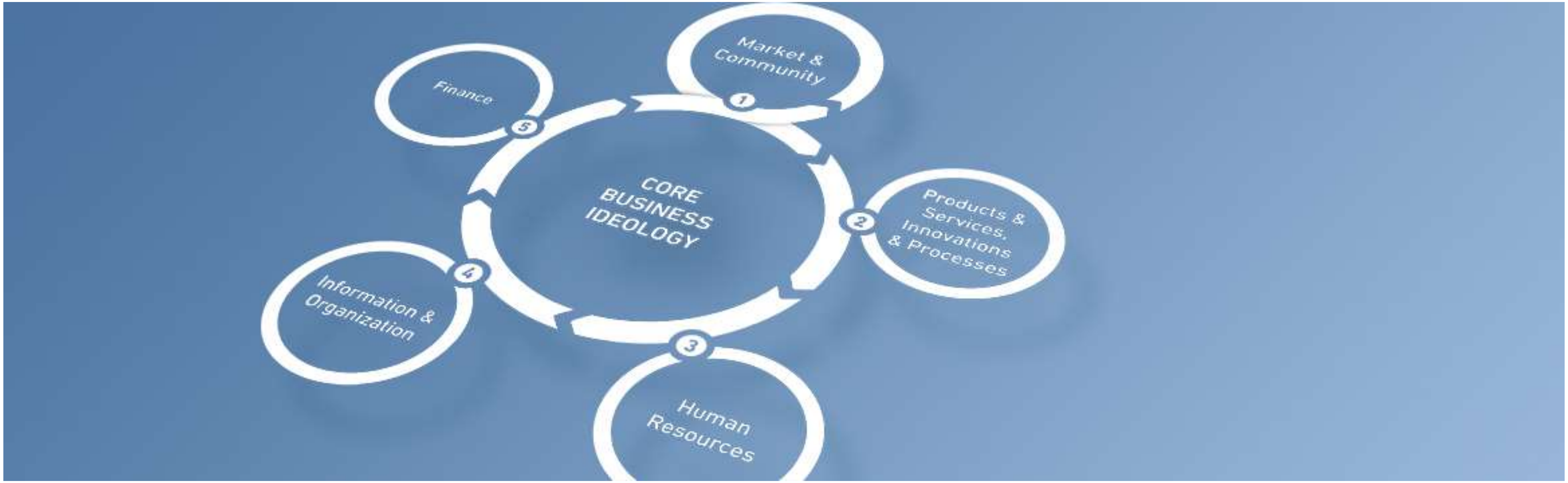

DATA SCIENCE COMPLEXITY AND SOLUTIONS IN REAL INDUSTRIAL PROJECTS

Artur Miller · PyCon.DE 2018 · Karlsruhe · 25-Oct-2018

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WHO AM I

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INTRODUCING THE ROSEN GROUP

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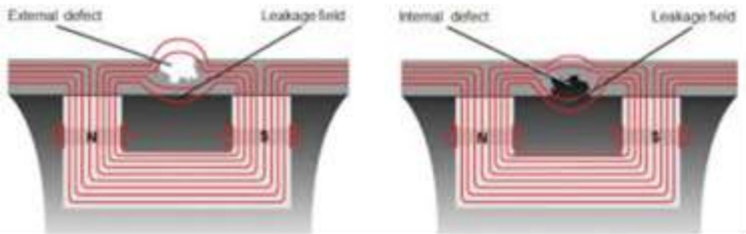
ROSEN develops and manufactures equipment, software, and methods for the inspection, diagnosis, and protection of industrial structures in a wide range of industries.

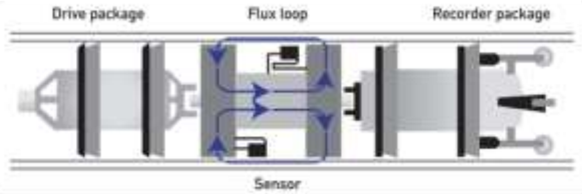
Because damage can cause serious impacts!

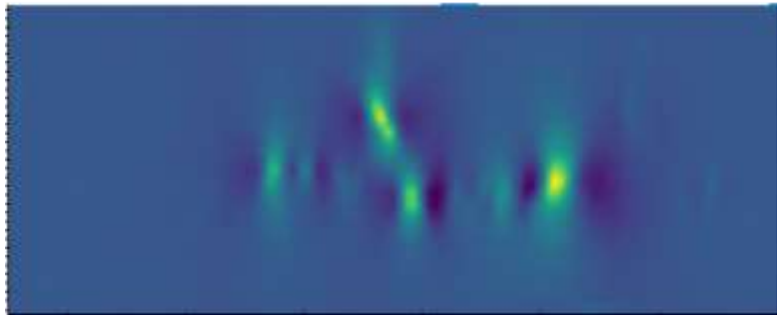
CHALLENGES IN INLINE INSPECTION

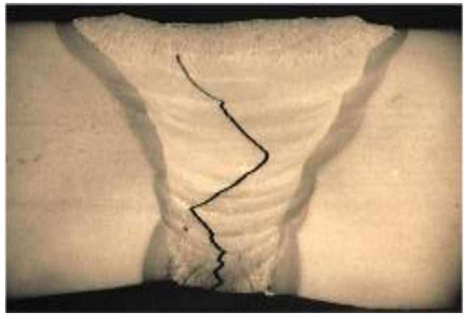
- **Classification** of installations and anomalies and accurate **estimation** of severity of defects.
- Our tools record a **huge amount data**, up to multiple terabytes per run.
- Severe defects threaten the integrity of the pipelines, therefore there is a **high risk** for environment and clients.

We address these challenges with **machine learning** and **Python**!



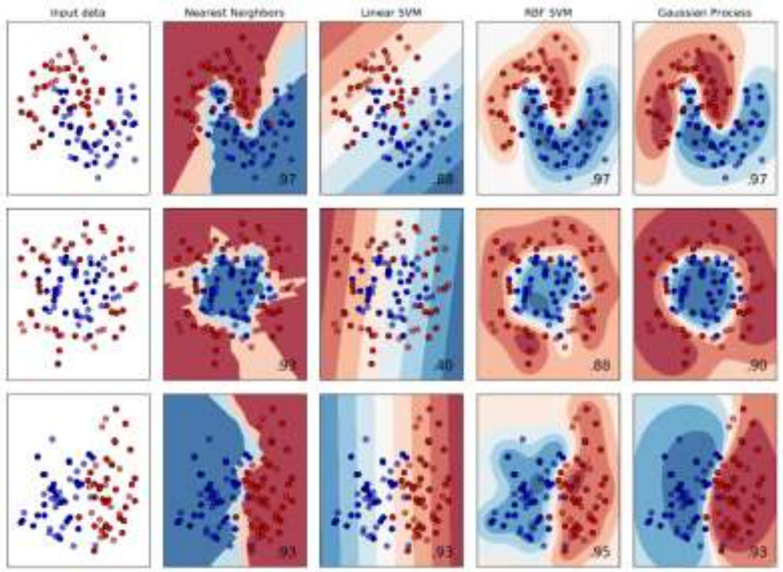






DATA SCIENCE MISCONCEPTION

- Misconception: Most of the time is spend tweaking machine learning models
- A lot of time is spend on data wrangling
- Real data is much more complex than toy datasets
- What is missing?
  - Collecting data
  - Data cleaning
  - Missing and imbalanced data
  - Scaling



MANUFACTURING

- Tool is constructed and manufactured
- Laboratory measurements
- Pull-test or Pump-test
- Pipes with artificial defects

Manufacturing → Modeling and Training → Inspection → Verification

MODELING AND TRAINING

- Estimating the depth and shape of defects with regression models
- Classification of installations and anomalies
- Data from
  - Pull-tests and pump-tests
  - Laboratory measurements

Manufacturing → Modeling and Training → Inspection → Verification

INSPECTION

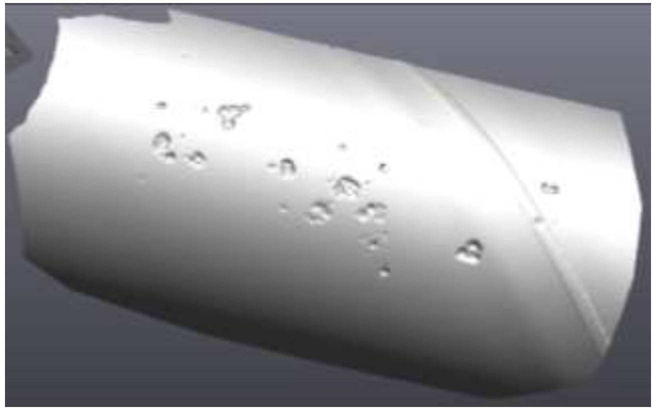
- Preparing, transporting and launching the tool
- Tool takes measurements of the pipeline
- Processing and analyzing the data
- Reporting

Manufacturing → Modeling and Training → Inspection → Verification

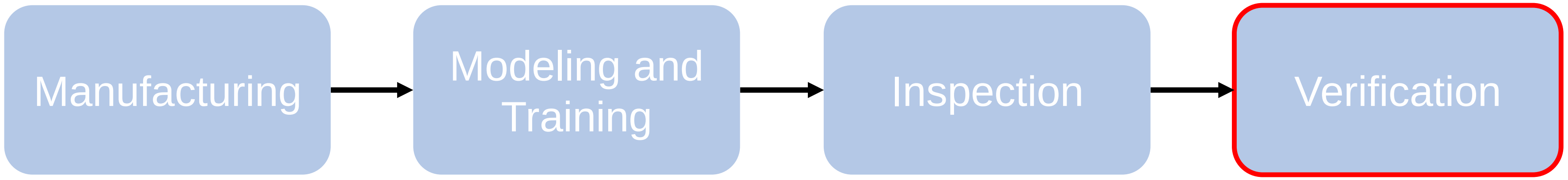
VERIFICATION

- Excavations for reparations
- Only severe defects

Old: Pit Gage



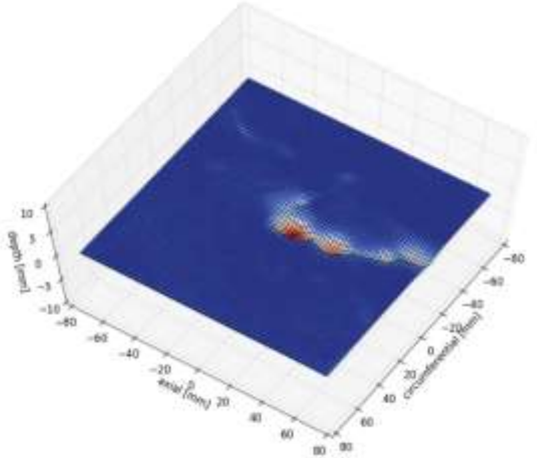
Modern:
- Laser-scans
- X-ray computed tomography

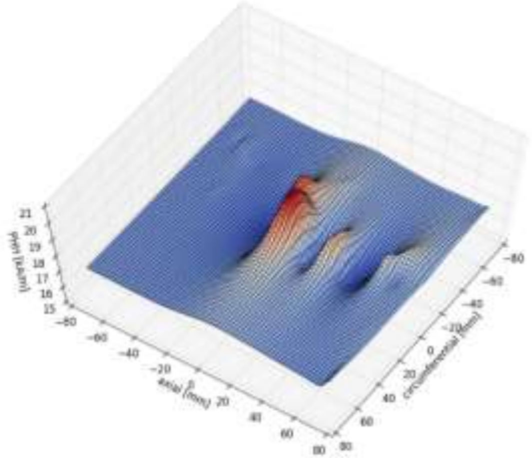


VERIFICATIONS

Laser-scans

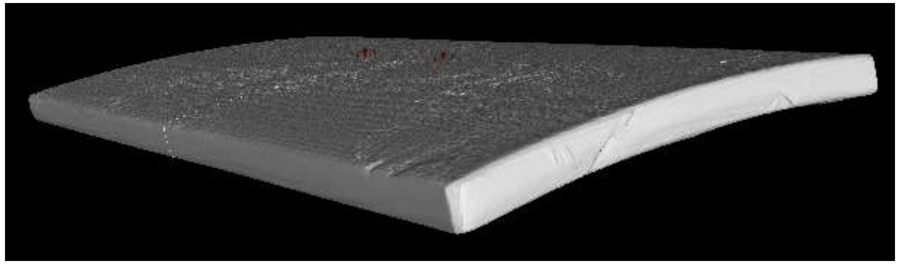
- High resolution image of the outer pipeline wall
- Good image of corrosion
  - Depth and shape
- Better than artificial defects (e.g. ellipses)
- Non destructive





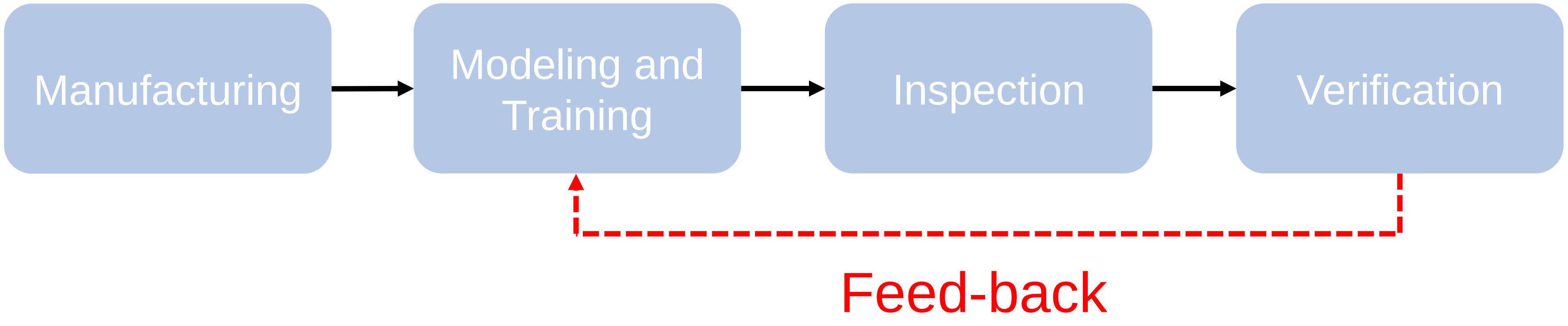
X-ray computed tomography

- High resolution 3D image of pipeline
- Good image of cracks (submillimeter resolution)
- Very expensive
- Sample has to be cut out (destructive)
- Shut down pipeline



IMPROVED APPROACH

- Strong potential to improve the quality of our models
- Feeding back verification results into machine learning models
- Real defects are better than artificial defects
- A lot of distributed and non standardized data in-house



WHAT MAKES THIS FEEDBACK LOOP HARD TO ACHIEVE?

- How to get the verifications from the clients to the data scientists?
- We don’t define what is verified
- Data is not clean
- Data is not aligned

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HOW TO GET THE VERIFICATIONS FROM THE CLIENTS TO THE DATA SCIENTISTS?

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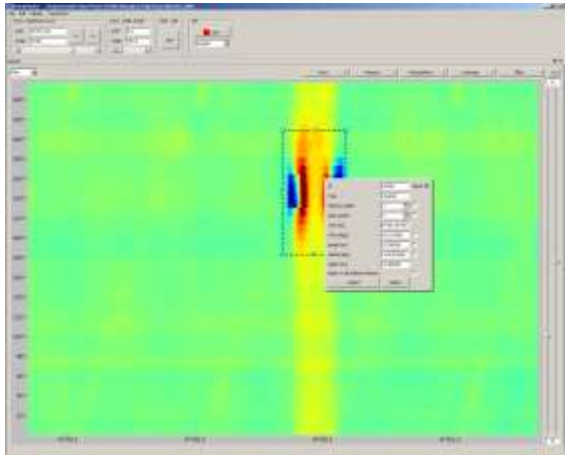
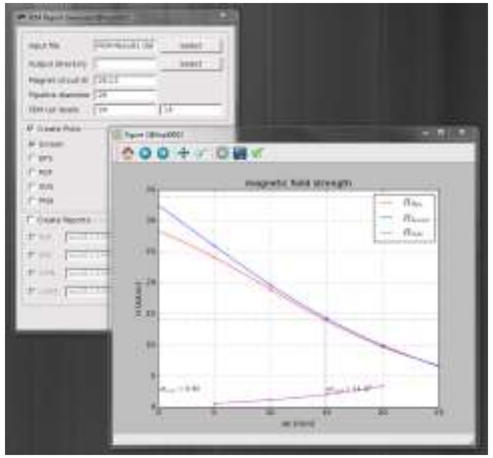
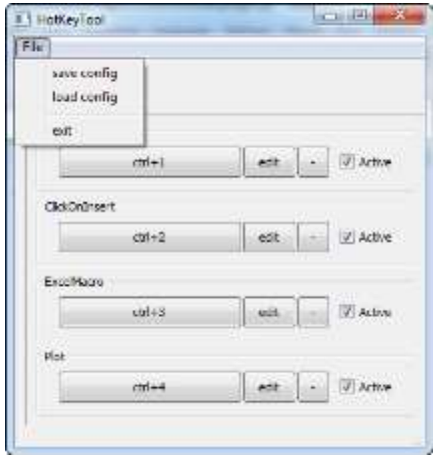
- Know the delivery chain
  - Client ➡ Project Manager ➡ Data Engineer ➡ Annotator ➡ Data Scientist
- Define structures and processes
- Inform and train contact persons
- Help people who can help you
  - E.g. write small tools (in Python), which help them solve their problems
  - Automate the boring stuff







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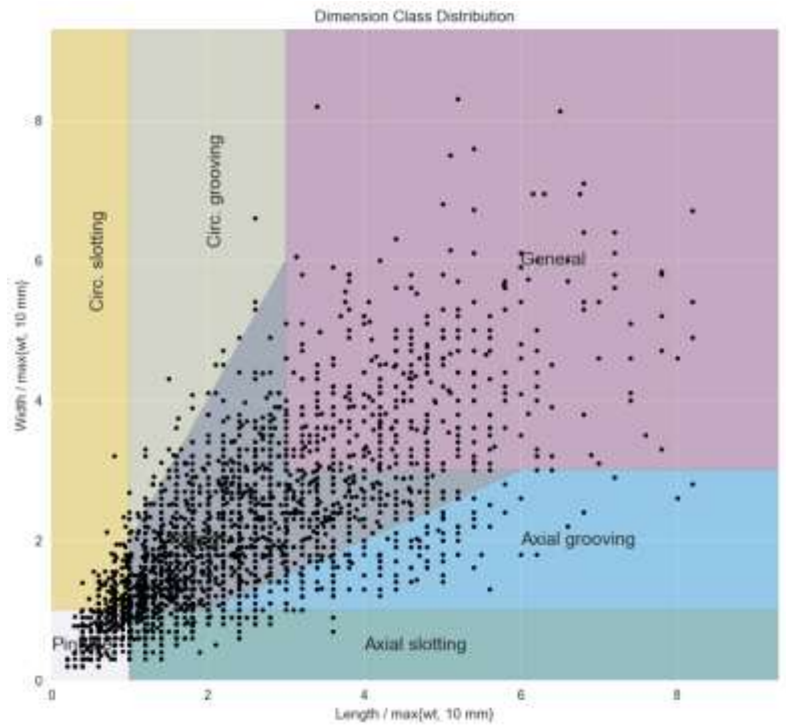
WE DON'T DEFINE WHAT IS VERIFIED

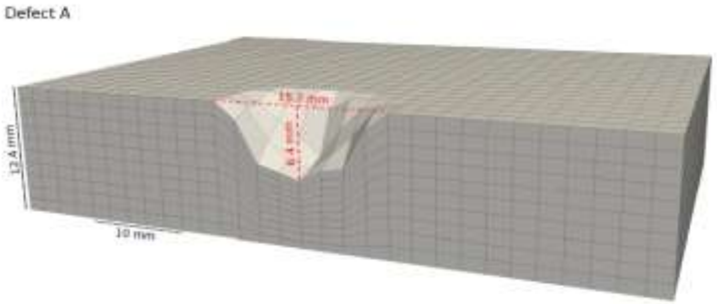
- Clients decide where excavations are done
- Very expensive!

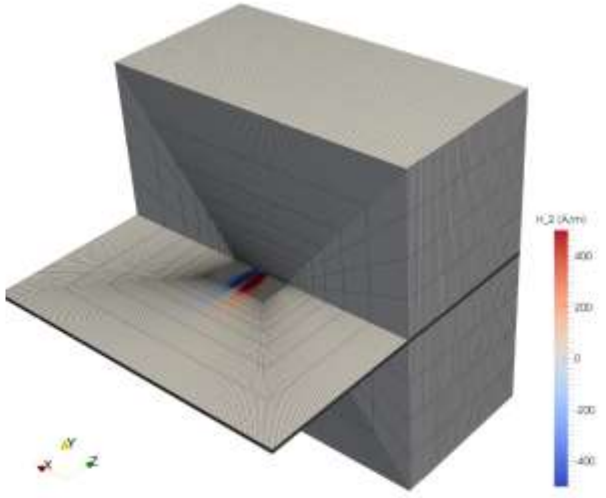
- Fill the gaps:
  - Pull-tests and pump-tests
  - Laboratory measurements
  - Synthetic data (PyCon2017: Synthetic Data for Machine Learning Applications)



SMART WAYS TO FILL GAPS

- Synthetic defects
  - Distort laser-scans
  - Basic geometric shapes (e.g. ellipsoids)
  - Simulate corrosion growth (3D Cellular automata)
- Tool measurements: FEM Simulations
- How to scale?
  - 15 min for each FEM simulation on one core
  - Distributed computation with a Docker cluster





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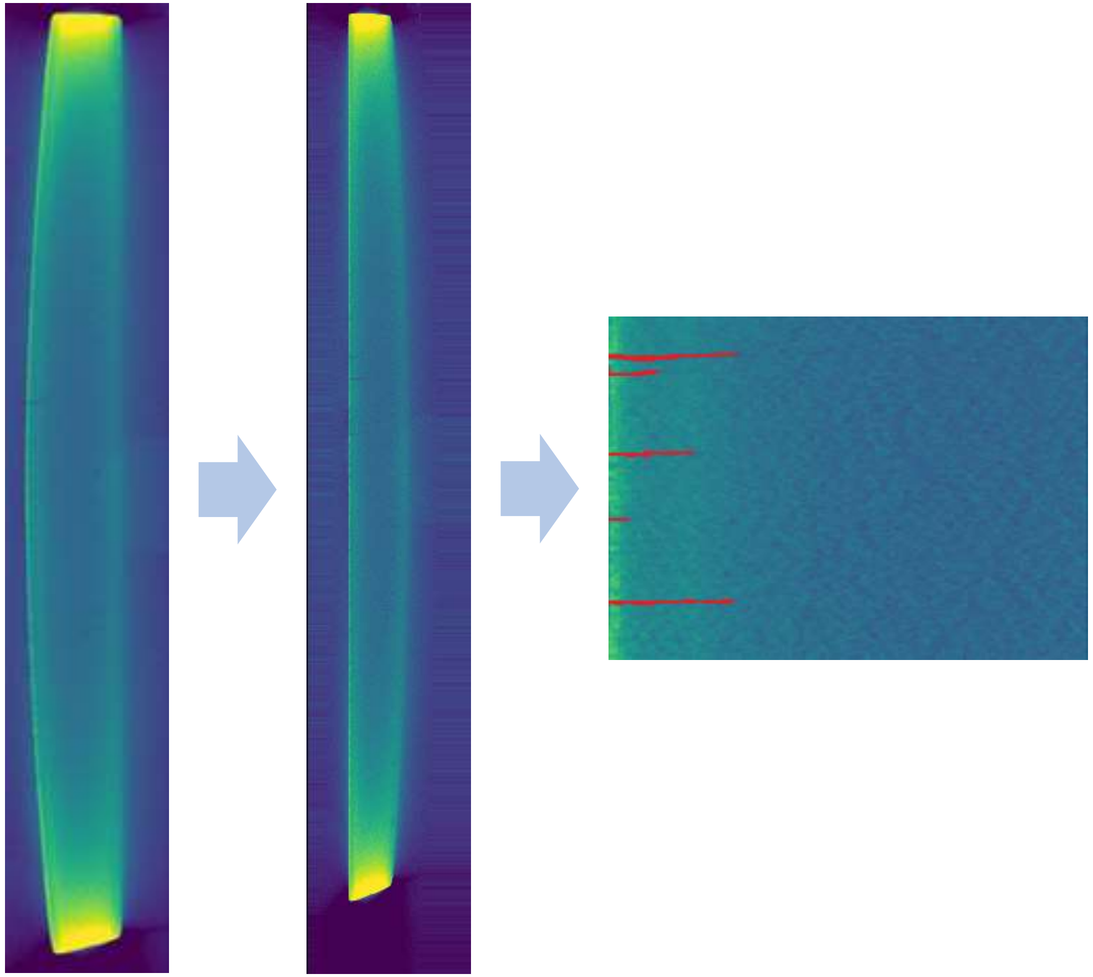
DATA STANDARDIZATION

- Clients use different data formats
- Flexible converter tools
- CSV or HDF5 as data container
- MongoDB for the meta data
- Proper interfaces for data access
- Data storage
- IT-support

DATA NORMALIZATION

- Data is not comparable to other data
  - Wall-thickness
  - Pipeline curvature
- Image processing
  - Filtering
  - Edge detection
  - Hough transformation
- Extraction of important information



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ALIGNMENT

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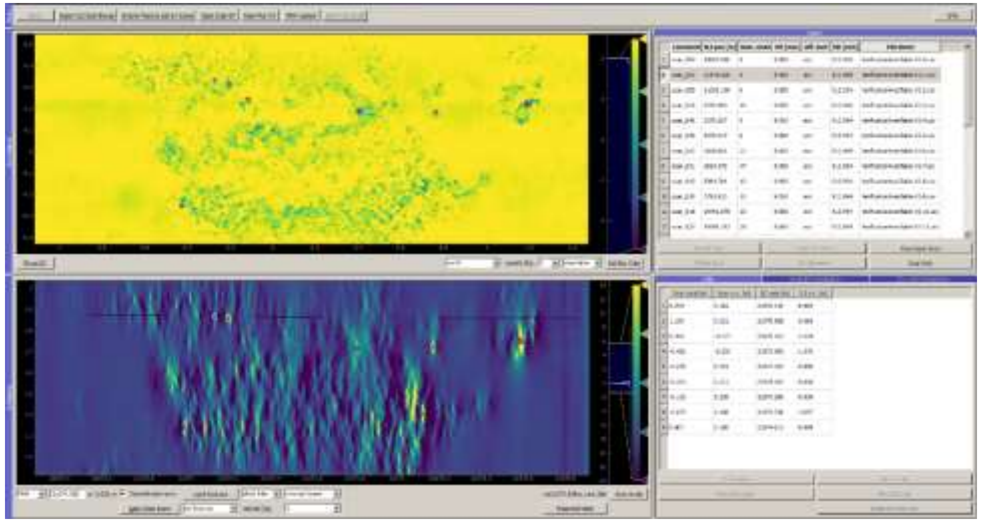
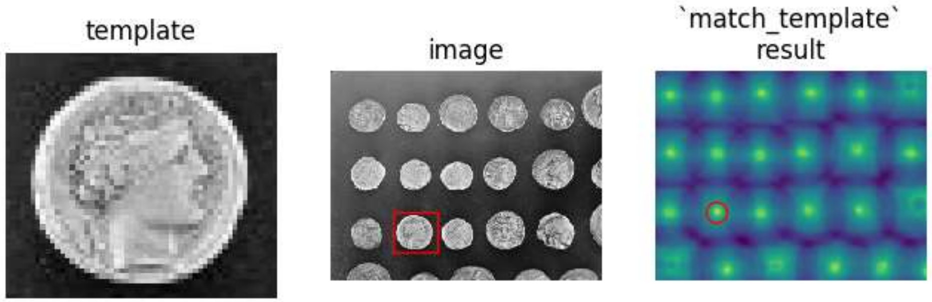
Scan Alignment Tool

- Tool to align laser-scans and ILI-data
- Combines data from different sources
- Manual alignment (tedious and time consuming)



Automated alignment

- Template matching
- Direct comparison of laser-scans and ILI-data is not possible
- FEM simulations bridge this gap

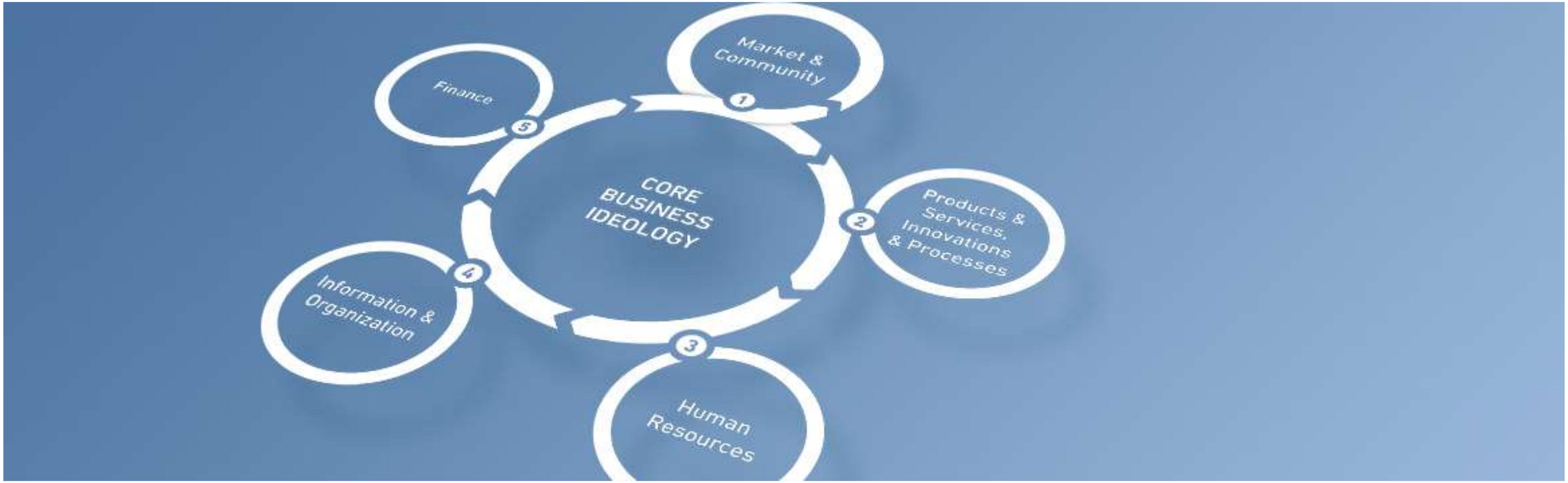


SUMMARY

- Data science challenges in ILI
- Misconception in data science
- Our classic and improved approaches
- Feeding back verification data is hard
- Various methods to tackle these challenges

Conclusion

- It is hard to feed-back validation data into our models
- But it is worth it!
    - Strong increase of classification and regression accuracies
    - Completely new approaches became possible



THANK YOU FOR JOINING THIS PRESENTATION.