AC-DS, SCSU, USA, April 9-10, 2021 Peter Rausch, Nuremberg, GER

Intelligent Data Analysis in the Construction Industry

Intelligent Data Analysis in the Construction Industry

Overview

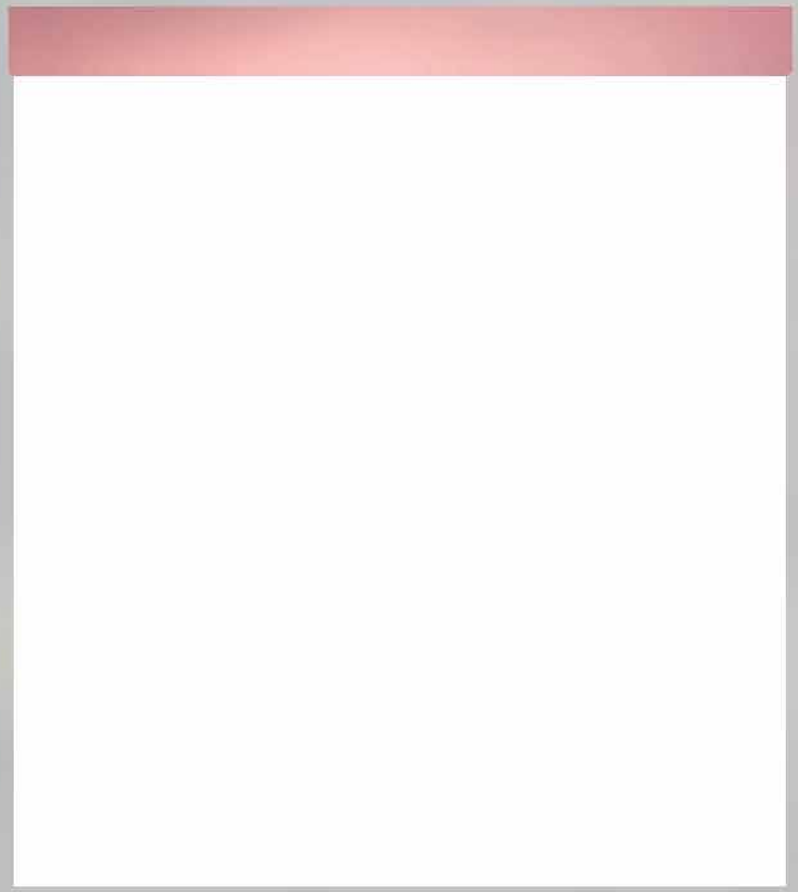
1 Construction – Some Facts

2 Challenges

3 Intelligent Data Analysis Processes

4 Benefits and Issues

5 Further Developments and Takeaways



1 Construction – Some Facts

- Total output construction (US) $ 977 bln.
- > 3,400 k enterprises
- Providing
  > 11,200 k jobs
  in the U.S.A.

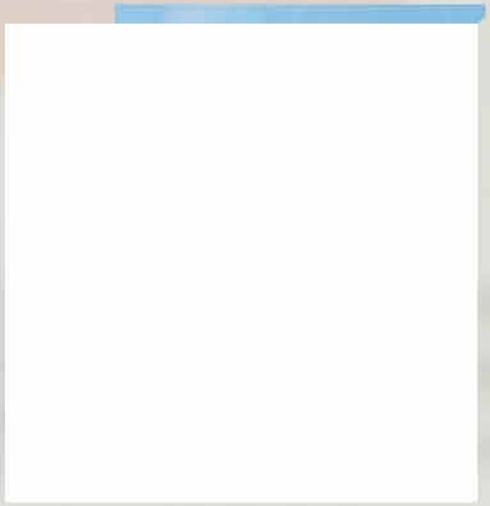
(Year 2019)

Sources:
statista.com (2021), ibisworld (2021)

1 Construction – Some Facts

Subcategories: examples

- Earth works & road construction
- Buildings
- Industrial facilities
- Demolition and deconstruction
- ...



2 Challenges

- Very tight time scales
- Avoidance of delays
- Low profit contributions of projects
- Lack of intelligent planning and control tools

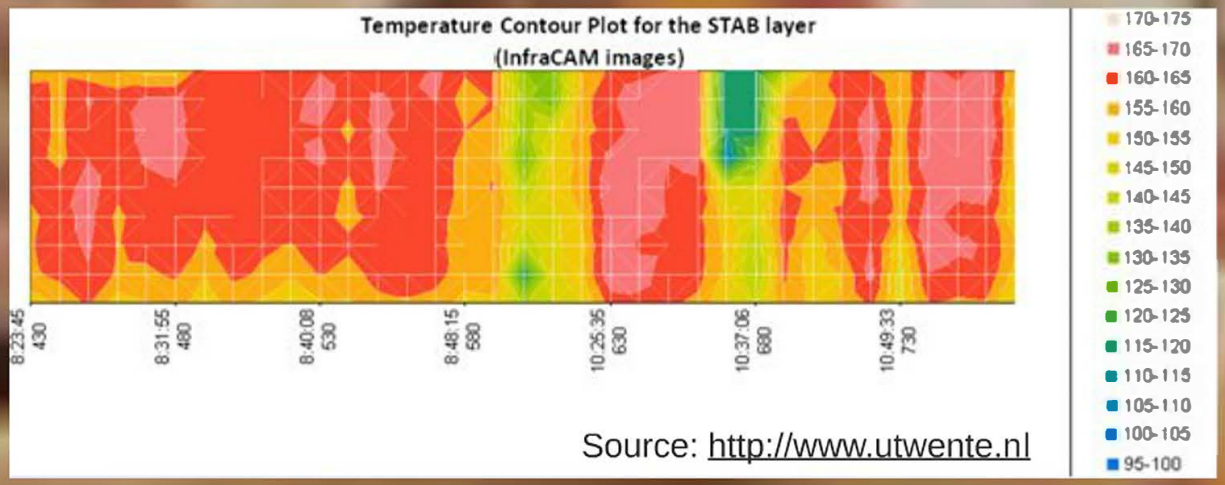
2 Challenges

- Management of complex on- and off-site supply chain processes
- Compliance with legal requirements
- Being competitive/making profit

3 Intelligent Data Analysis Processes

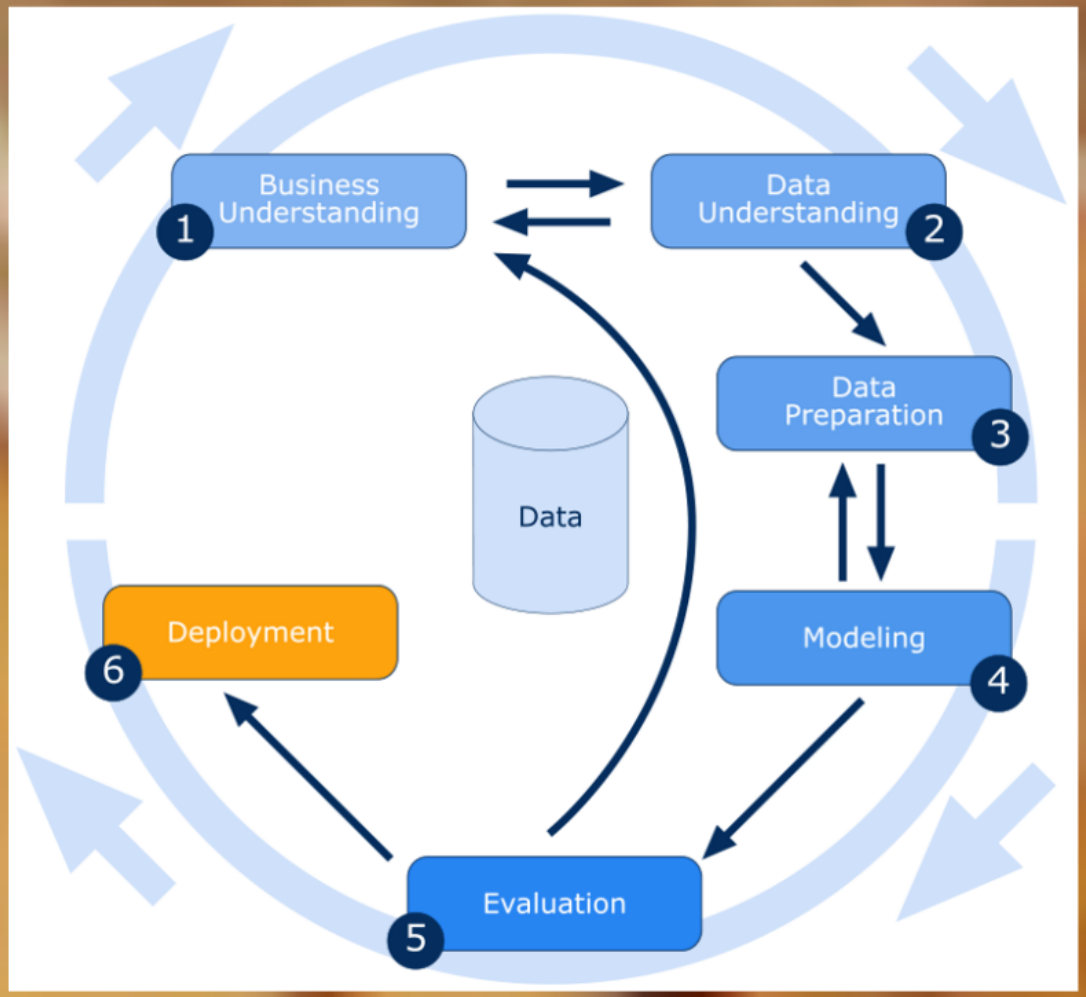
Examples for applications

- Safety management
- Cost estimation
- Performance analysis
- Predictions
  - about equipment
  - of delay risks



Source: http://www.utwente.nl

3 Intelligent Data Analysis Processes

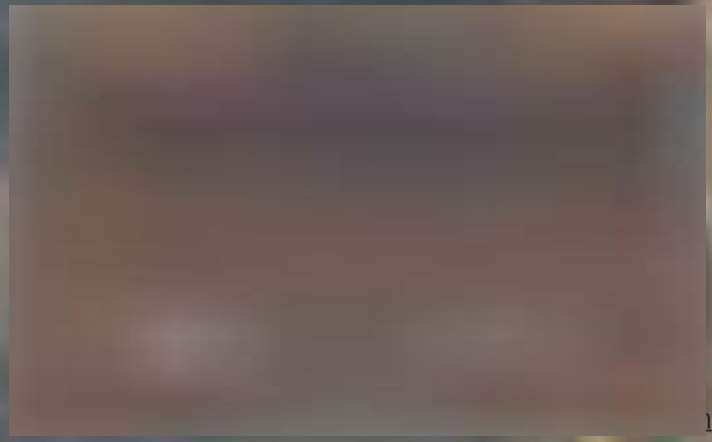


Source: Witten 2016

3 Intelligent Data Analysis Processes

Data Sources

- ERP Systems
- Production Activity Control Systems
- Project Planning Systems
- Building Information Modeling Systems
- Sensor data
  - Construction machines
  - ...



3 Intelligent Data Analysis Processes

Data Source: Construction Machines

- Bulldozers
- Excavators
- Trucks/ Autonomous haulage systems
- Asphalt pavers
- Demolition equipment

3 Intelligent Data Analysis Processes

Data Sources: Bulldozers

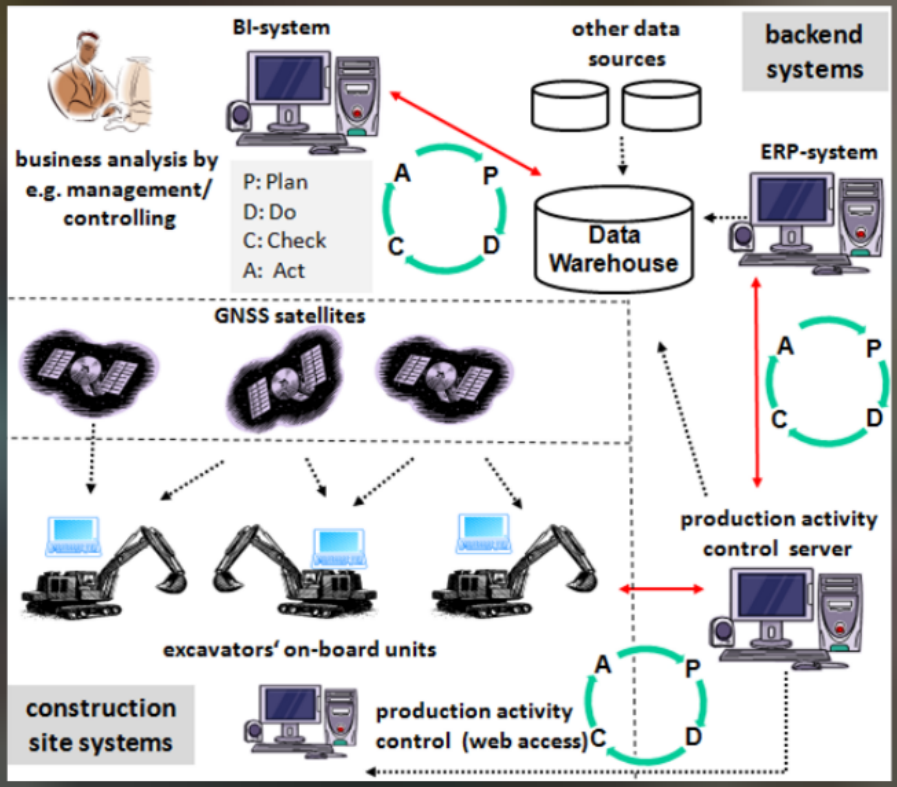
- 1st experiments at Univ. of Nottingham in 2002
- Machine guidance
- Comparisons of actual and planned performances

3 Intelligent Data Analysis Processes

EPOS* System

- Multi-layer closed-loop approach to analyze and control earthworks

Source: P. Rausch



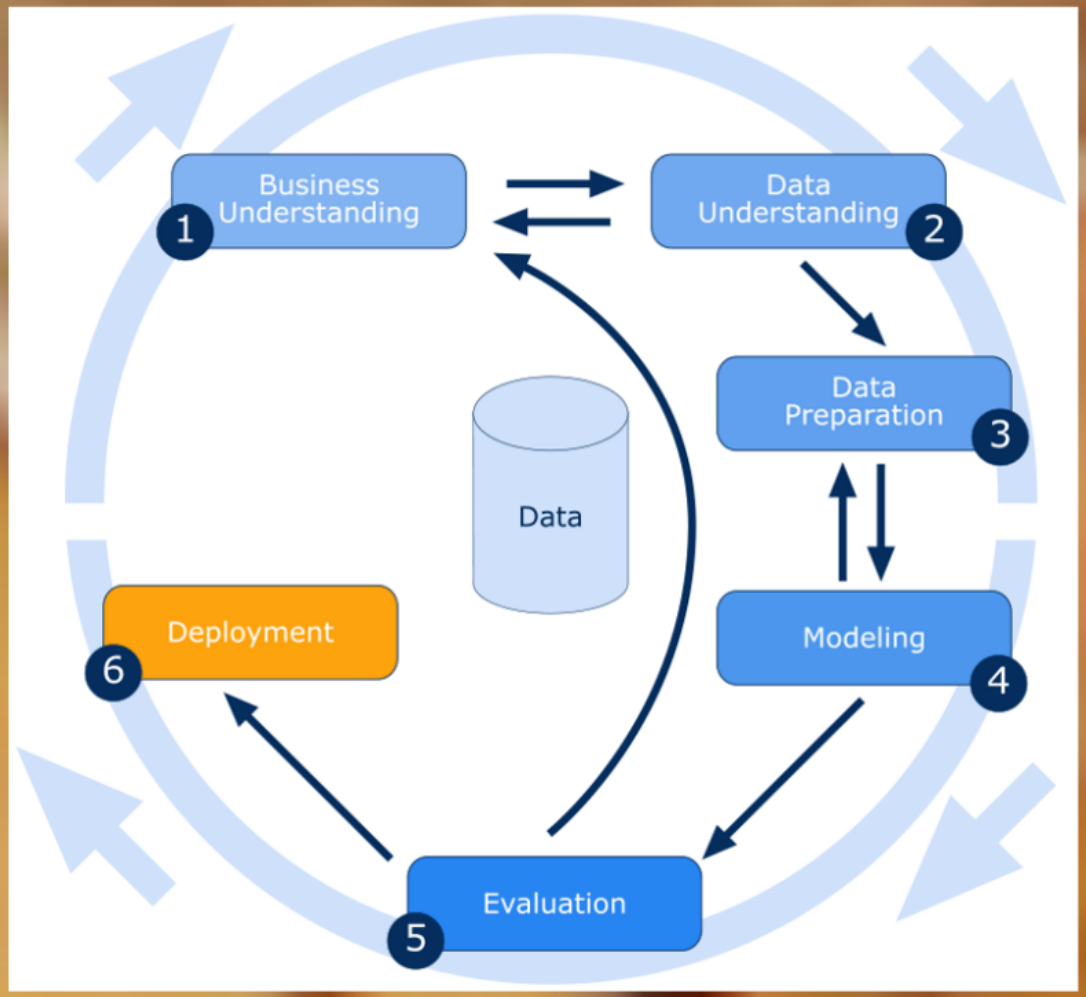
*EPOS = Efficient PrOcess design by Satellite supported software in the earth moving and road construction industry

3 Intelligent Data Analysis Processes

- Better quality of information/full transparency
- Performance issues become visible
- Increased basis of information for decisions (operational and strategic)
- Predictions of future performances
- Continuous process improvements
- Avoidance of future costs

Source: P. Rausch

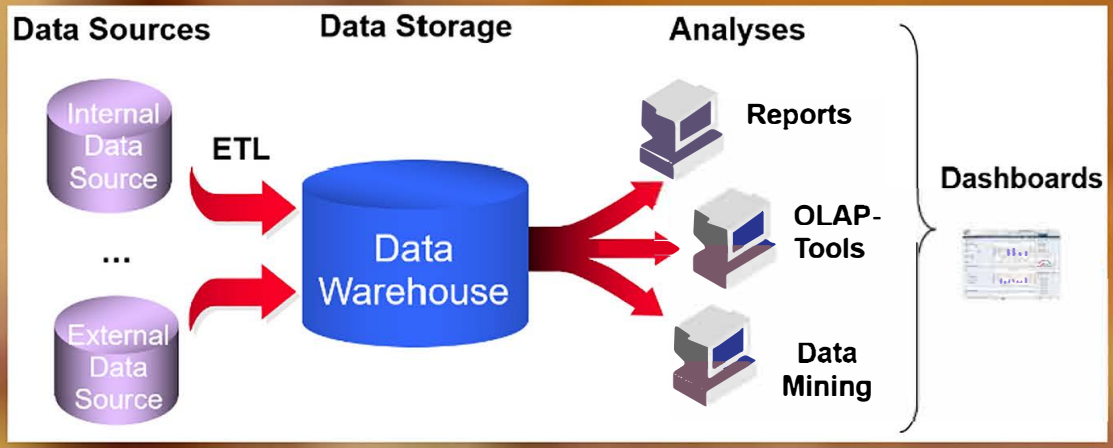
3 Intelligent Data Analysis Processes

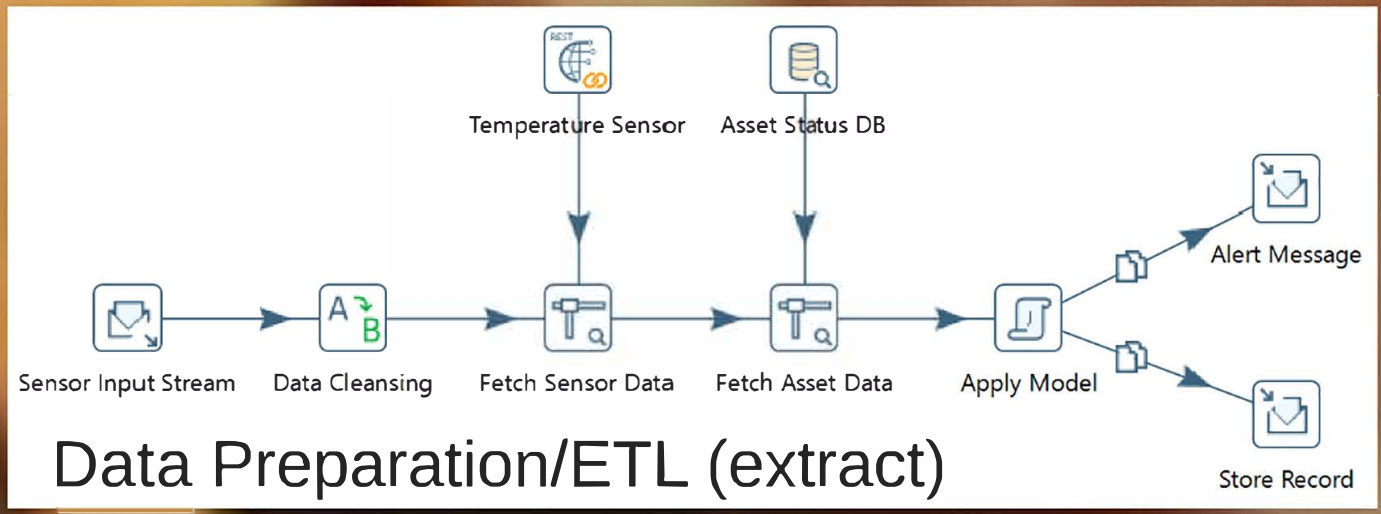


Source: Witten 2016

3 Intelligent Data Analysis Processes

Predictive Maintenance Case





Data Preparation/ETL (extract)

Sources: own representation

3 Intelligent Data Analysis Processes

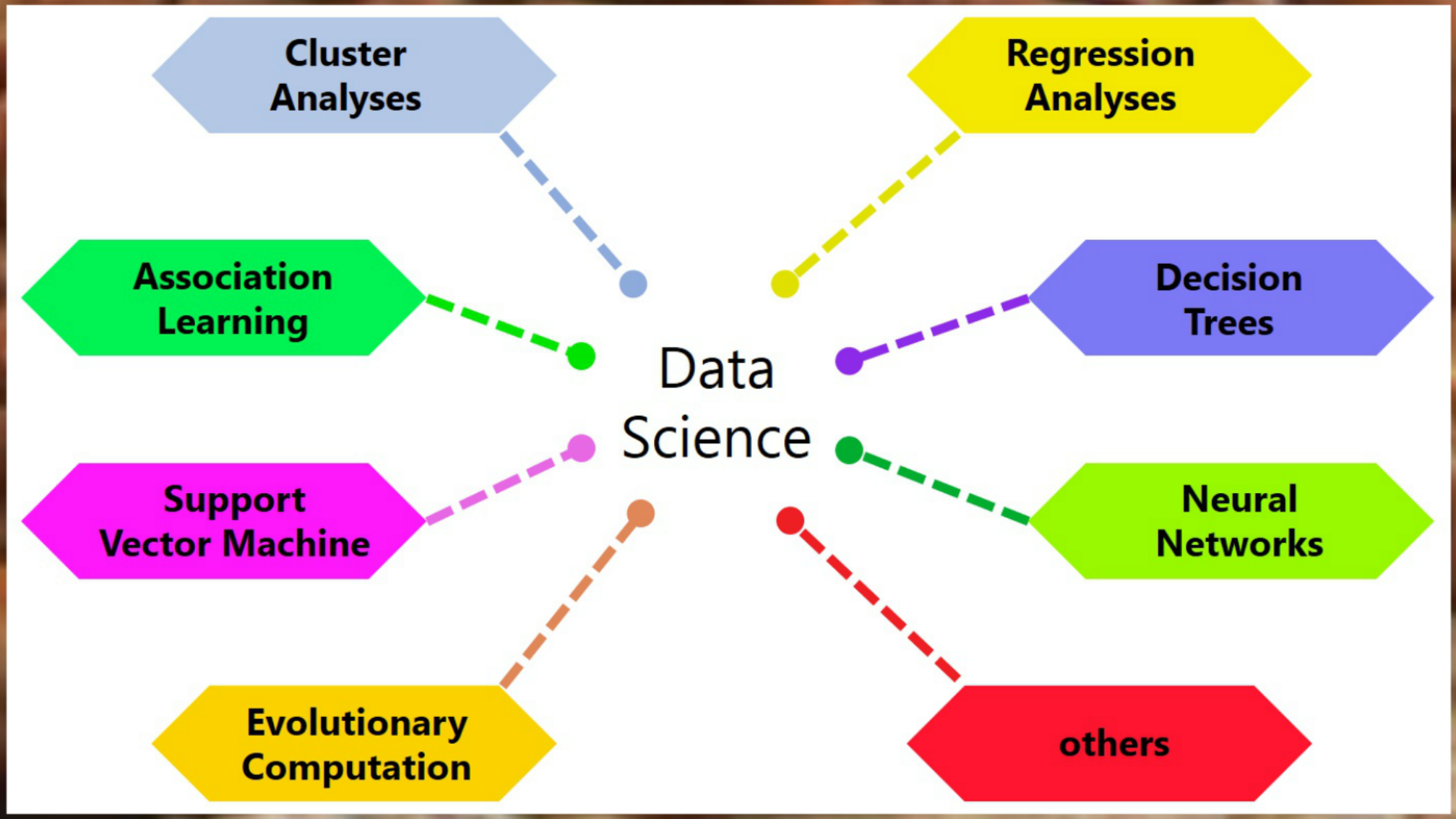
Approaches

- Descriptive
  - Exploration of patterns and relationships
  - For instance, summarization, clustering and association
  - "What has happened?"

- Predictive
  - To forecast values
  - "What could happen?"

3 Intelligent Data Analysis Processes

Selected Approaches



Source: own representation

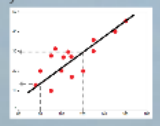
Predictive Maintenance Case:
Regression Analysis

General idea:
Simple case with 1 predictor

$$\hat{y}_j = \hat{\theta}_0 + \hat{\theta}_1 x_j \quad (1)$$

$$\sum_{j=1}^{m} (\hat{y}_j - y_j)^2 \rightarrow min! \quad (2)$$

$$y_j = f(x_j) = \hat{\theta}_0 + \hat{\theta}_1 x_j + \epsilon \quad (3)$$



Our case is more complicated!

Predictive Maintenance Case:
Regression Analysis

Remaining Useful Lifetime of excavator j at time t

$$\mathrm{RUL}_j(t) = f(S_{j,1}(t), S_{j,2}(t), ..., S_{j,n}(t)) \quad (4)$$

$$\mathrm{RUL}_j(t) = \theta_0 + \sum_{i=1}^{n} \theta_i S_{j,i}(t) + \epsilon \quad (5)$$

Source: own representation

Predictive Maintenance Case: Regression Analysis

General idea:
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$$\sum_{j=1}^{m} (y_j - \hat{y}_j)^2 \rightarrow min \quad (2)$$

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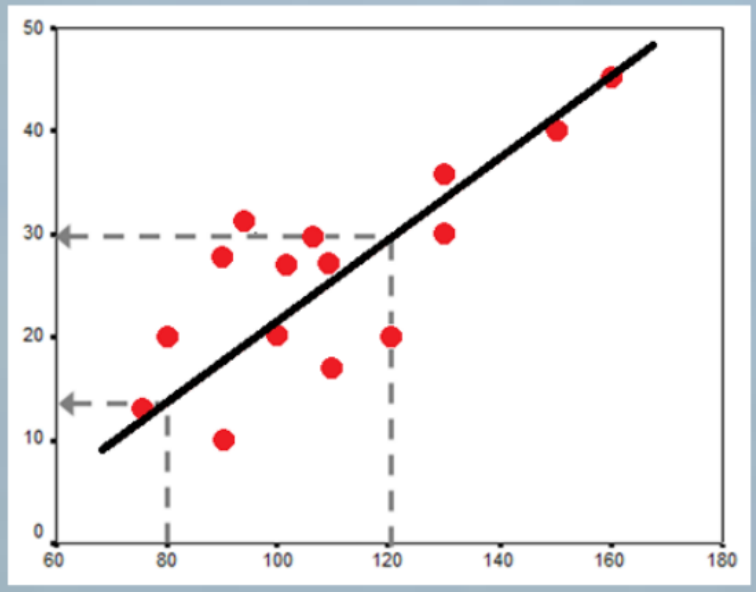

Our case is more complicated!

Source: own representation

Predictive Maintenance Case: Regression Analysis

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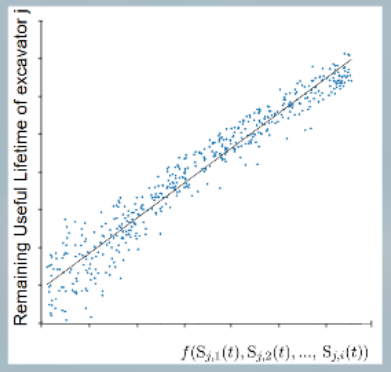
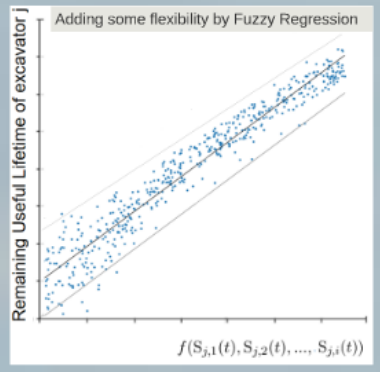




Source: own representation

3 Intelligent Data Analysis Processes

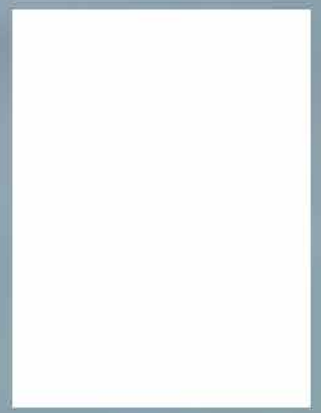
A selection of tools

- MATLAB
- WEKA
- R Statistical Environment
- Rapid Miner
- Python
- SPSS

4 Opportunities and Issues

Opportunities

- Higher transparency of complex on- and off-site supply chain processes
- Avoidance of delays
- Saving human and other resources
- Better utilization rates
- Improved safety
- Insights for offering processes
- Higher profits



4 Opportunities and Issues

Issues

- Data quality
- Handling of various data types
- Data security/ Privacy issues
- Interpretation of results
- Costs
- Reluctant attitude to new IT tools

5 Further Developments and Takeaways

Further developments

- Exploitation of a rapidly growing amount of data sources
- Ubiquitous Data Mining
- Hybrid approaches
- Cross-fertilization of AI and Data Science

5 Further Developments and Takeaways

Takeaways

- Key importance of choice and quality of data sources
- Respect legal require-ments
- Don’t underestimate the effort for data preparation and modeling
- Test various approaches
- Benefits surplus effort in many cases: Grab the opportunities!

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