Three Ways to make your Industrial Data Science Projects a Success

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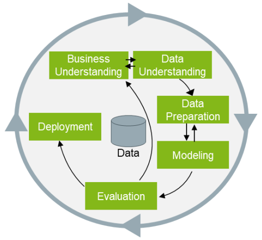
IDS 2019

Institute of Production Systems

Institute of Production Systems, Leonhard-Euler-Str. 5, D-44227 Dortmund

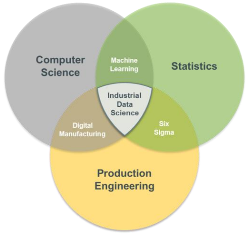
Defining the Process

- **Defining the Process**



- Dealing with Data Immaturity

- Combining Domain Knowledge with Data Science



- Conclusion

There is a Variety of Knowledge Discovery Processes

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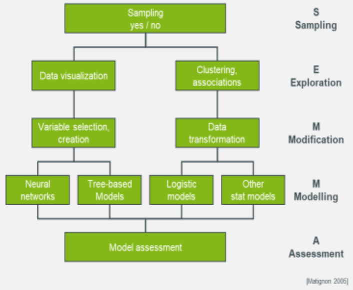
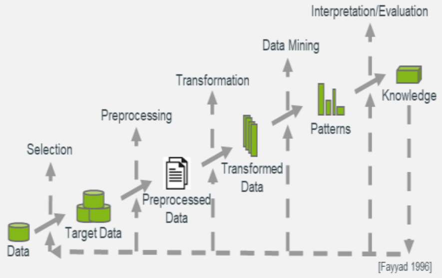
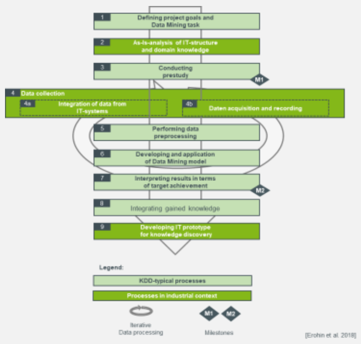
SEMMA of SAS



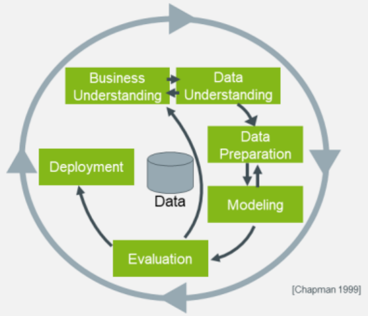
Knowledge Discovery in Databases (KDD)



Knowledge Discovery in Industrial Databases (KDID)

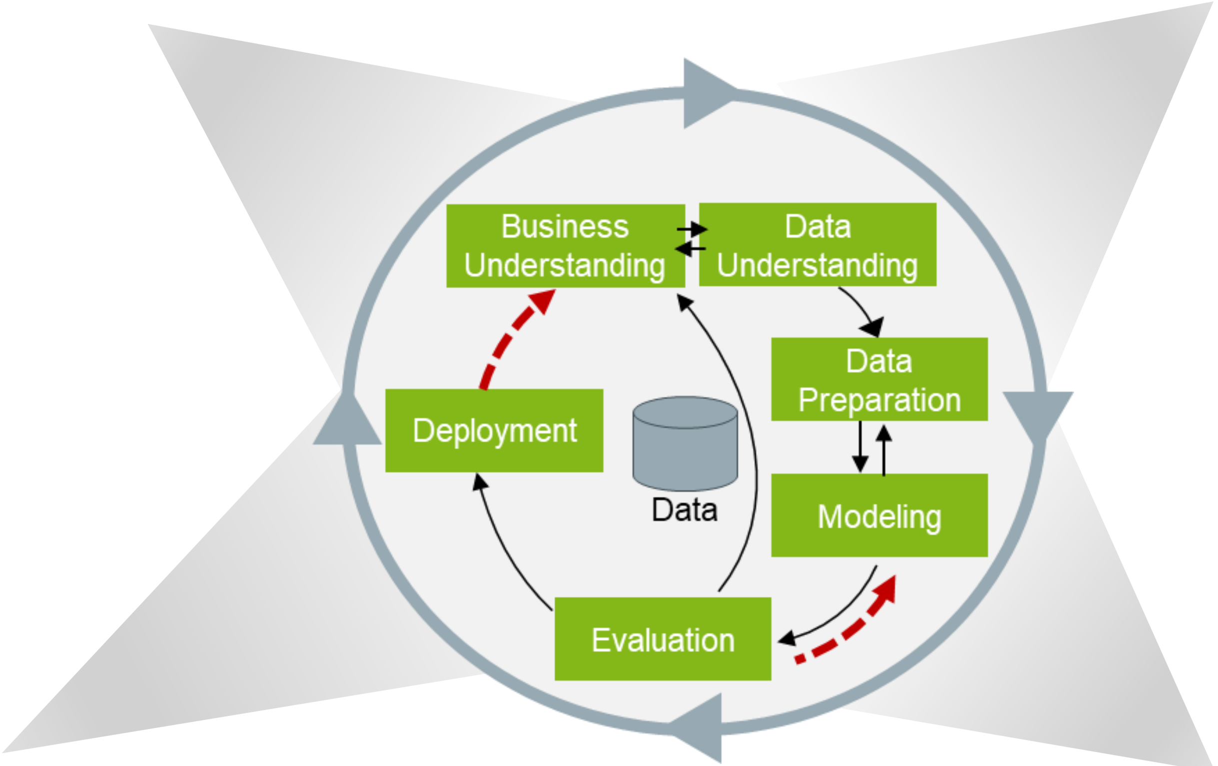


Cross-Industry Standard Process for Data Mining (CRISP-DM)



So why do we follow CRISP-DM?

- From a domain expert‘s perspective, the process is very intuitive
- It resembles a PDCA- respectively a DMAIC-circle



- It provides a well defined project structure
- It can easily be adapted across different industries

CRISP-DM provides a well defined Project Structure

SMD-Value Stream: Shortening quality control loops and reducing the need for X-Ray inspection

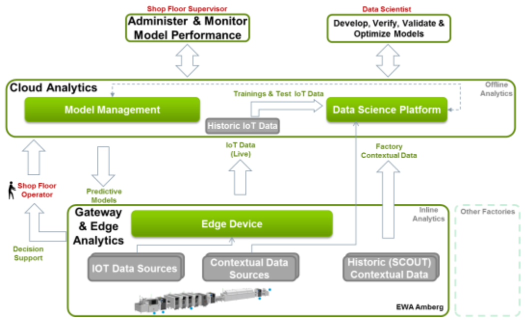
ATTRIBUTE

SPI Daten
- CSV-Dateien
- Eine Datei pro Nutzenseite
- Kopfzeile + Rumpfdaten
- 37 Attribute (numerisch & nominal)

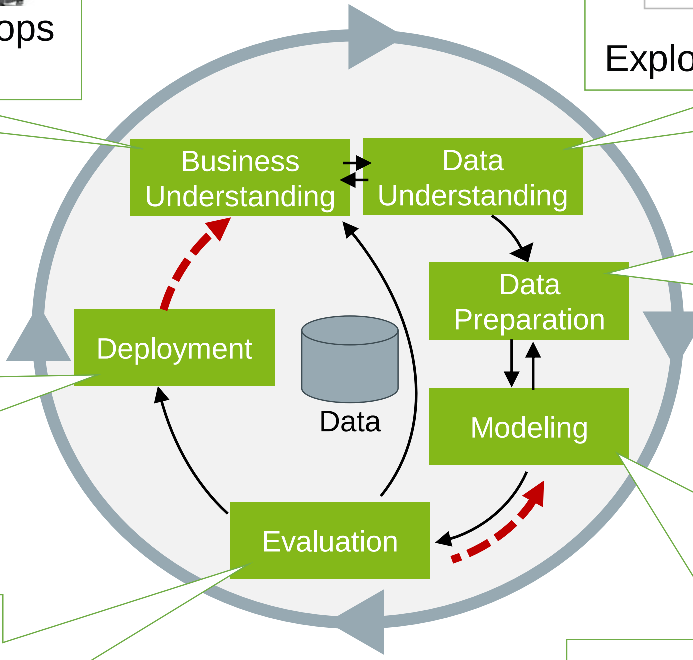
LABEL

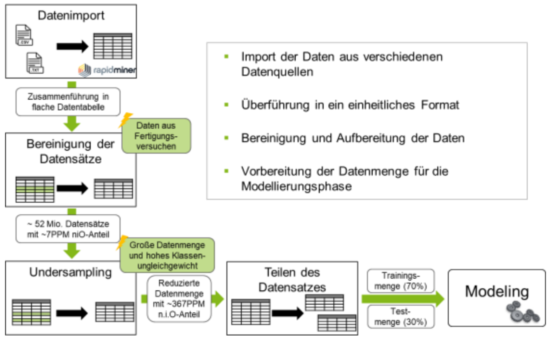
Röntgen Daten
- TXT-Dateien
- Eine Datei pro Nutzen
- Leer wenn Nutzen i.O., sonst fehlerhafte Board_Component_Pin

Exploring process and inspection data



Deploying based on IoT-Architecture



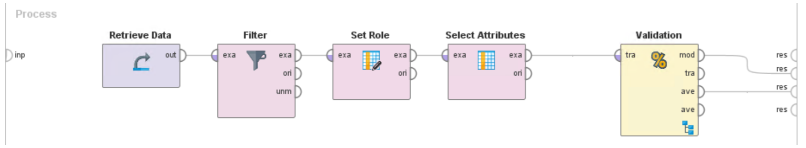


- Import der Daten aus verschiedenen Datenquellen
- Überführung in ein einheitliches Format
- Bereinigung und Aufbereitung der Daten
- Vorbereitung der Datenmenge für die Modellierungsphase

Aggregating and cleansing of data

300.103 Datensätze Gesamt		Wahres Ergebnis: n.i.O (Positive)	Wahres Ergebnis: i.O (Negative)		
Prognose	n.i.O (Positive)	107	110.664	Precision 0,10 %	Pseudofehlerrate 99,90 %
Prognose	i.O (Negative)	3	189.329	False Omission Rate 0,00 %	Negative Predictive Value 100 %
		Sensitivity / Recall 97,27 %	False Positive Rate 36,89 %	Accuracy 63,12 %	
		Schlupfrate 2,73 %	Specificity 63,11 %		

Optimising slack rate and pseudo faults



Selecting and configuring suitable prediction models

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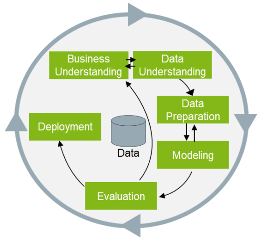
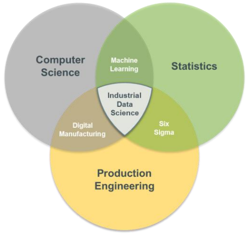
- Defining the Process



- **Dealing with Data Immaturity**

- Combining Domain Knowledge with Data Science



- Conclusion

Data Maturity can be assessed by applying a defined Set of Criteria

- Data Acquisition – How is data collected along the value stream?
- Sample Size – Are there enough representatives of each class and are they evenly distributed?
- Reference Level – Is the data available in a high and uniform granularity?
- Consistency – Does the relevant data set contain logical contradictions?
- Traceability – Can label and feature value characteristics be joined unambiguously?
- …

We have specified ten Criteria and four Levels of Maturity each

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Criteria	Maturity level			
	1	2	3	4
Data collection	manual entry	electronical, must be triggered manually	data acquisition is carried out automatically in most cases	fully automated data collection
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Reference: Eickelmann et al. (2019): Bewertungsmodell zur Analyse der Datenreife.
In: ZWF Jg. 114, 1-2, S. 29-33

Non uniform Reference Levels prohibit Supervised Learning

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Supervised Learning of Quality Labels from End-of-Line-Test Data

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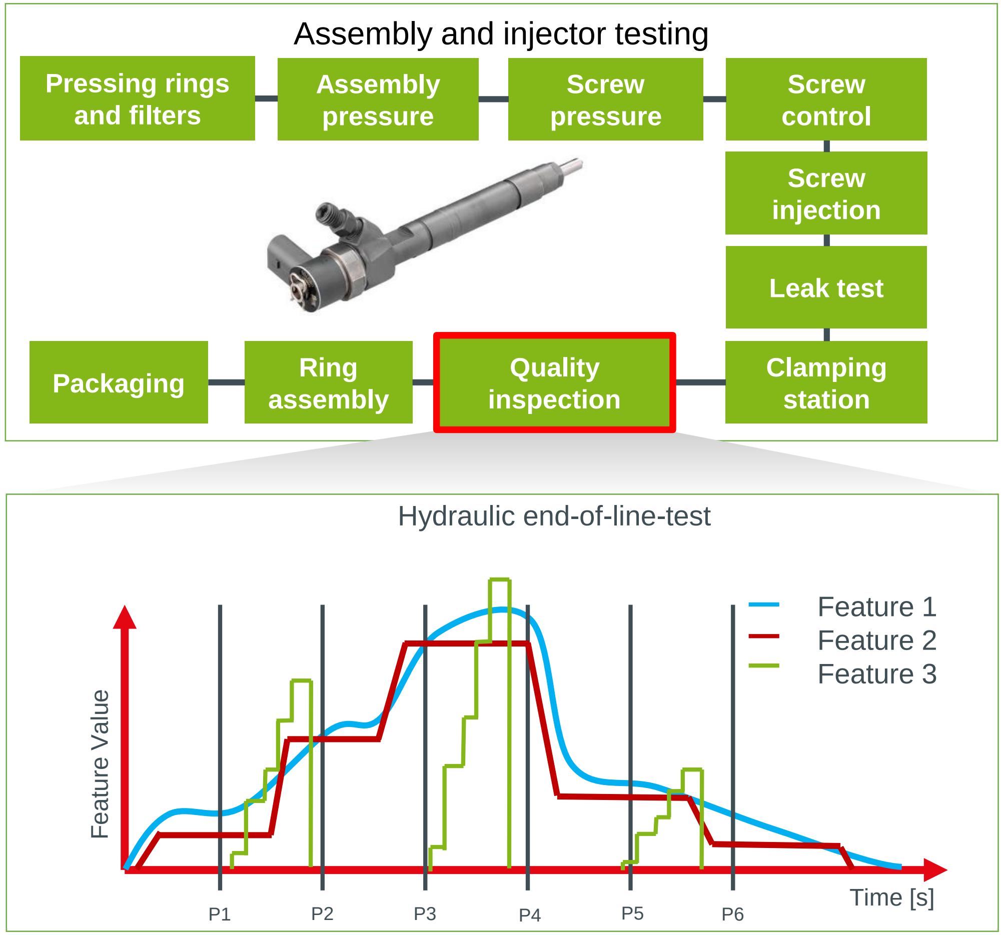
- Diesel Injector Nozzle Manufacturing Value Stream



		True result			
		NOK 3.018 (4,42 %)	**OK** 65.302 (95,58 %)		
Forecast	**NOK** 1.656 (2,42 %)	1.021	635 Pseudo faults	Precision 61,65 %	Pseudo fault rate 38,35 %
Forecast	**OK** 66.664 (97,58 %)	1.997 Slack	64.667	False omission rate 3,00 %	Negative predictive value 97,00 %
		Sensitivity / Recall 33,83 %	False Positive Rate 0,97 %	Accuracy 96,15 %	
		Slack rate 66,17 %	Specificity 99,03 %		

Unbalanced Label Proportions result in high Recall Rates

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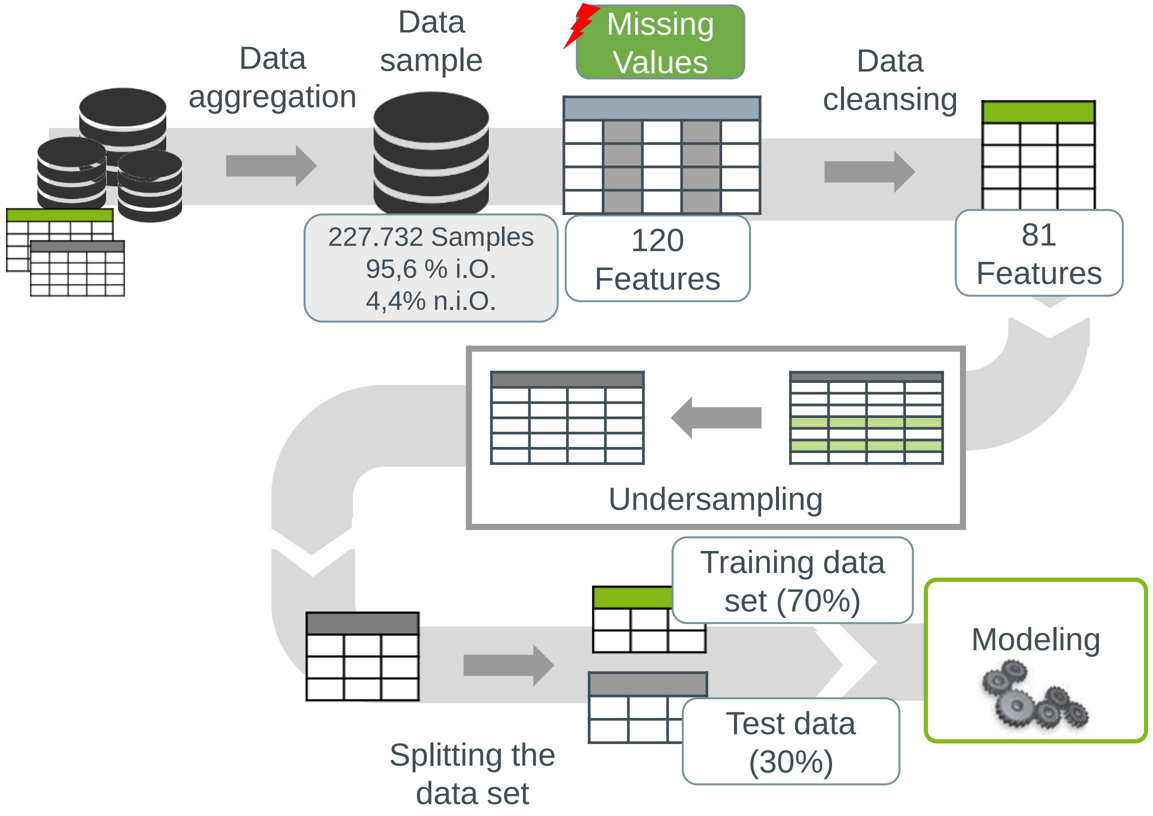
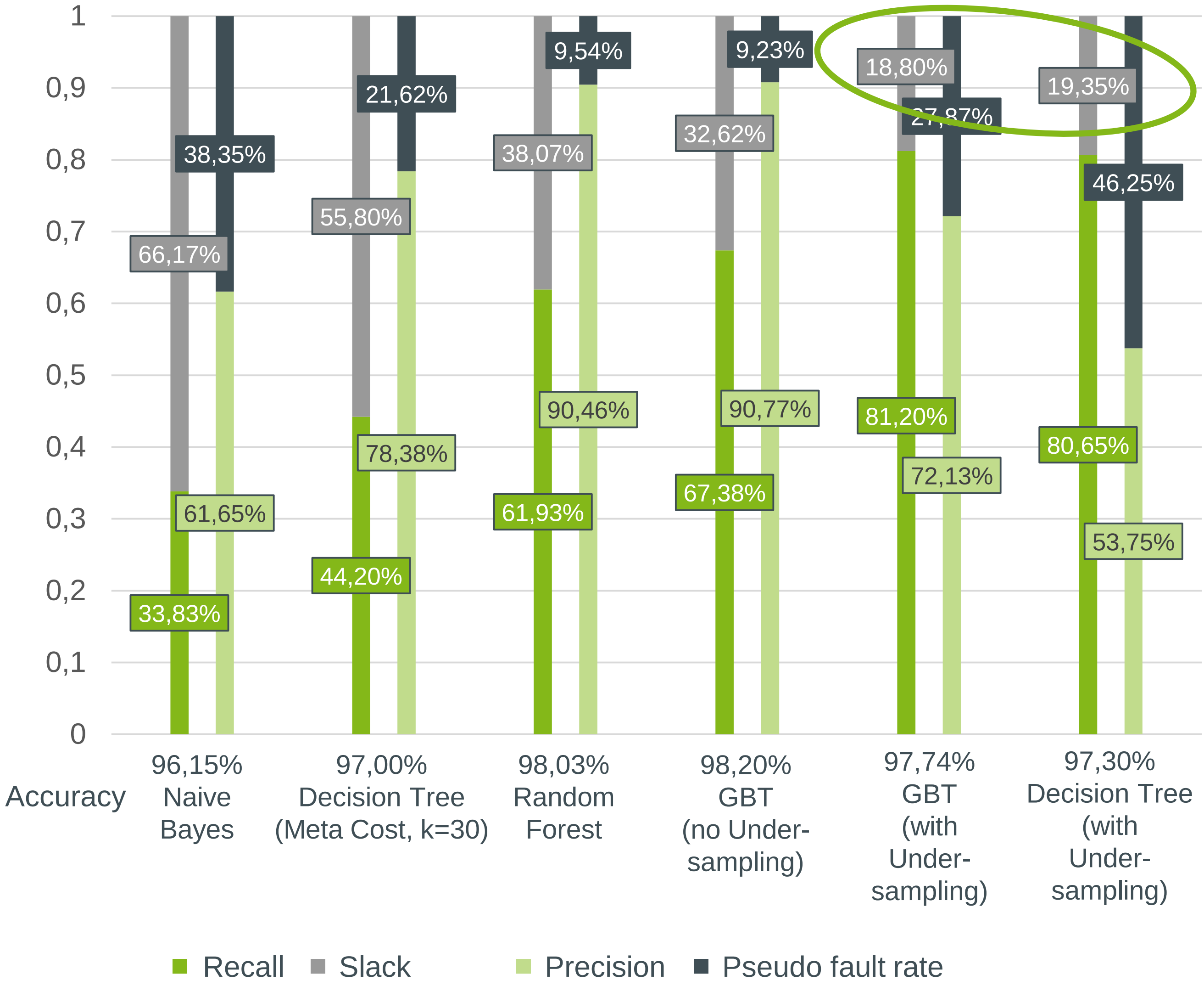
Undersampling reduces the Effect of unbalanced Label Proportions





A Lack of Tracebility prohibits Supervised Learning

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Combining Domain Knowledge with Data Science

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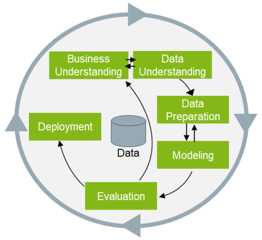

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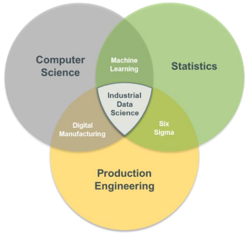

- Conclusion

Domain Knowledge is required in every Stage of CRISP-DM

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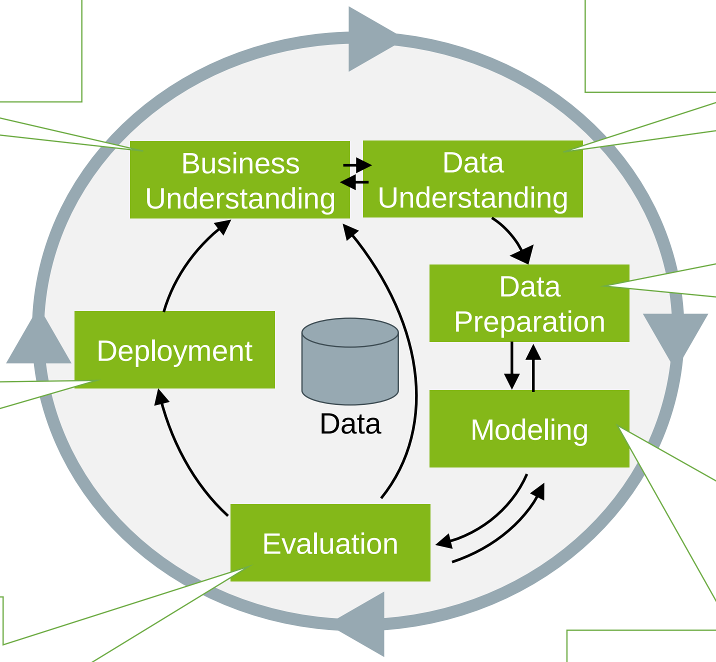
Business-related objectives are derived and suitable success criteria are defined

Faster and better selection of critical features and labels by applying domain knowledge



Implementation and integration of prediction models in manufacturing and business processes

Domain knowledge enables the identification and elimination of unrealistic/wrong data

The project team is able to interpret and validate the model results in an application-oriented manner

Existing domain knowledge can be applied to avoid overfitting

Data Scientists and Domain Experts have been learning from each other

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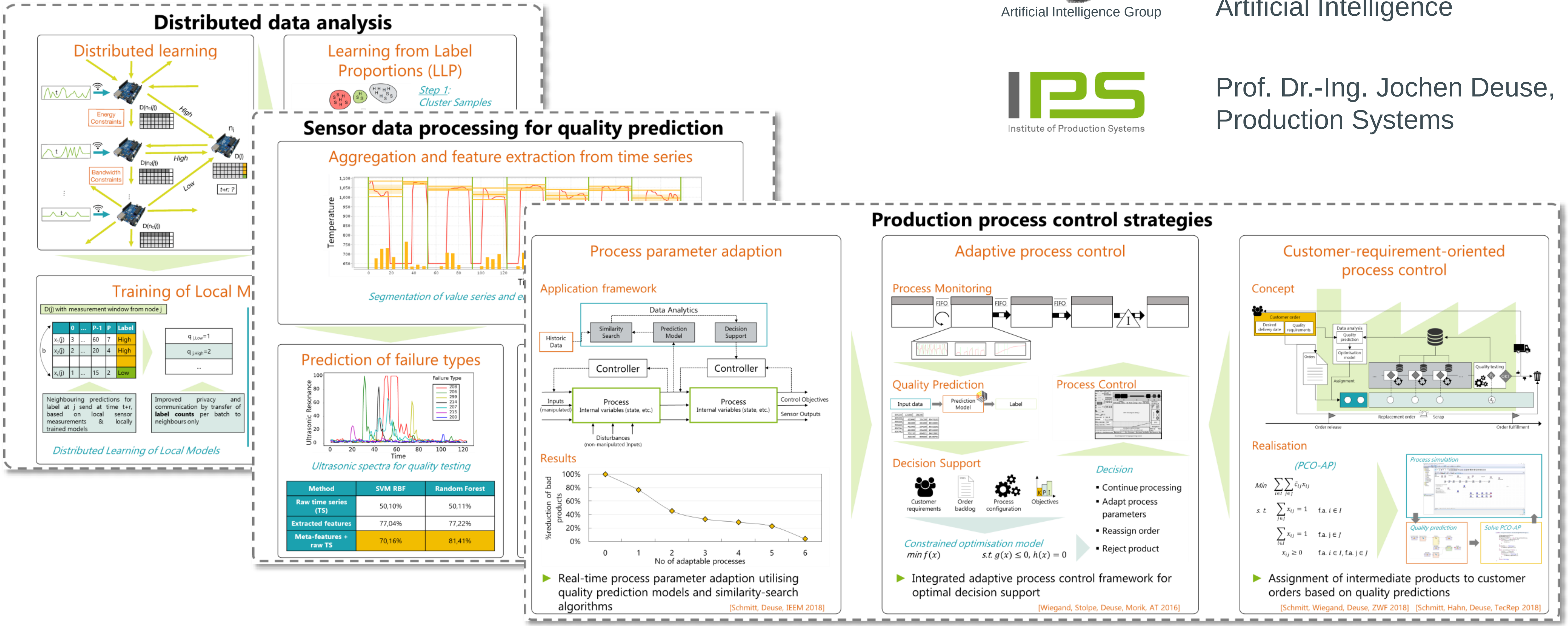
SFB 876 - B3: Data Mining on Sensor Data of Automated Processes

Artificial Intelligence Group

Prof. Dr. Katharina Morik,
Artificial Intelligence

Institute of Production Systems

Prof. Dr.-Ing. Jochen Deuse,
Production Systems



Citizen Data Scientists blending Domain Knowledge and Data Science

SYSKRON Citizen data scientists RIF Institut für Forschung und Transfer

BITBURGER BRAUGRUPPE STARKE MARKEN
Augustiner Bräu München gegründet 1328
Domain experts

rapidminer
Data scientists

Prediction of…

…malt processability

…lautering duration

…yeast processing yield

Interdisciplinary Training overcomes Faculty Boundaries

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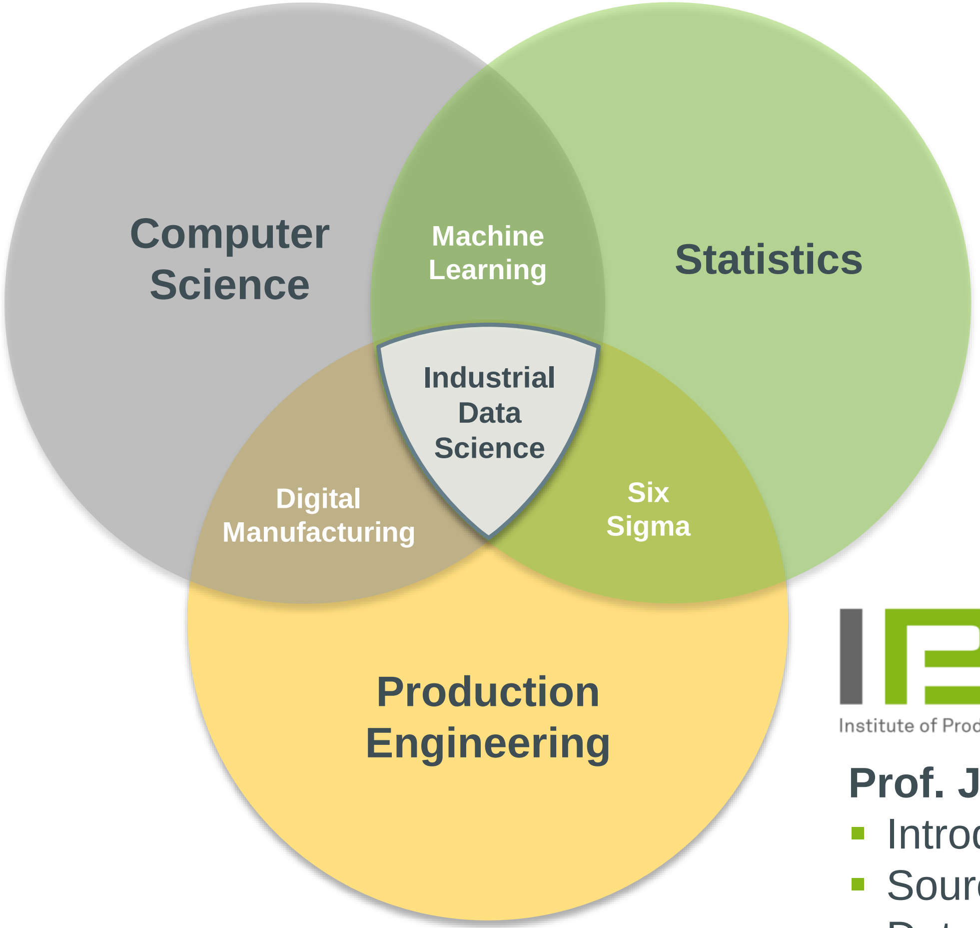
TECHNISCHE UNIVERSITÄT DARMSTADT

Prof. Kristian Kersting:
- Deep Learning
- Tree-based procedures
- Ensemble strategies

fakultät statistik

Prof. Claus Weihs:
- Association Analysis
- Data Transformations
- Concepts for Model Selection



fakultät für informatik

Prof. Jens Teubner:
- Basics of Data Management
- Database Systems
- Data Warehouses

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Prof. Jochen Deuse:
- Introduction to Industrial Data Science
- Sources of industrial data
- Data analysis in industrial environments

Students from all three Disciplines collaborating on Industrial Use Cases

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Project coaching

TECHNISCHE UNIVERSITÄT DARMSTADT

fakultät für informatik

fakultät statistik

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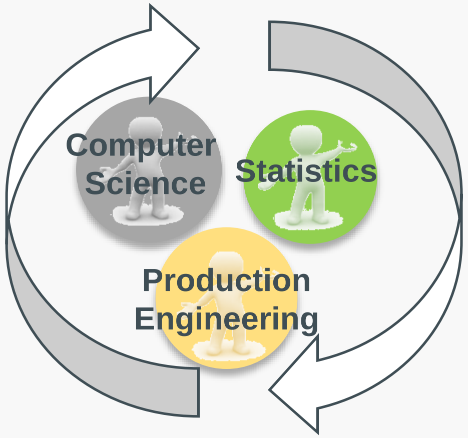
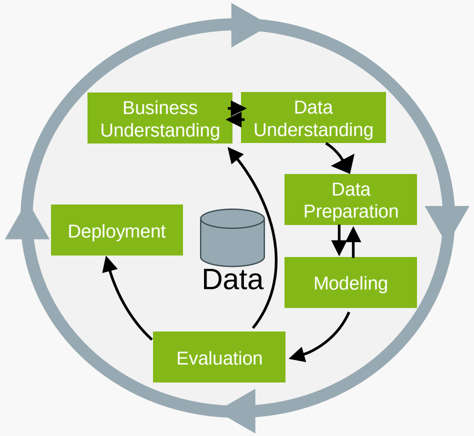
Use case driven competence development



Interdisciplinary project teams



Common project structure

Industrial use cases

Weidmüller

Quality prediction for injection molding

EVONIK KRAFT FÜR NEUES

Yield prediction for chemical processes

ebmpapst

Quality prediction for fan assembly

BMW GROUP

Quality prediction for engine assembly

Conclusion

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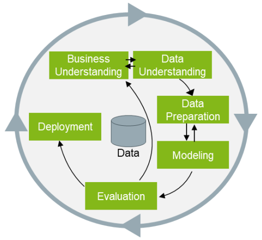

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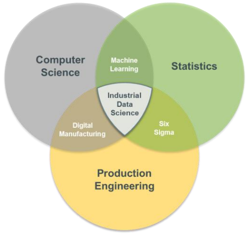

- **Conclusion**

Different Approaches can overcome Data Maturity Challenges

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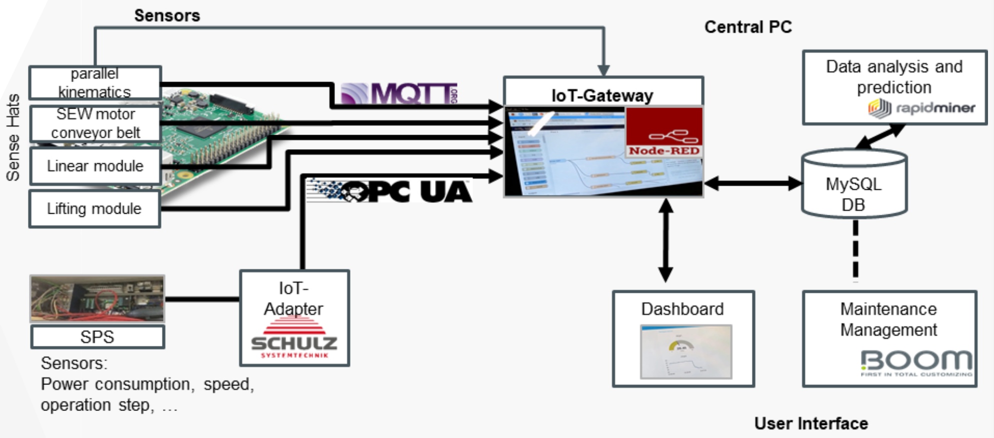
Improving data maturity (e.g. retrofitting)



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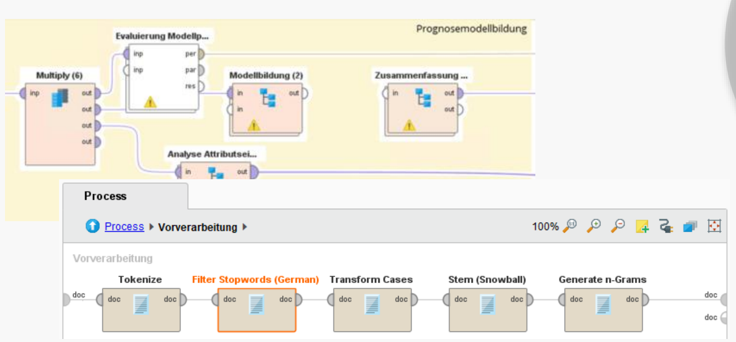
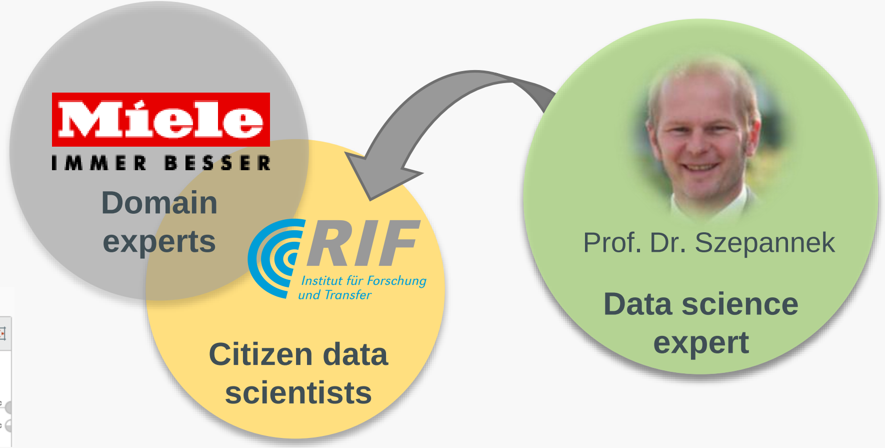
Involving senior data scientists





Thank you for your kind Attention!

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