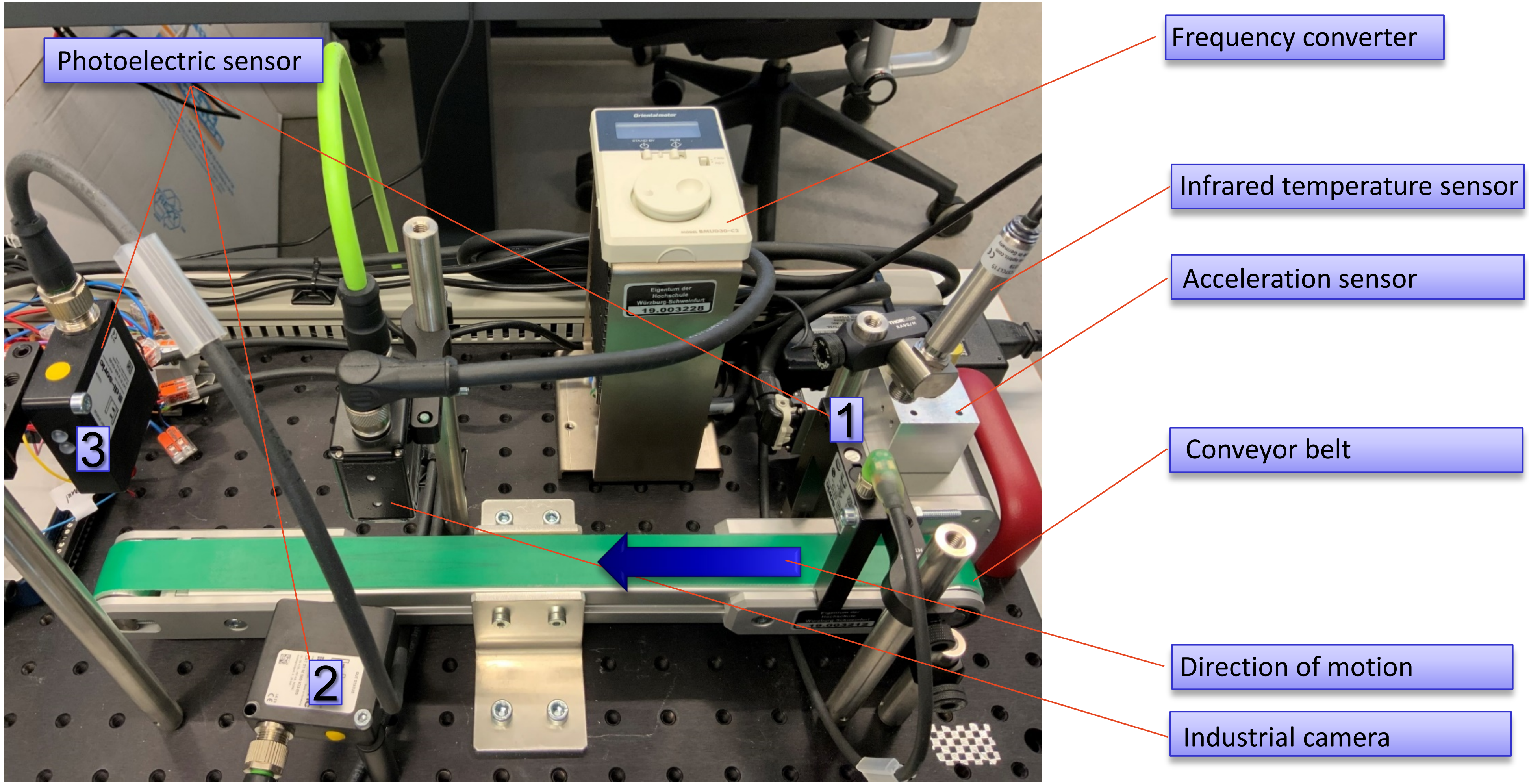
- Product features (name some in the chat !)

- Production features (name some in the chat !)

Our Use Case

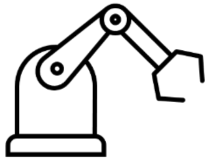


QA as a part of the production system

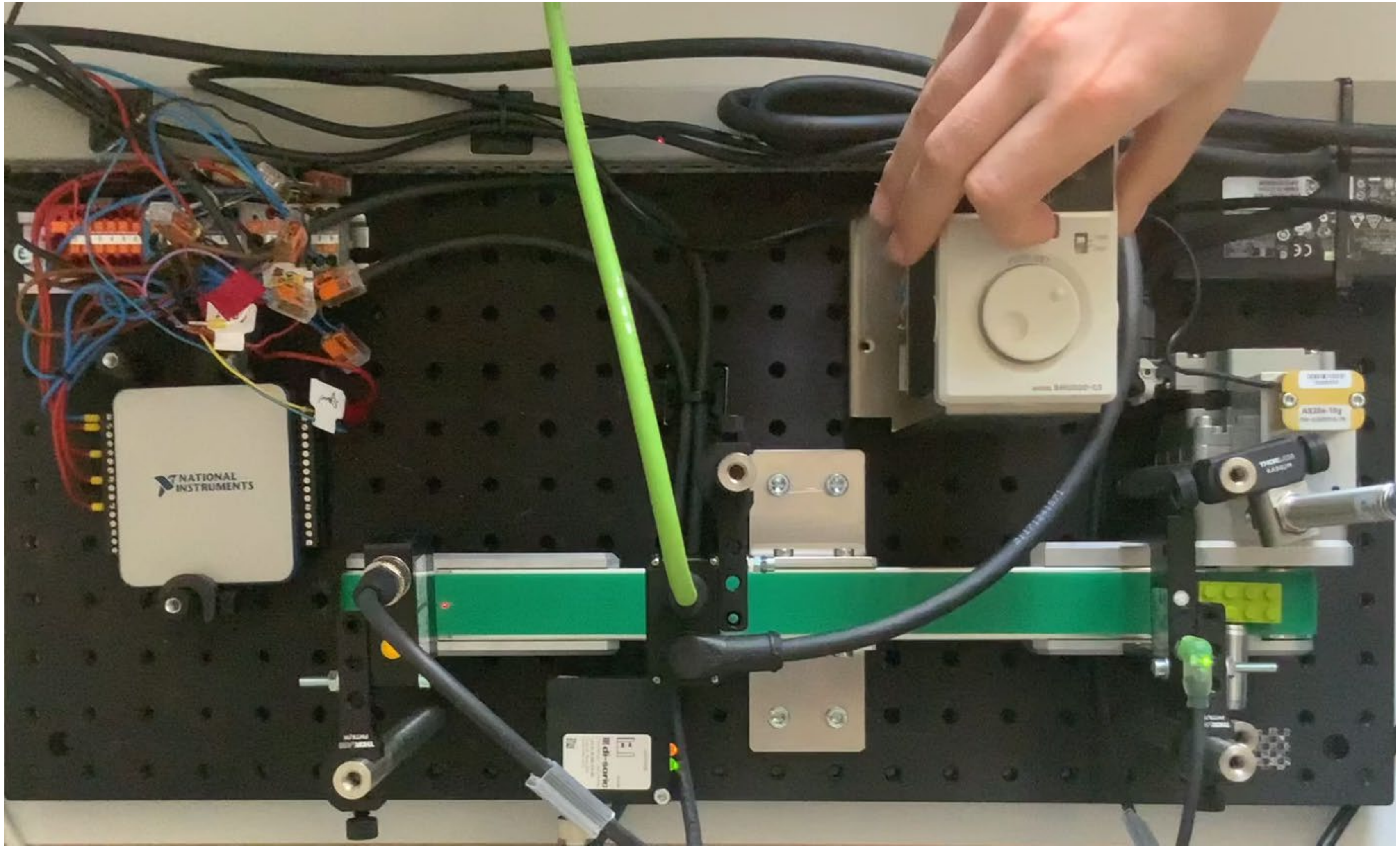


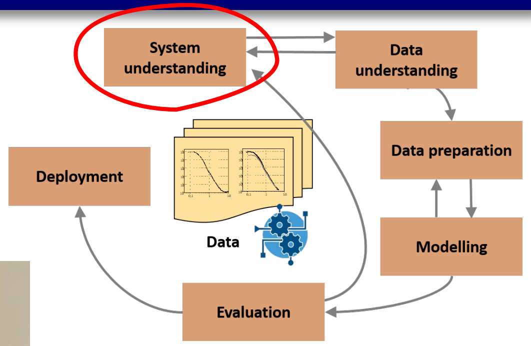
Purpose:
Quality Assurance of Lego stones

Our Use Case



The test bench





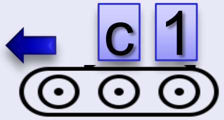
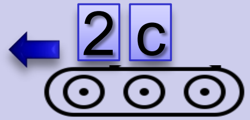
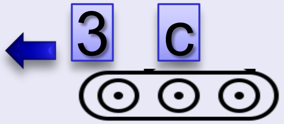
Our Use Case

tweedback

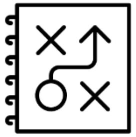
Moderator Session-ID 58dm

The functions of the production system components

[Tweedback]

Component	Function	Remarks
Conveyor belt		
Freqency converter		
Infrared temperature sensor		
Acceleration sensor		
Industrial camera		
Photoelectric sensor 1 = fork light barrier 		
Photoelectric sensor 2 		
Photoelectric sensor 3 		

Our use case



The scenario

Prof. Engelmann: Plant manager

- We have a lot of trouble with our automated quality assurance line
- The OEE KPI is a catastrophe!
- We have a lot of downtime
- Solve the problem, <u>**Now**</u> !
- We need to know what is our major issue.

You: data scientist

- OE... KP...What...?

Our Use Case - Excursion

Fundamentals of production control

- The OEE – Overall Equipment Effectiveness

$$OEE = Availability \cdot Effectiveness \cdot Quality\ rate$$

- Availability:

$$Availability = \frac{APT}{PBT}$$

- Effectiveness

$$Effectiveness = \frac{PRI \cdot PQ}{APT}$$

- Quality rate

$$Quality\ Rate = \frac{GQ}{PQ}$$

Our Use Case - Excursion

Overall Equipment Effectiveness (OEE) factors combined with loss types and possible causes of loss

OEE Factor	***Loss type***	***Cause of loss***
– Availability:	– Equipment failure – Setup & adjustment	
– Effectiveness	– Idling & minor stoppages – Reduced speed	
– Quality rate	– Quality deviations – Deviations from product changeover	

Our use case

The scenario

Prof. Engelmann: Plant manager

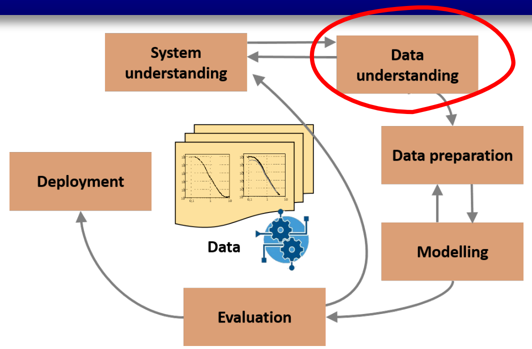
- We have a lot of trouble with our automated quality assurance line
- The OEE is a catastrophe!
- We have a lot of downtime
- Solve the problem, **<u>Now</u>** !
- We need to know what is our major issue/failure class.

You: data scientist

- OK, I know the system and OEE
- Let me have a look at the data

Our Use Case

The dataset



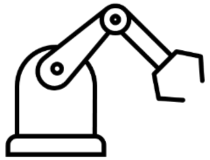
Row: Dataset for each product *P1* with many features *(cycle_time, duration_cam…)*

	cycle_time	duration_cam	duration_end	wait	fork_light_barrier	acc_sensor	motor_temp	Lego_check	width_Lego	length_Lego	horizontal_distance	vertical_distance
	00:00:02	00:00:02	00:00:00	00:05:39	1	2.6416	28.5206	1	164.23	246.44	-0.032533	-0.389930
1	00:00:02	00:00:02	00:00:00	00:07:05	1	2.6519	26.7138	1	163.77	246.32	-0.033498	-0.367090
2	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6487	24.1249	1	163.53	246.42	-0.038323	-0.366120
3	00:00:07	00:00:07	00:00:00	00:00:03	1	2.6484	28.7740	1	163.35	246.28	0.025371	-0.016770
4	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6513	27.0664	1	163.36	246.68	0.021510	-0.024169

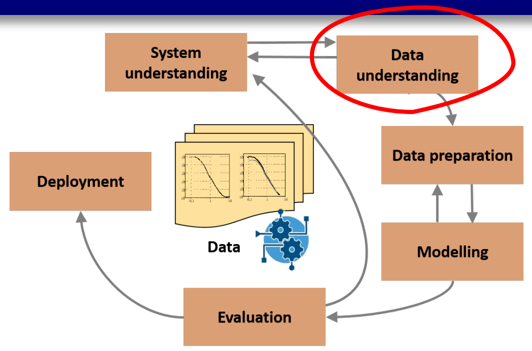
n = 7757 datasets

Maybe we can train a Machine Learning model, which is feasible to evaluate the major issues in our production line automatically?

Our Use Case



The dataset + label



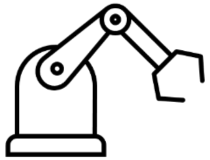
	cycle_time	duration_cam	duration_end	wait	fork_light_barrier	acc_sensor	motor_temp	Lego_check	width_Lego	length_Lego	horizontal_distance	vertical_distance
0	00:00:02	00:00:02	00:00:00	00:05:39	1	2.6416	28.5206	1	164.23	246.44	-0.032533	-0.389930
1	00:00:02	00:00:02	00:00:00	00:07:05	1	2.6519	26.7138	1	163.77	246.32	-0.033498	-0.367090
2	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6487	24.1249	1	163.53	246.42	-0.038323	-0.366120
3	00:00:07	00:00:07	00:00:00	00:00:03	1	2.6484	28.7740	1	163.35	246.28	0.025371	-0.016770
4	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6513	27.0664	1	163.36	246.68	0.021510	-0.024169

....

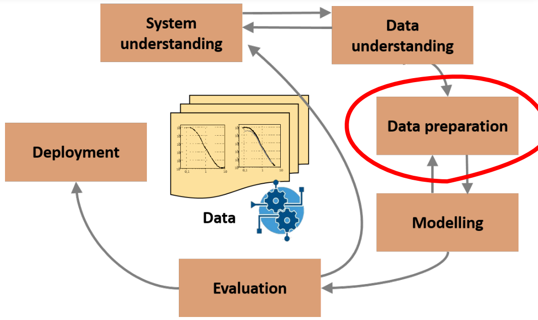
Maybe we can label each dataset with a failure mode or normal production mode

Failure mode XX

Our Use Case



The dataset



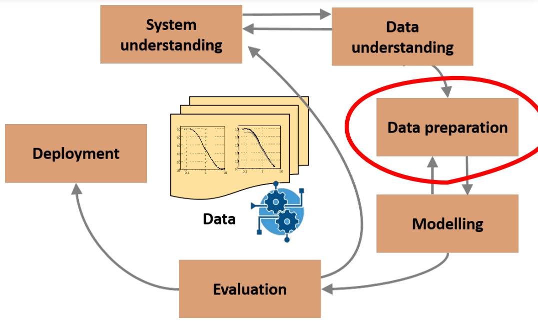
Our maintenance department label failure classes (1, 2, 3, 4, 6, 7, 8) and the normal production mode (5) in the data set

- 'Blocked_Lego‘: 1
- 'Fallen_Lego‘: 2
- 'Machine_Downtime_Long‘: 3
- 'Machine_Downtime_Short': 4
- 'Normalfall‘: 5
- 'Reduced_Motorspeed‘: 6
- 'Unplanned_Maintenance‘: 7
- 'Waiting_Time': 8

Now, we can train a model with common failure classes & in the future we are able to identify the most relevant failures automatically.

Our Use Case

The dataset

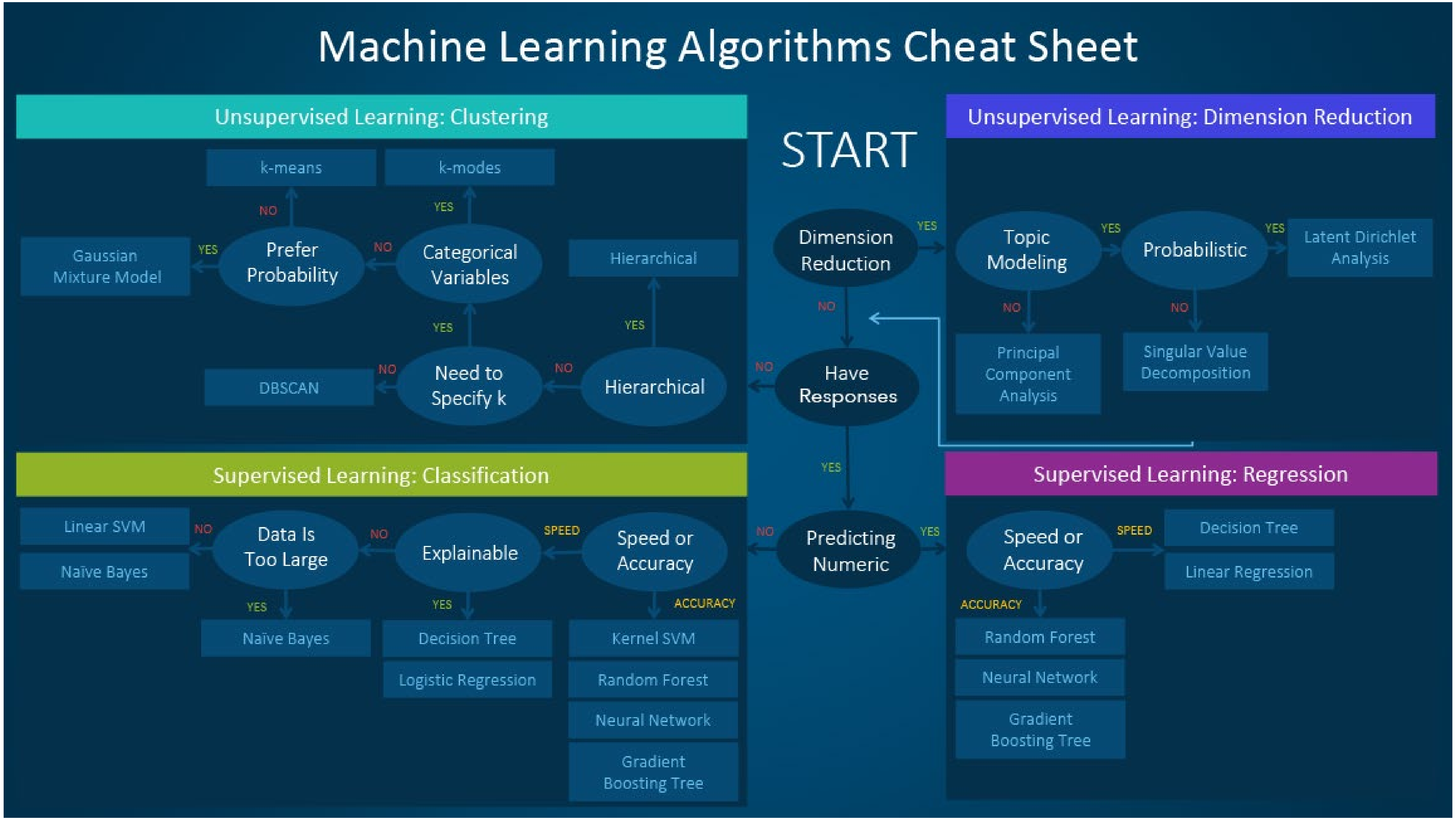


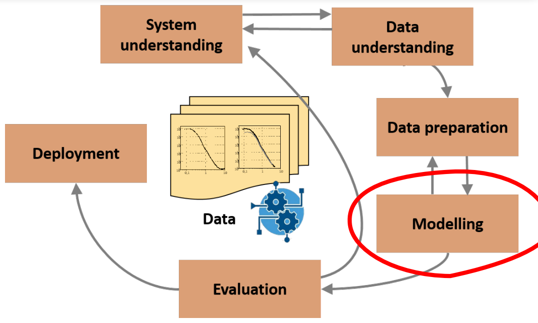
We can train a model with common failure classes & in the future we are able to identify the most relevant failures automatically

	cycle_time	duration_cam	duration_end	wait	fork_light_barrier	acc_sensor	motor_temp	Lego_check	width_Lego	length_Lego	horizontal_distance	vertical_distance	failure_class
0	00:00:02	00:00:02	00:00:00	00:05:39	1	2.6416	28.5206	1	164.23	246.44	-0.032533	-0.389930	7
1	00:00:02	00:00:02	00:00:00	00:07:05	1	2.6519	26.7138	1	163.77	246.32	-0.033498	-0.367090	7
2	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6487	24.1249	1	163.53	246.42	-0.038323	-0.366120	5
3	00:00:07	00:00:07	00:00:00	00:00:03	1	2.6484	28.7740	1	163.35	246.28	0.025371	-0.016770	1
4	00:00:02	00:00:01	00:00:01	00:00:03	1	2.6513	27.0664	1	163.36	246.68	0.021510	-0.024169	5

Which model can be used ?

Our Use Case – cheat sheet





Our Use Case – Hands On

Data: converted_data_eng.xlsx

Jupyter Notebook: SV_lego_with_converted_data.ipynb

Minute Paper