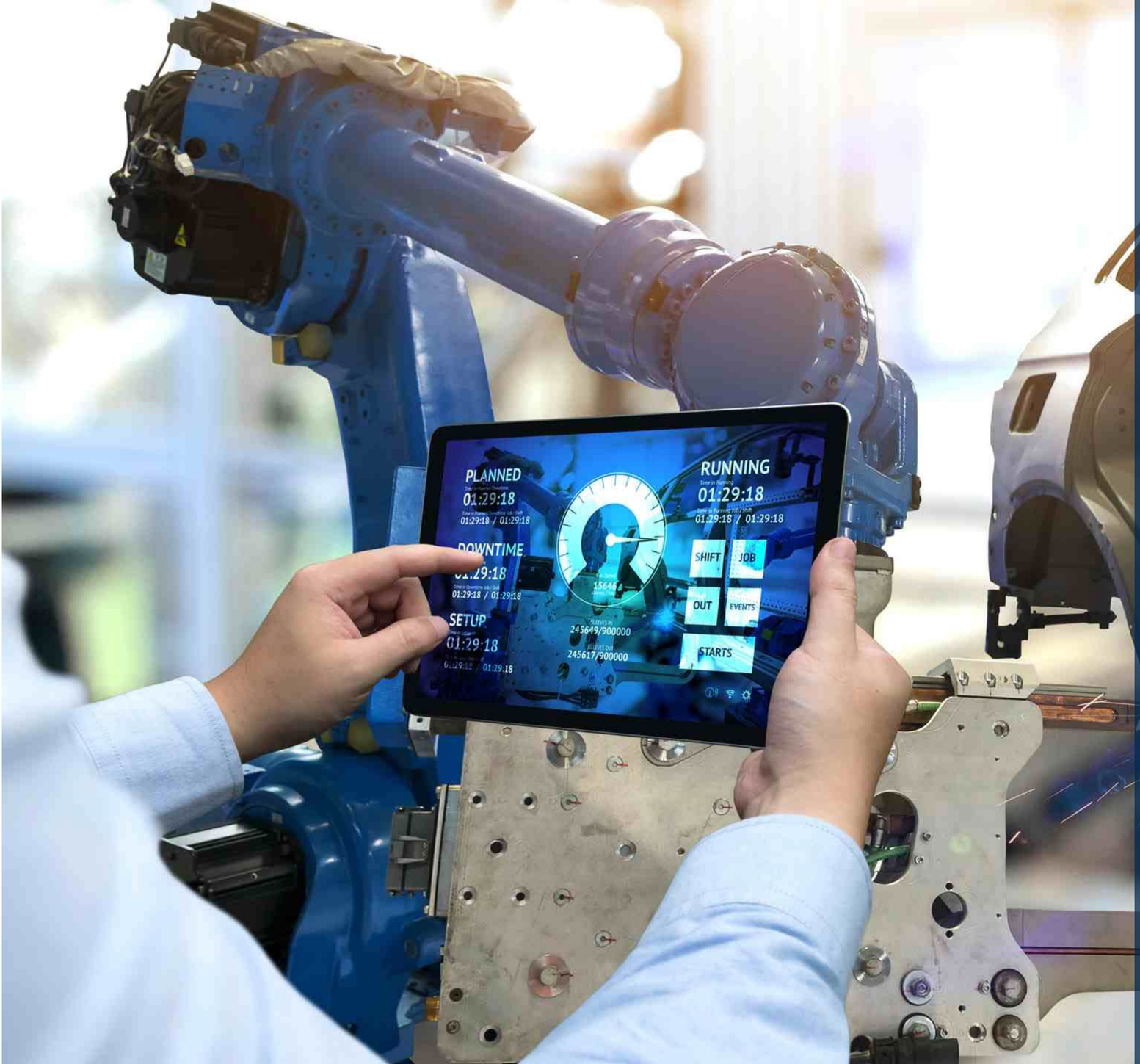


Workshop AI in Photonics

Swissmem und Swissphotonics

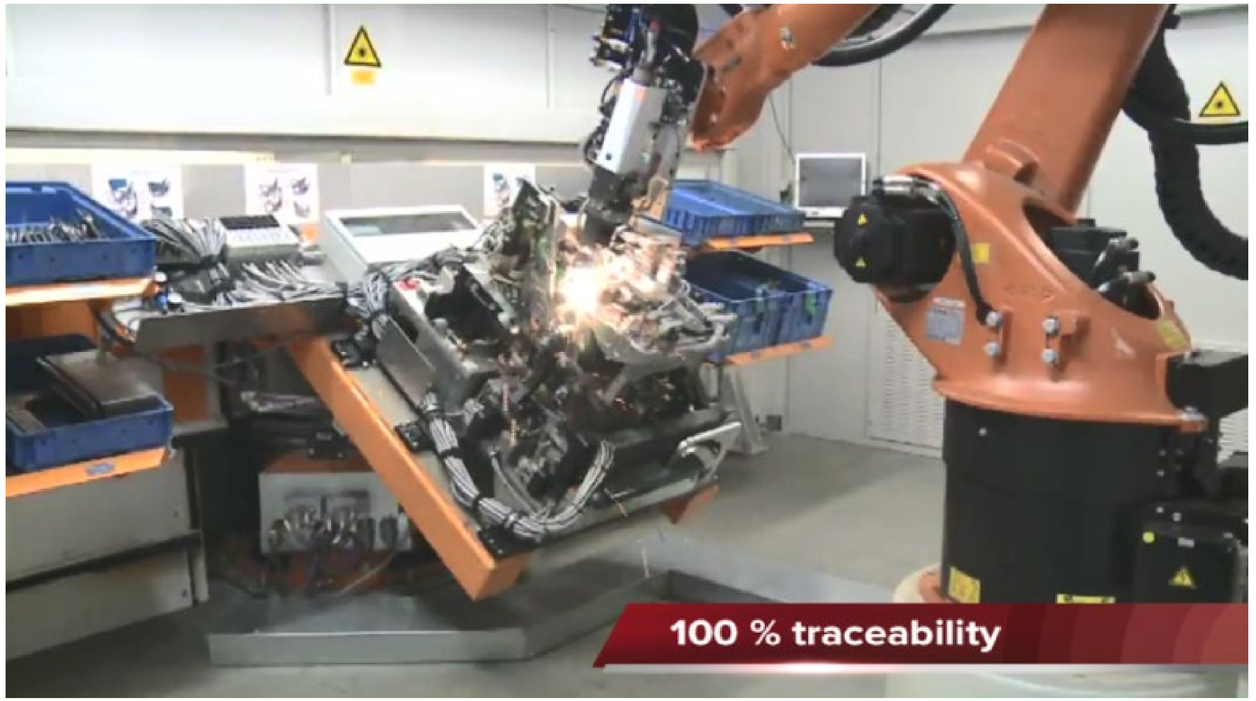
Machine learning for optical quality inspection

Thomas Grünberger
plasmo Industrietechnik GmbH
Vienna

2019-09-03

content

- company presentation plasmo
- data is not information
  - human intelligence
  - artificial intelligence
- examples machine learning



company plasmo

global. focussed. independent.

800

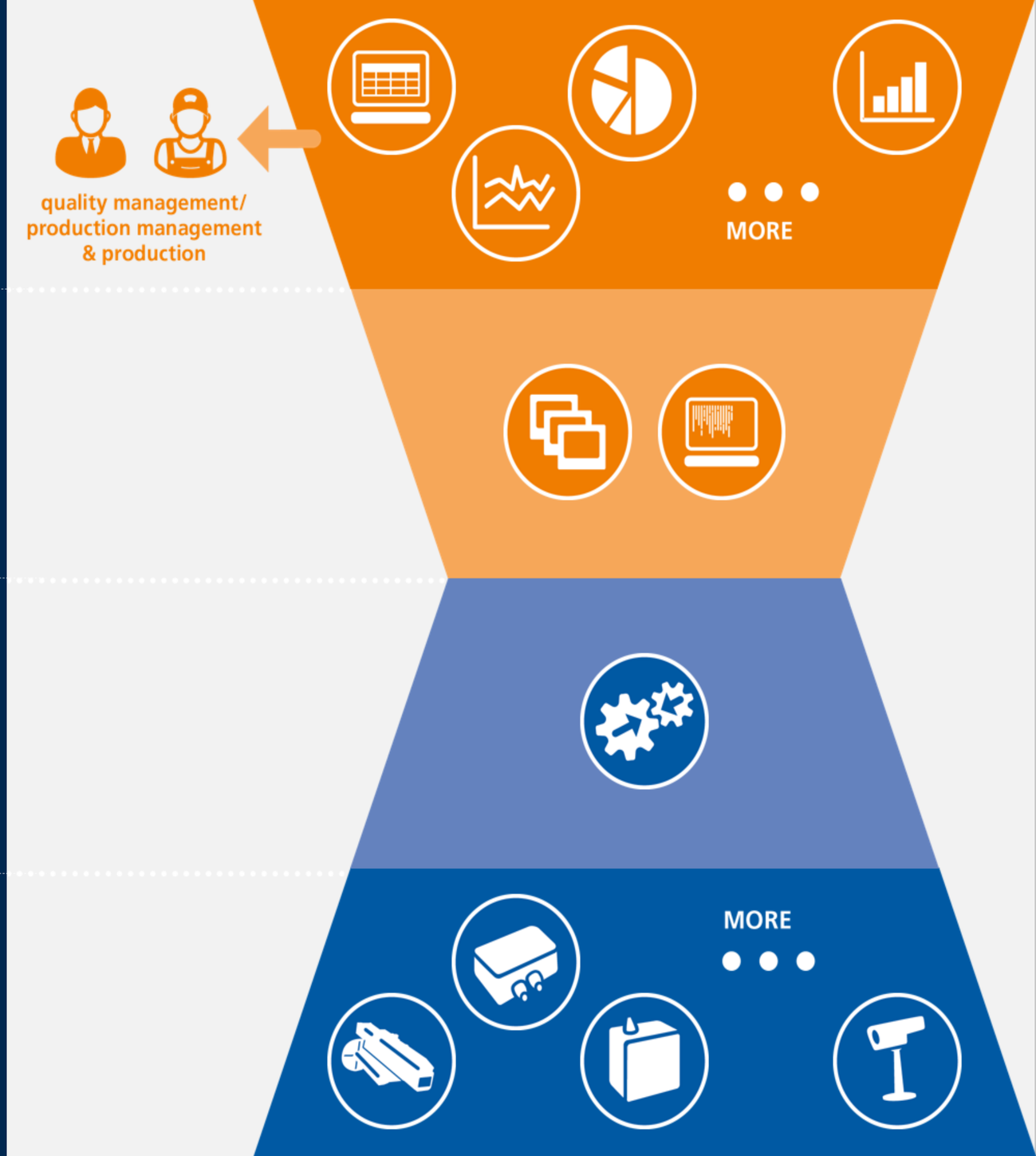
more than 800 plasmo systems in operation

100

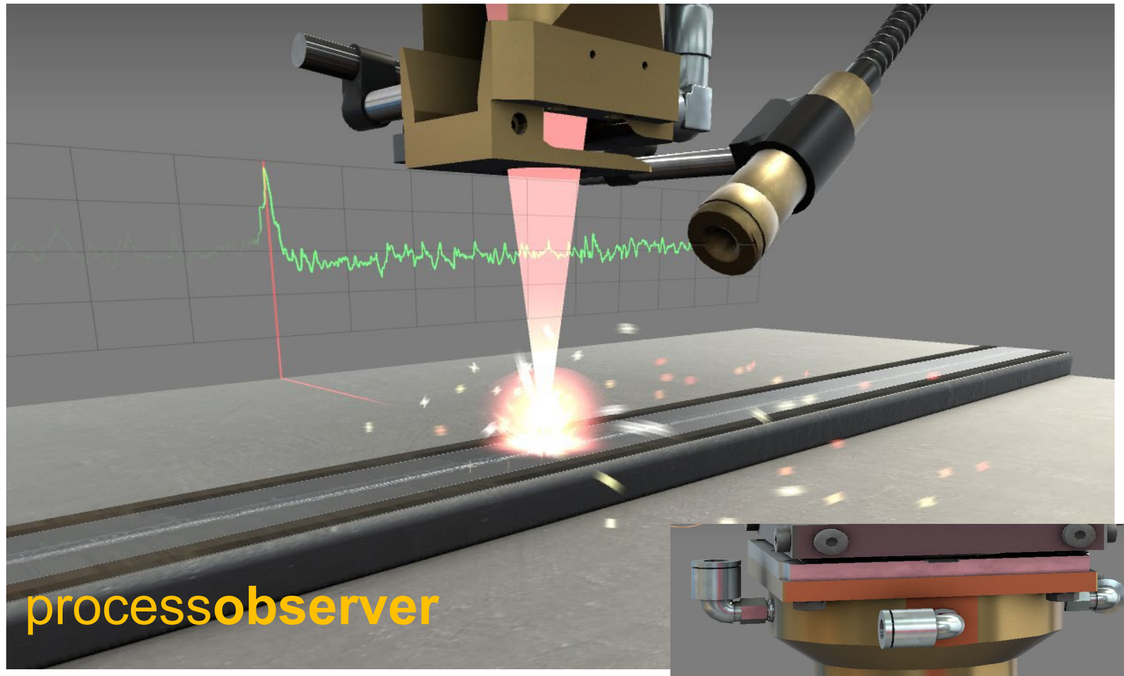
more than 100 global customers using plasmo

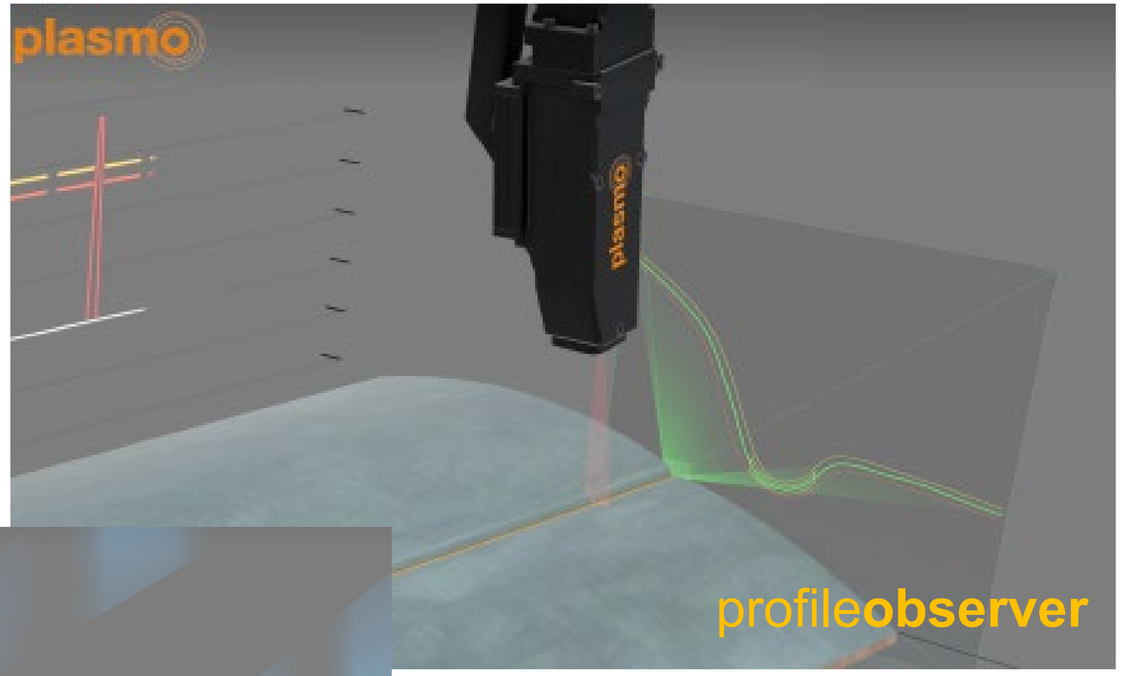
plasmo quality suite

- visualization
- correlation
- integration
- sensors



basic technologies





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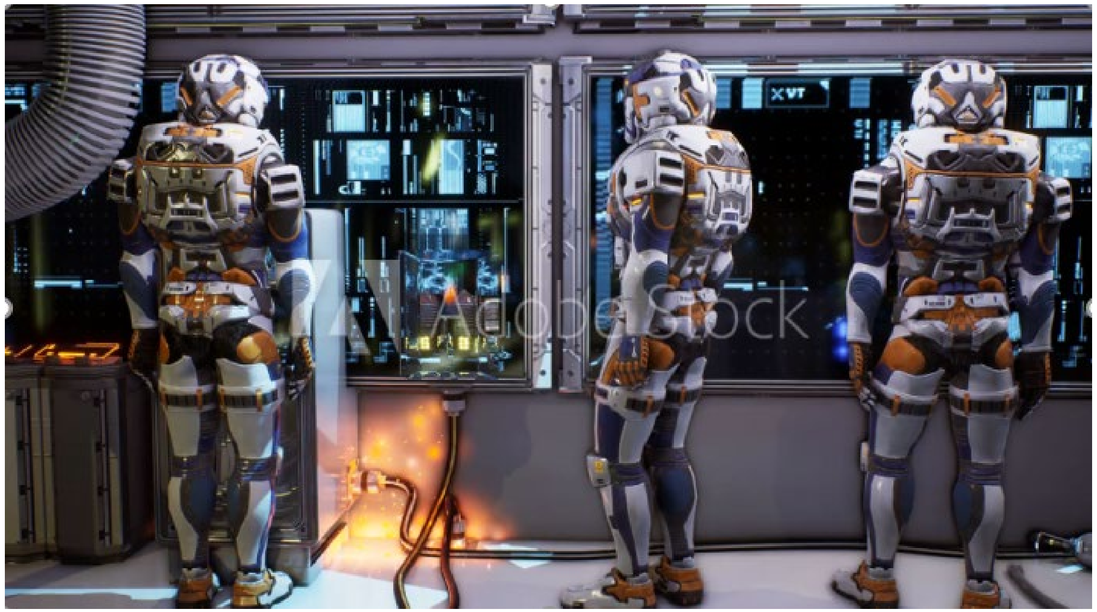
data is not information

how to extract
information from data

- data plausibility
- data analytics
  - human intelligence
  - artificial intelligence
    - machine learning
      - deep learning



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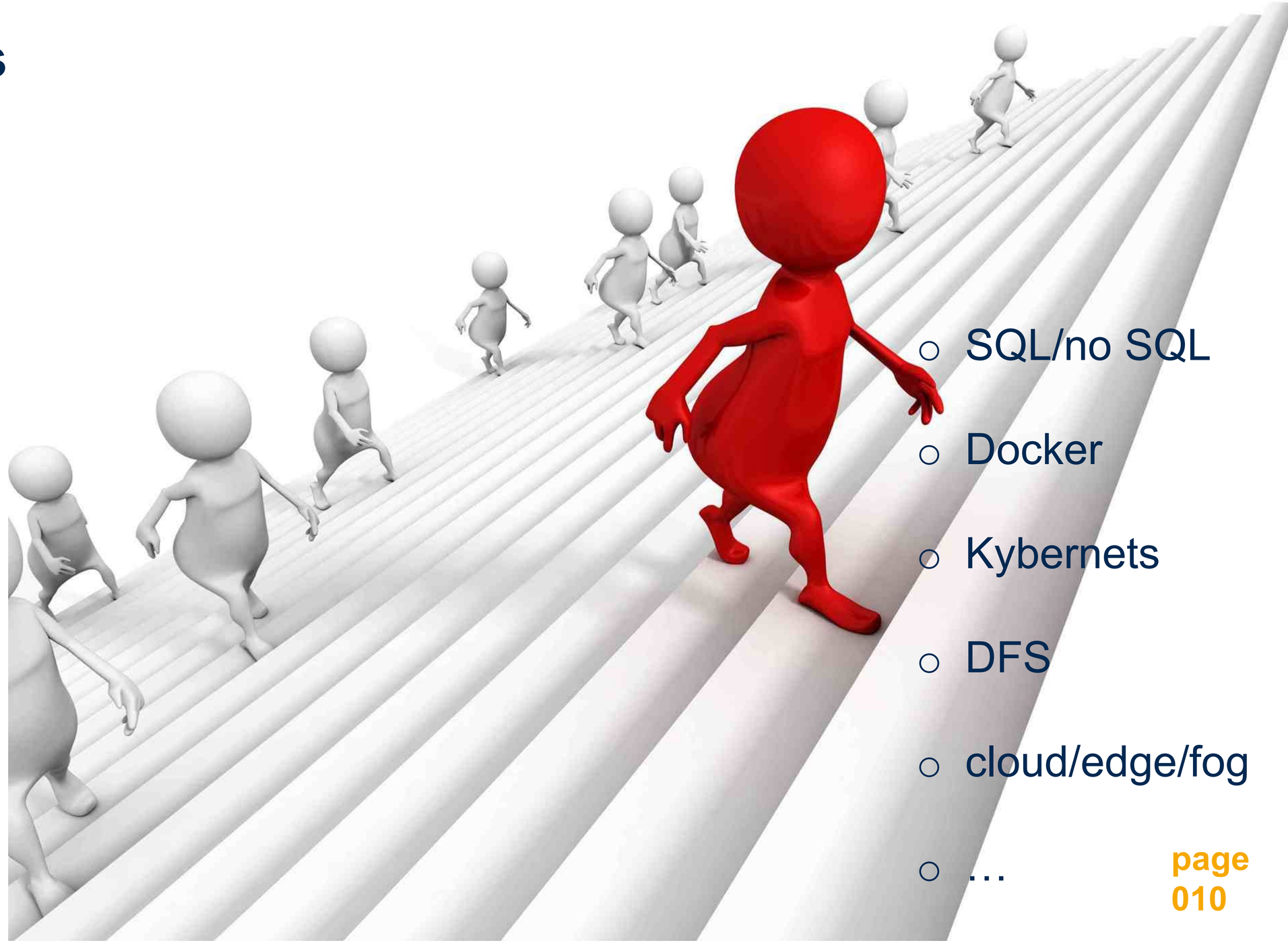
data analytics

- data architect
- data engineer
- data scientist
- business analyst
- devops



- SQL/no SQL
- Docker
- Kybernets
- DFS
- cloud/edge/fog
- …

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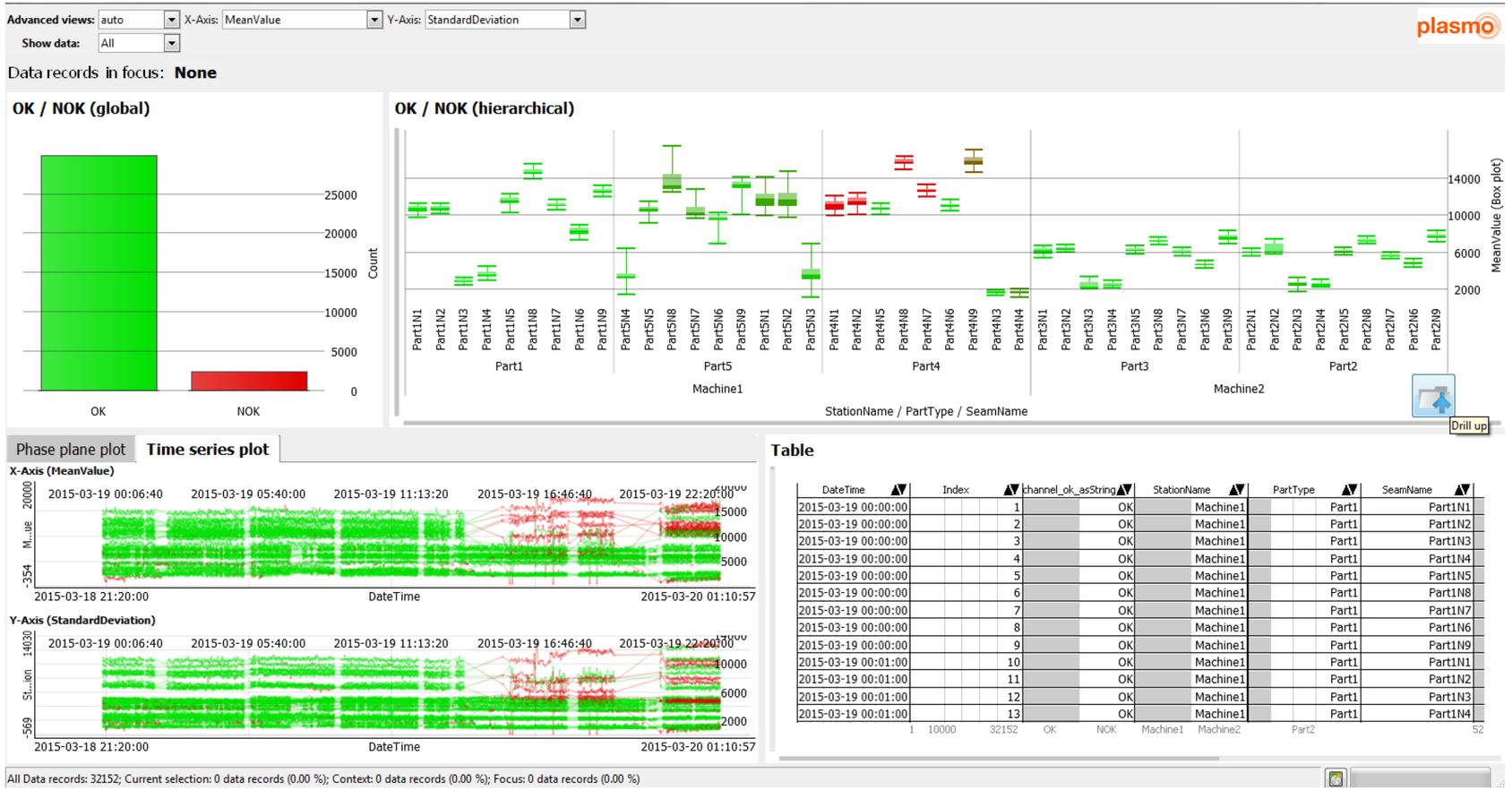
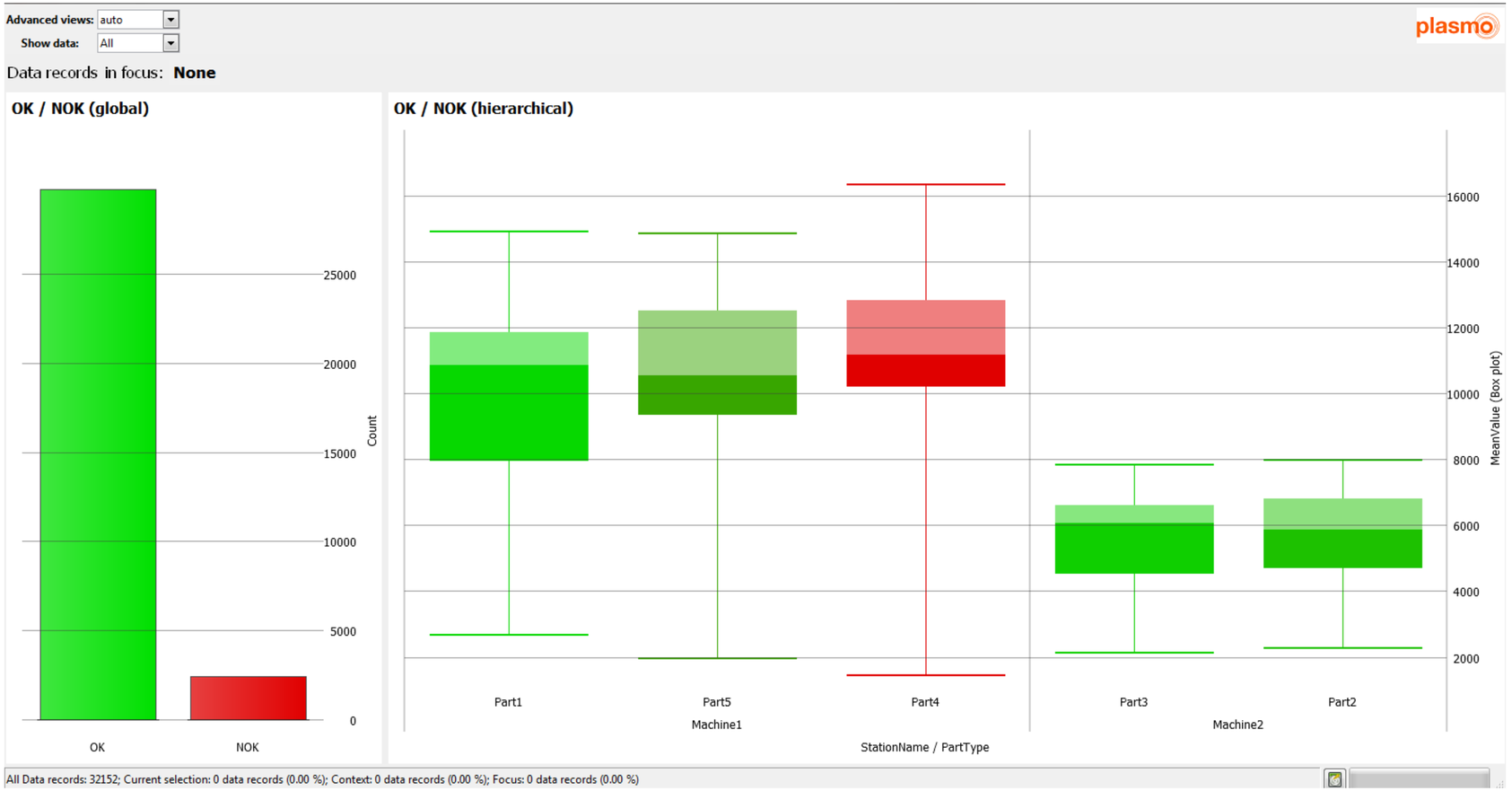
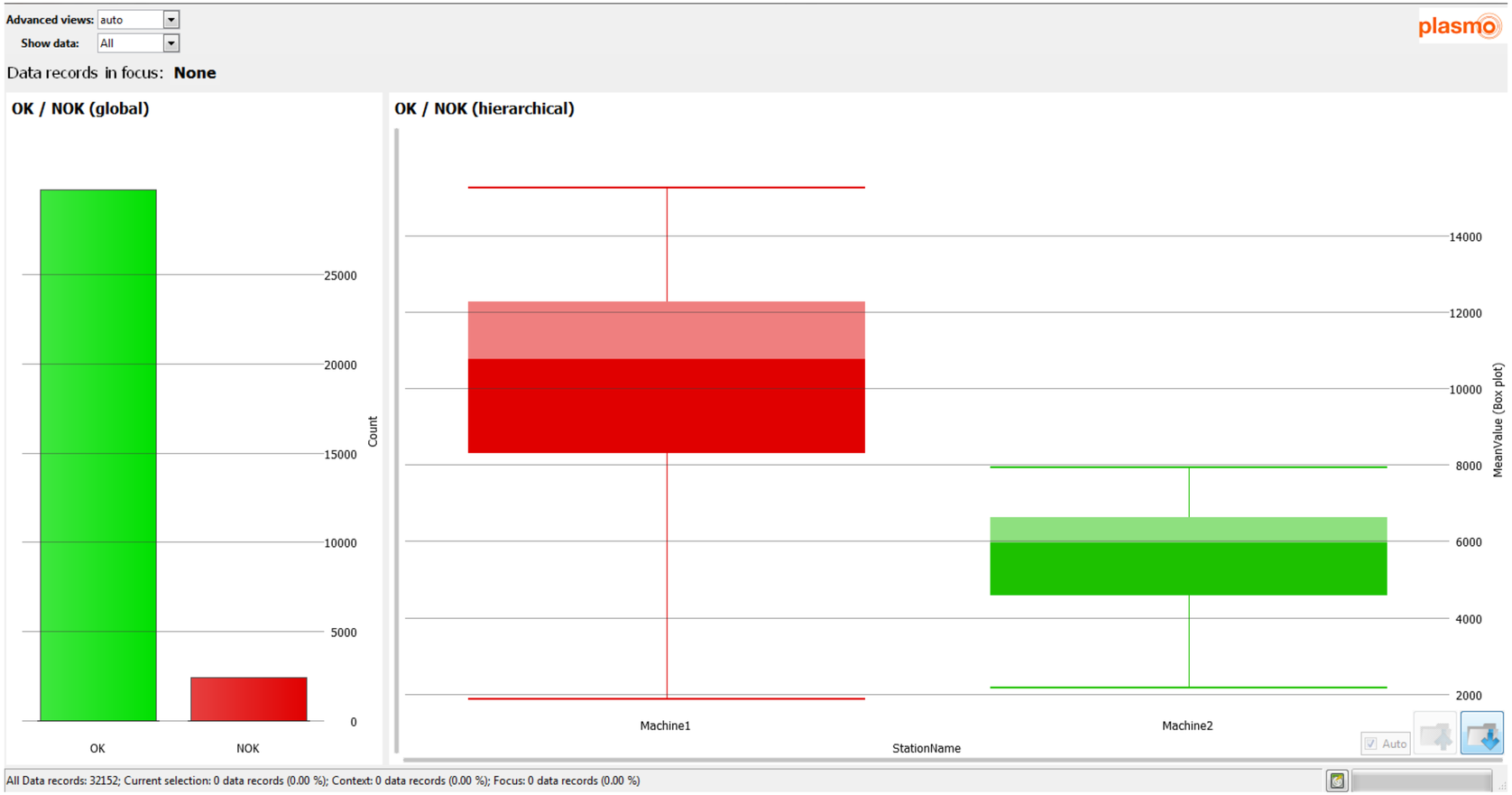
human intelligence and graphical data analytics
aggregation seam and part level



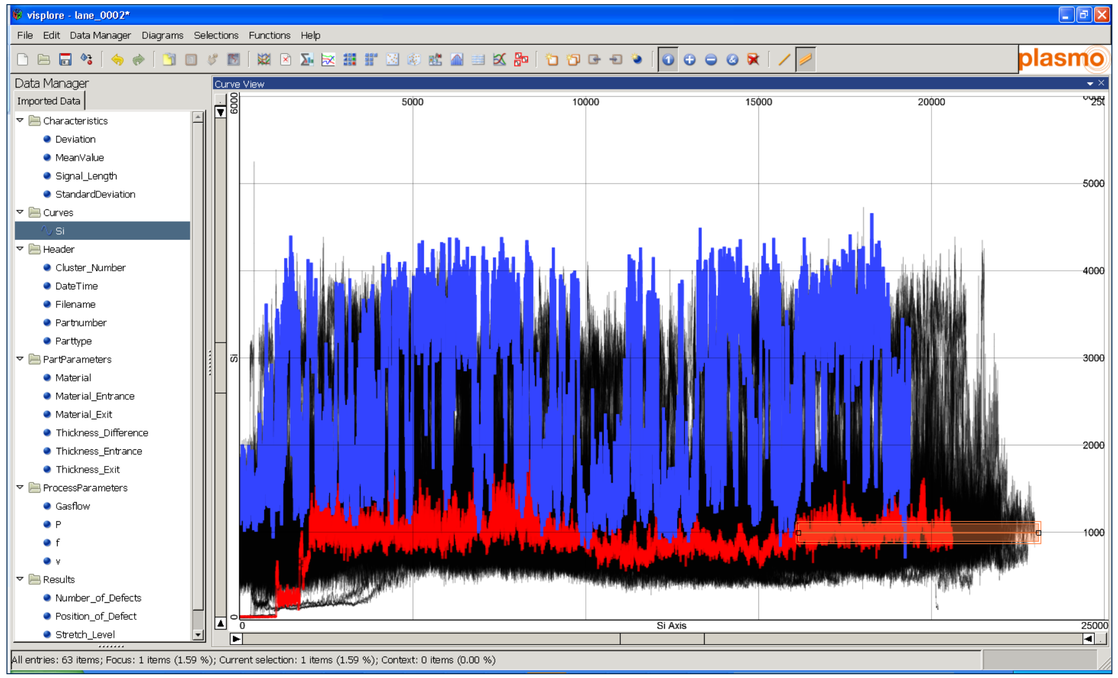
human intelligence and graphical data analytics
aggregation machine level

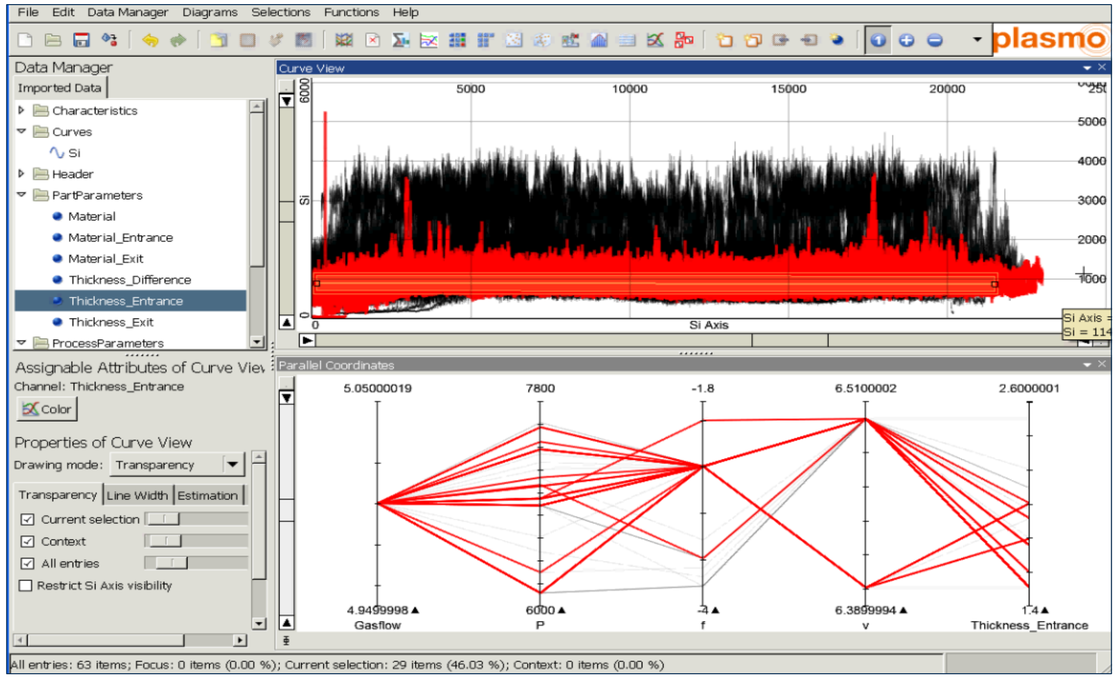


human intelligence and graphical data analytics
aggregation site level



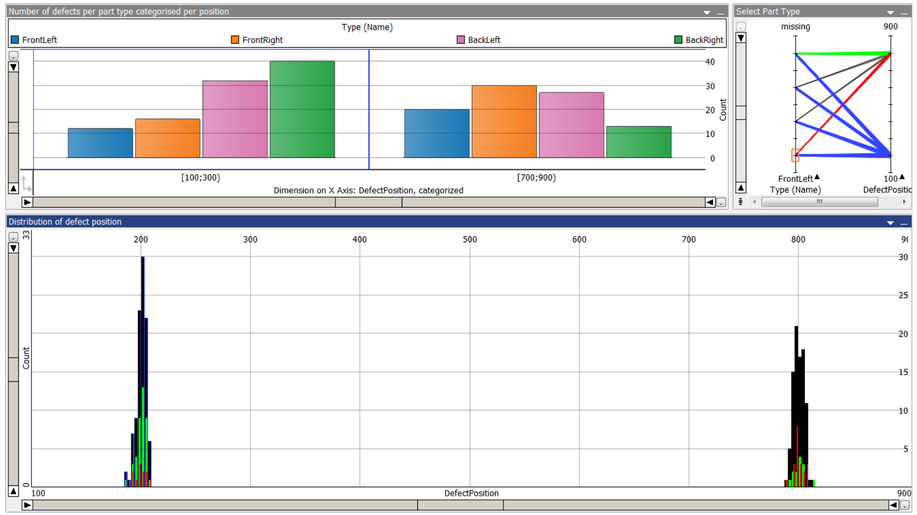
human intelligence and graphical data analytics
root cause analysis

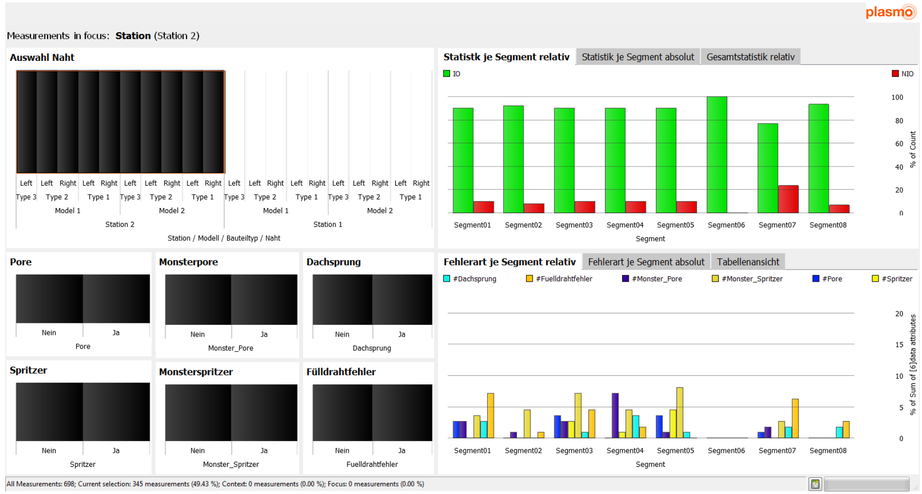




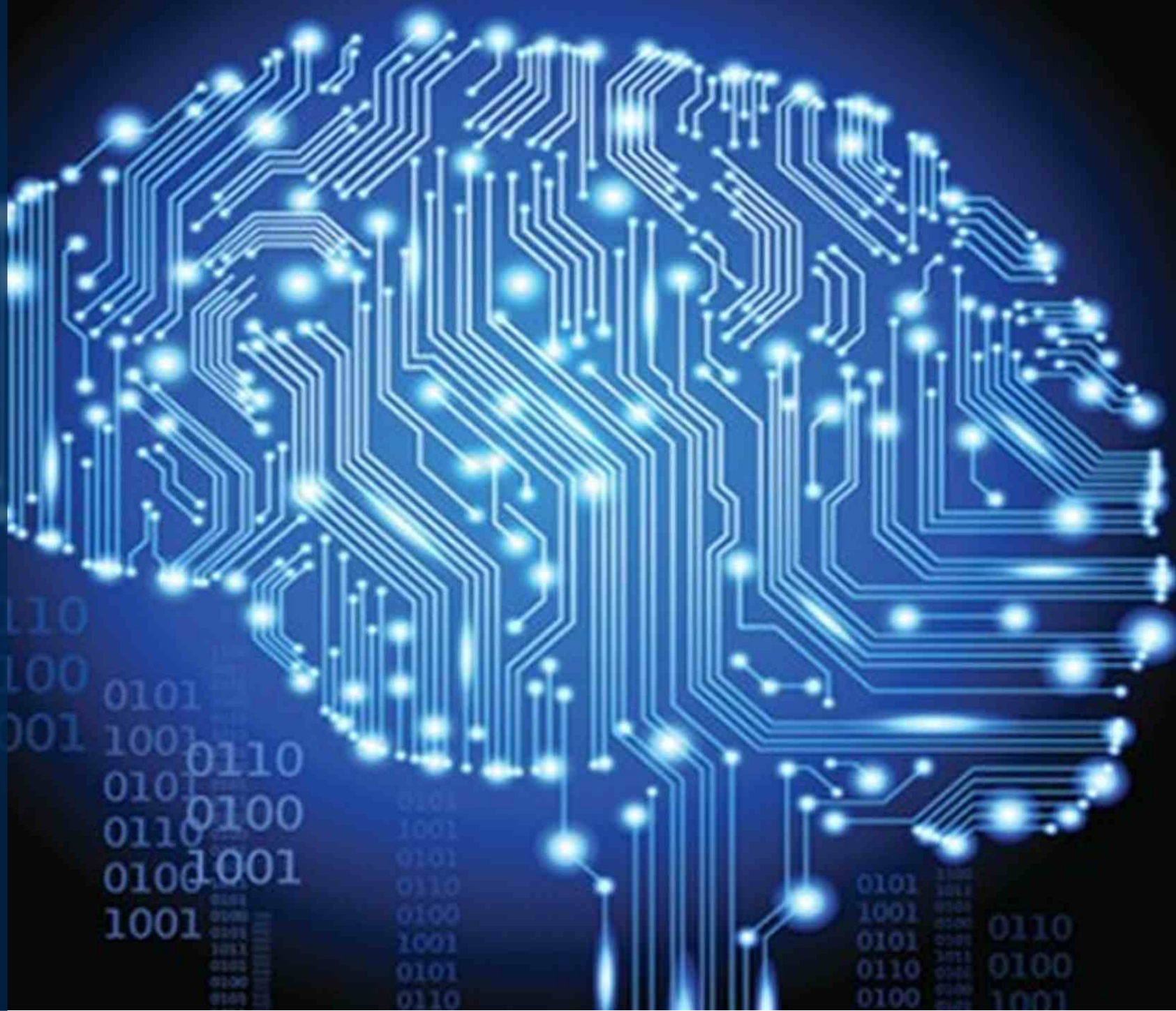
human intelligence and graphical data analytics
process optimization

- statistical analysis of
  - defect positions
  - defect types
  - date/time
  - material/vendor
  - maintenance planning
  - …
  - finding correlations, trends





artificial intelligence



artificial intelligence
definitions

- AI Artificial Intelligence
  - tries to model human intelligence
  - cybernetics, …
- statistics
  - tries to define what happened
  - DM and ML came from statistics
- DM Data Mining
  - tries to explain why something happens (e.g. root cause)
- ML Machine Learning
  - tries to explain what will happen in future and how to optimize or avoid certain situations
  - ML is a first step for model human intelligence and can be seen as part if AI

machine learning
techniques

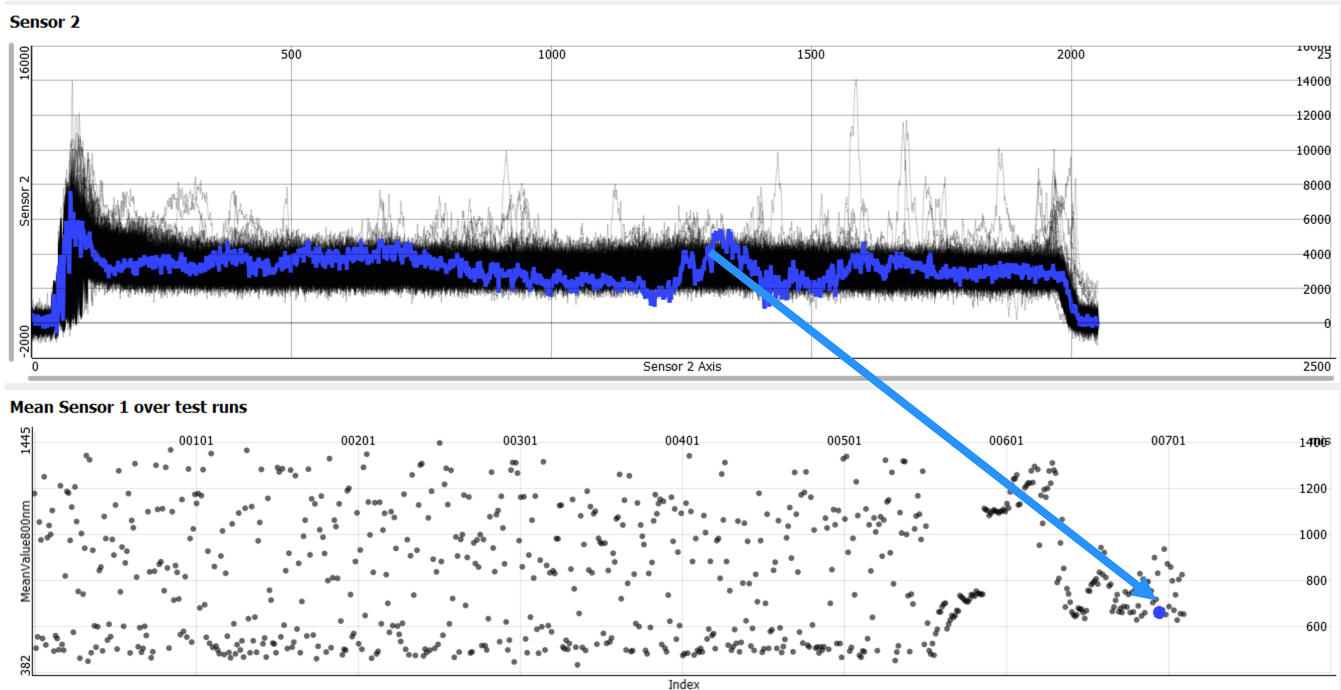
- supervised learning
  - target is known
  - develop model based on input and output data
- unsupervised learning
  - group and interpret data based only on input data

examples

diode based process monitoring
welding of thin sheets

- 2 sensors are used (different wavelengths), 710 test runs (index), one measurement consists of 2050 measurement values.

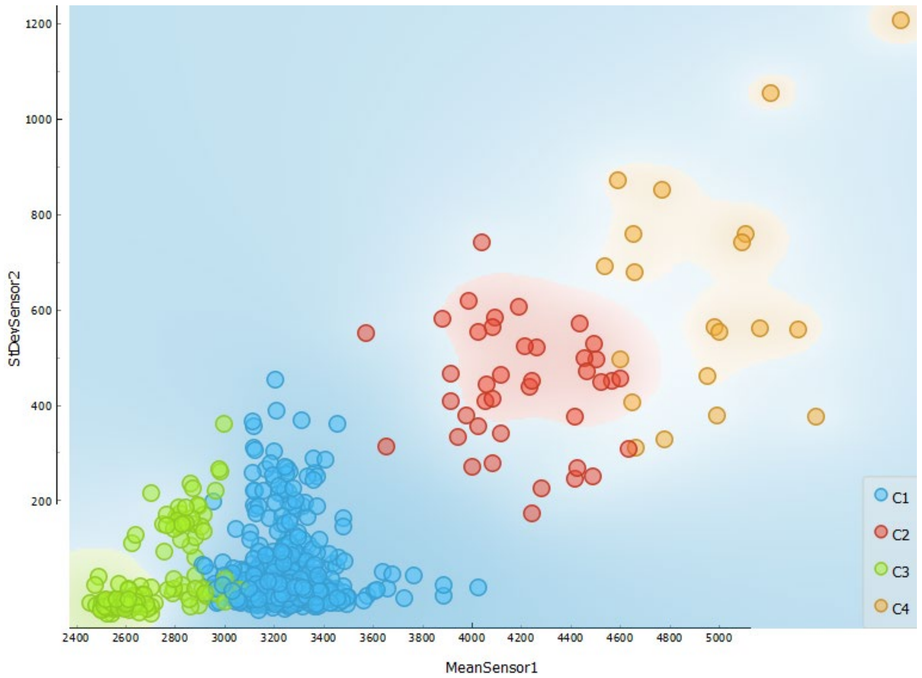
- information is expected in the characteristics mean value and standard deviation for one complete seam (4 dimensions)



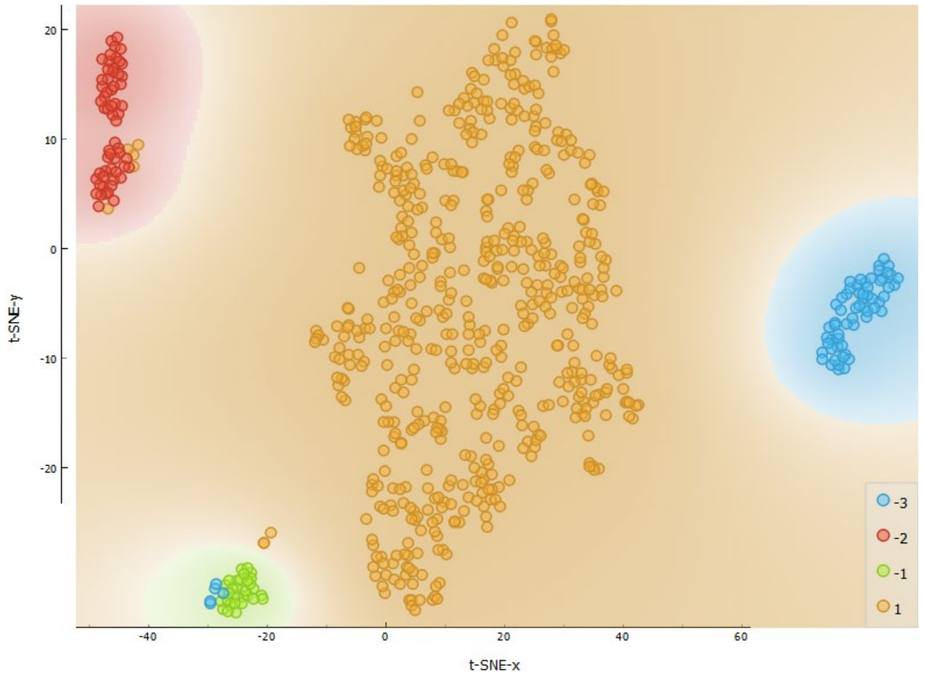
diode based process monitoring
unsupervised learning

- are there clusters in the data?

k-means



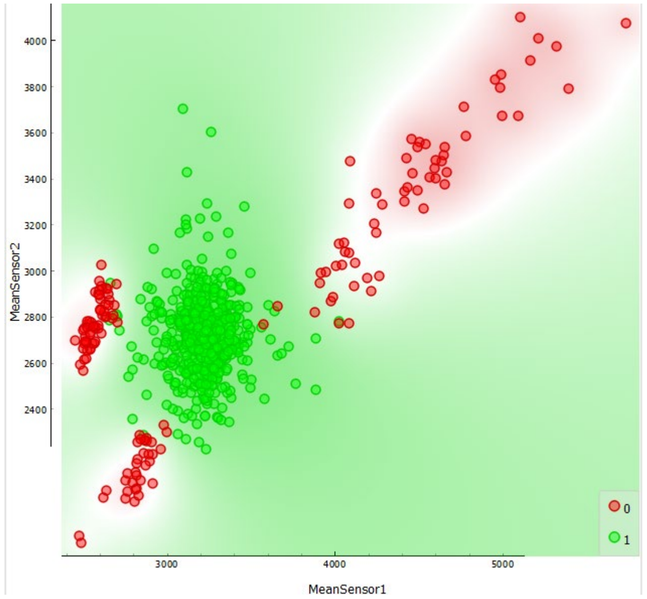
manifold learning



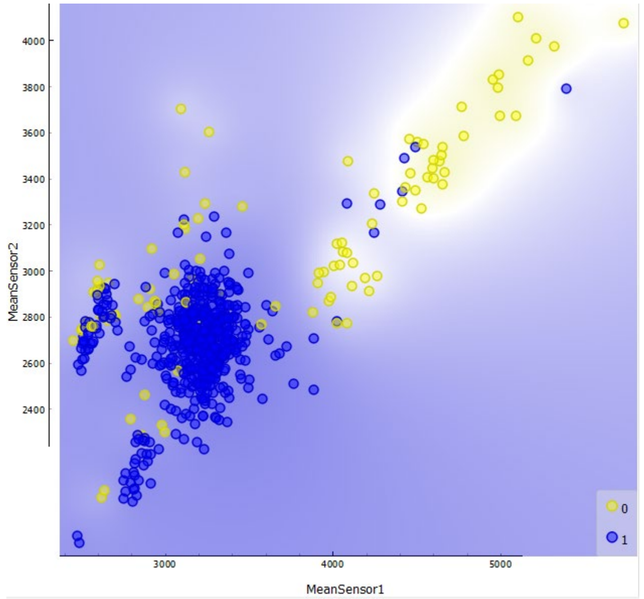
diode based process monitoring
supervised learning

- OKNOK and defect types were analysed via DT and NDT techniques

OKNOK distribution



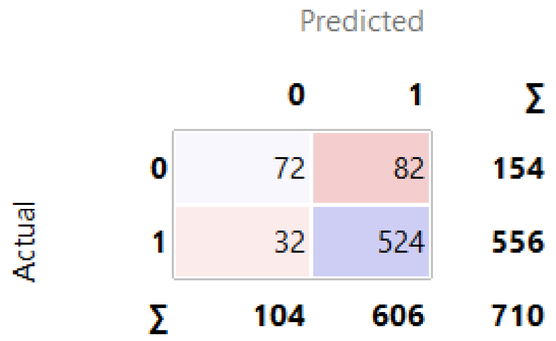
classification logistic regression



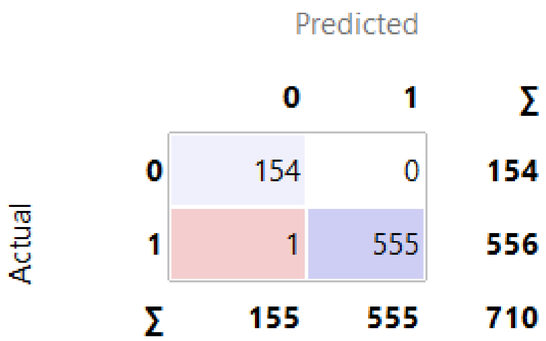
diode based process monitoring
supervised learning

- comparison of different modelling techniques for OKNOK, ANN and random forest yields in optimal results (comparison based on confusion matrix)

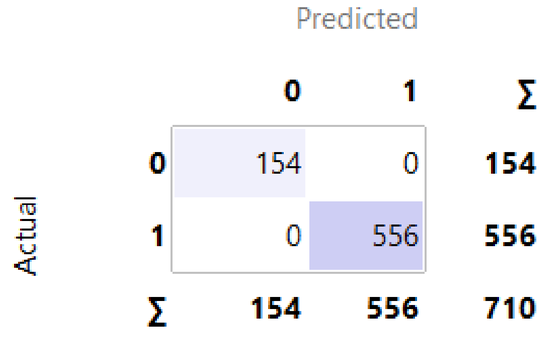
logistic regression



random forest

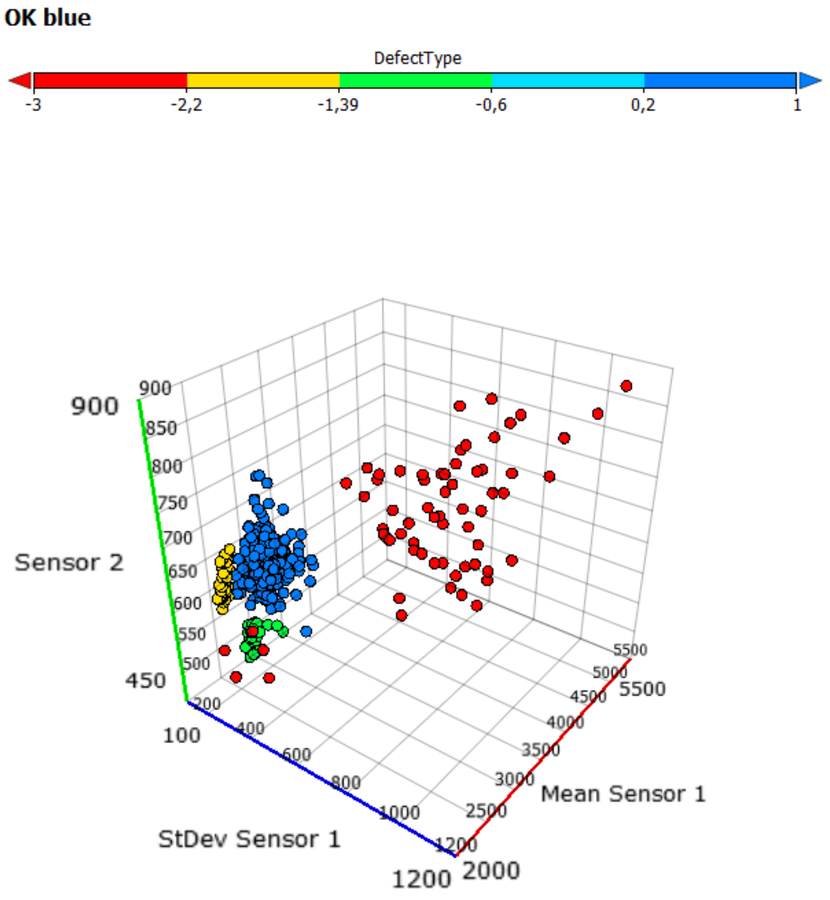


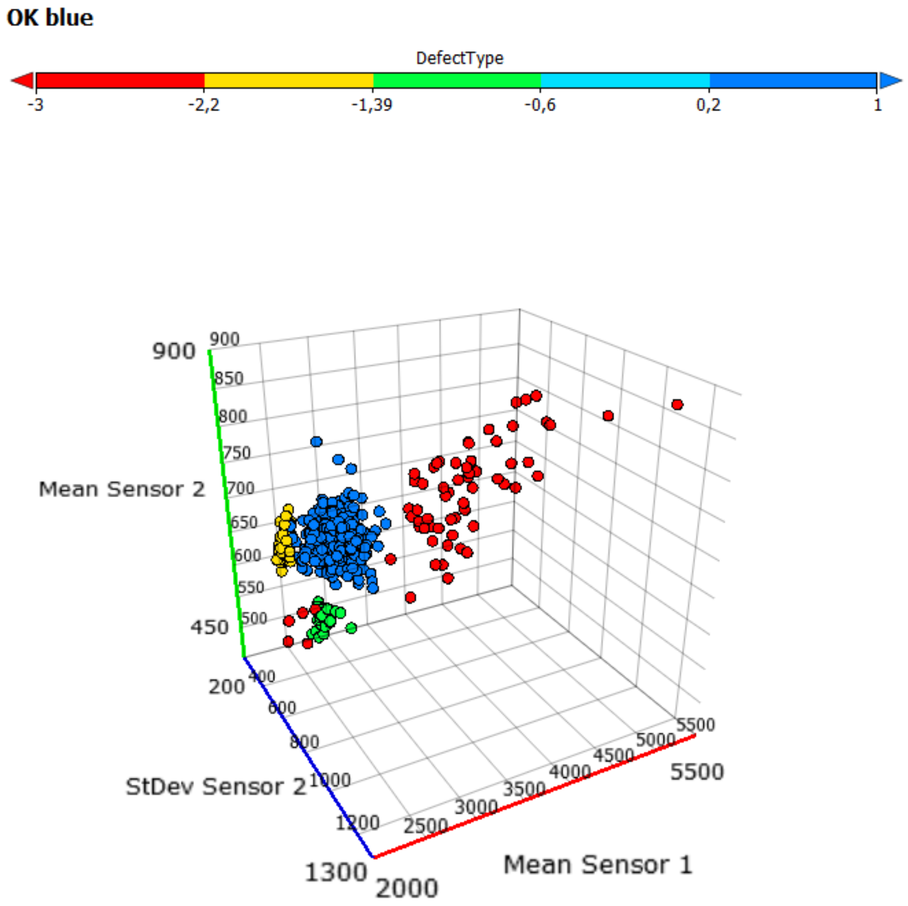
artificial neural network



diode based process monitoring
supervised learning

- 3D visualisation of the task (OK runs type 1 and 3 defect types (-3, -2, -1)



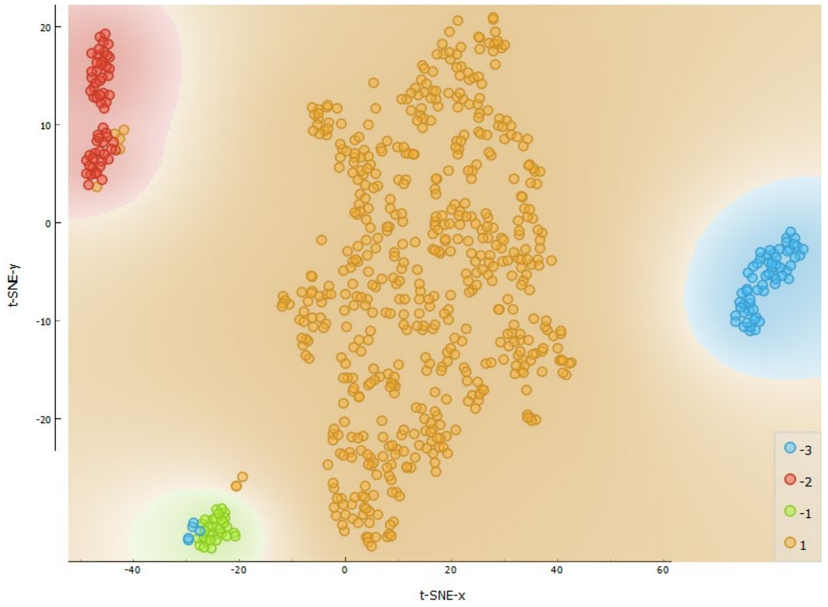


diode based process monitoring
summary

- at least 3 different characteristics and at least 2 different diode signals needed

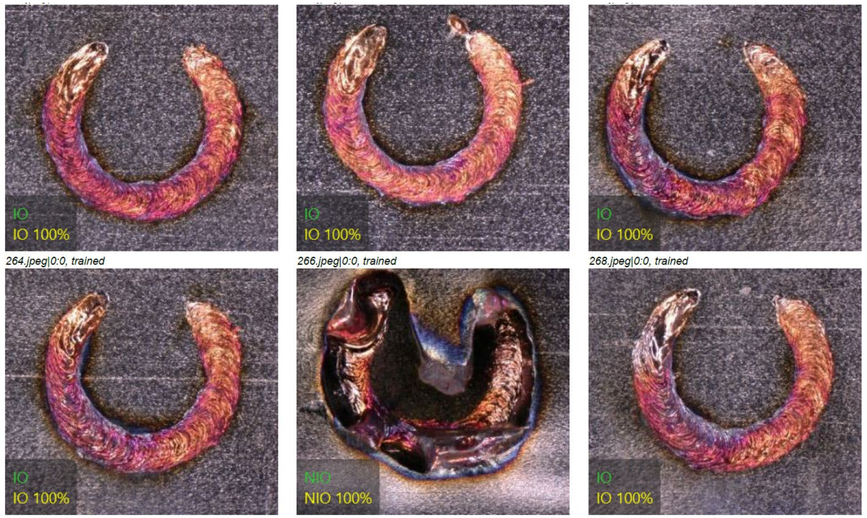
- unsupervised learning shows 4 different clusters correlating with the 4 defect types

- supervised learning using machine learning techniques enables correct classification



camera based weld seam monitoring

- camera based weld seam monitoring enables the detection of visible defects
- used in addition to process monitoring systems detecting defects defects like lack of fusion, porosity, no full penetration, …, which can‘t be seen at the top of the seam
- gray value or color images useable
- example welding of C shaped seams

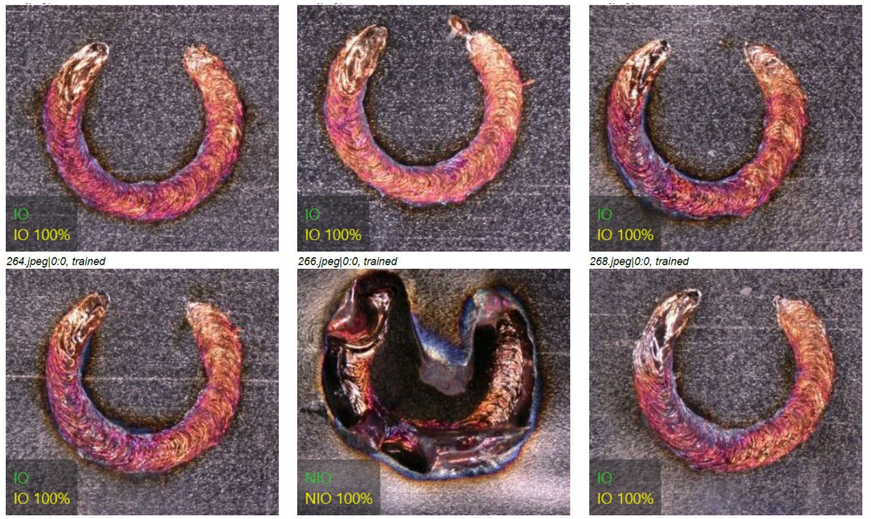


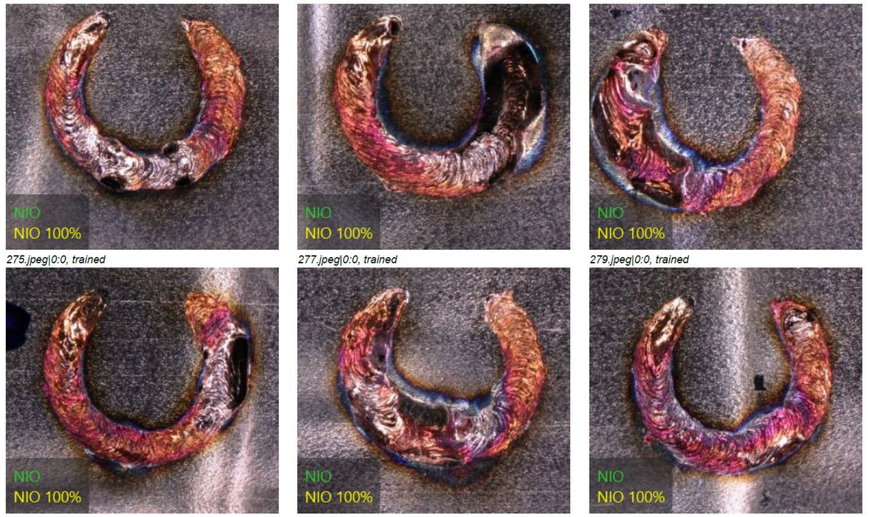
camera based weld seam monitoring
supervised training, deep learning

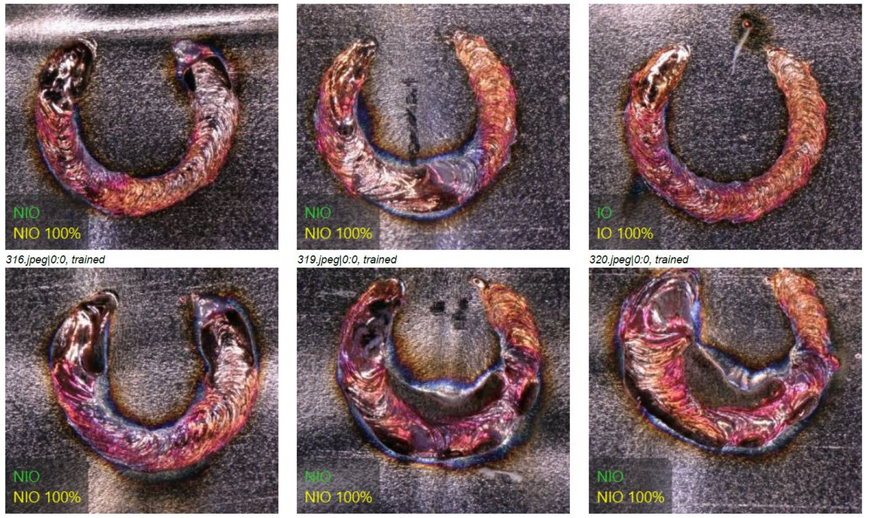
- deep learning are available the last few years due to computational power (e.g. GPU processing)
- artificial neural networks are used typically using many neurons
- different approaches available including pretrained nets for specific tasks
- unsupervised deep learning also usable
- supervised learning using training, test and validation data set
  - check for inter- and extrapolation capabilities (e.g. overtraining)

camera based weld seam monitoring
supervised training, deep learning

- trainings data set classified correct







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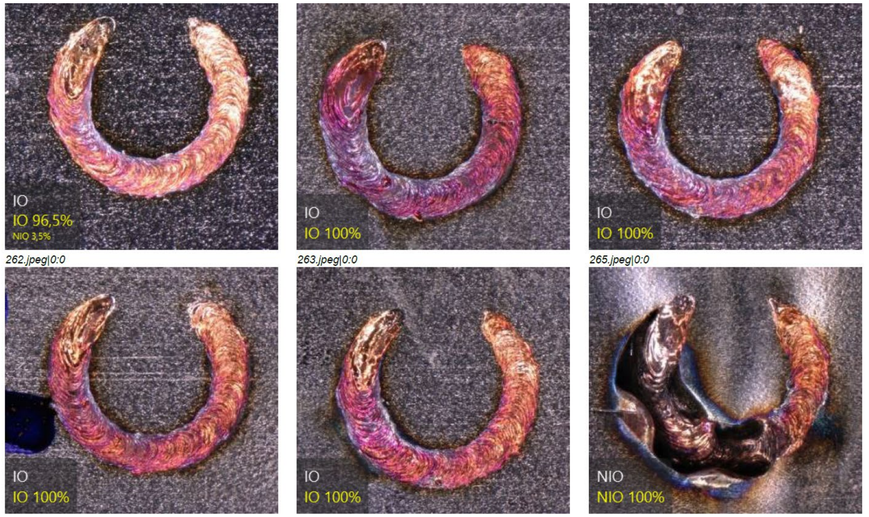
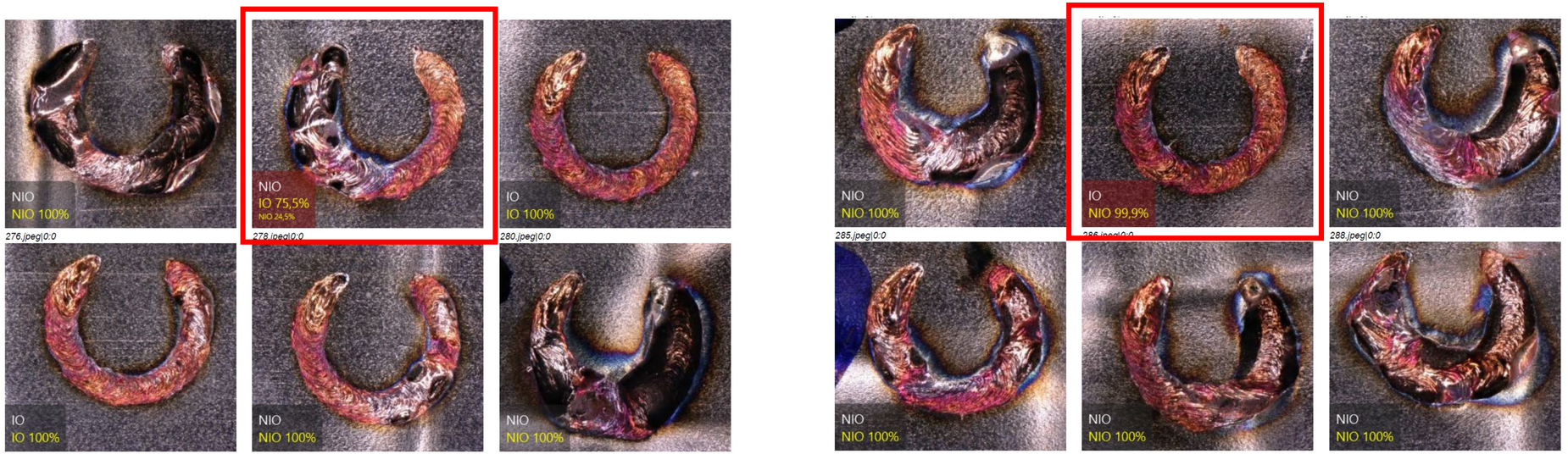
camera based weld seam monitoring
supervised training, deep learning

- test data set
  1 false positive and
  1 false negative





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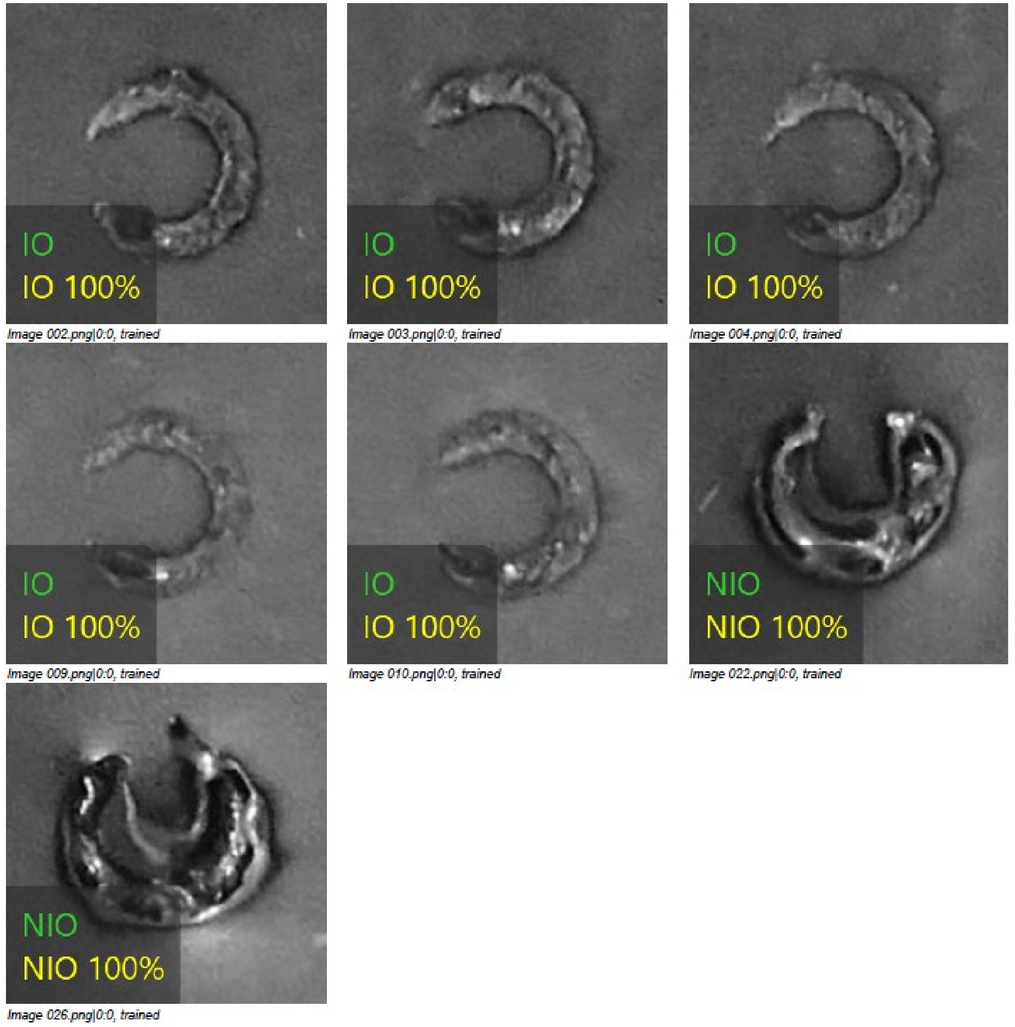
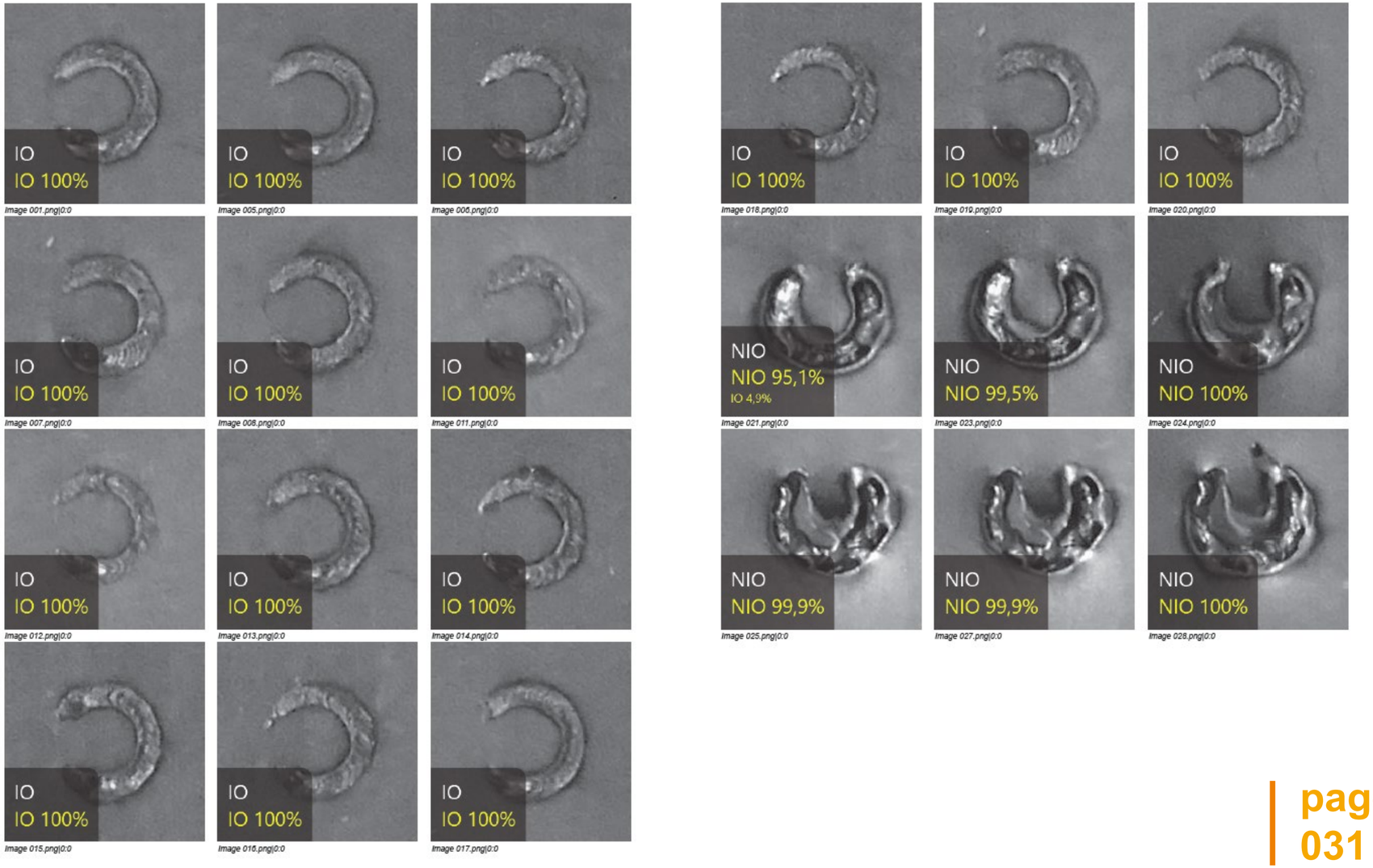
camera based weld seam monitoring
supervised training, deep learning

- trainings data set classified correct



camera based weld seam monitoring
supervised training, deep learning

- test data set
  classified correct



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camera based weld seam monitoring
summary

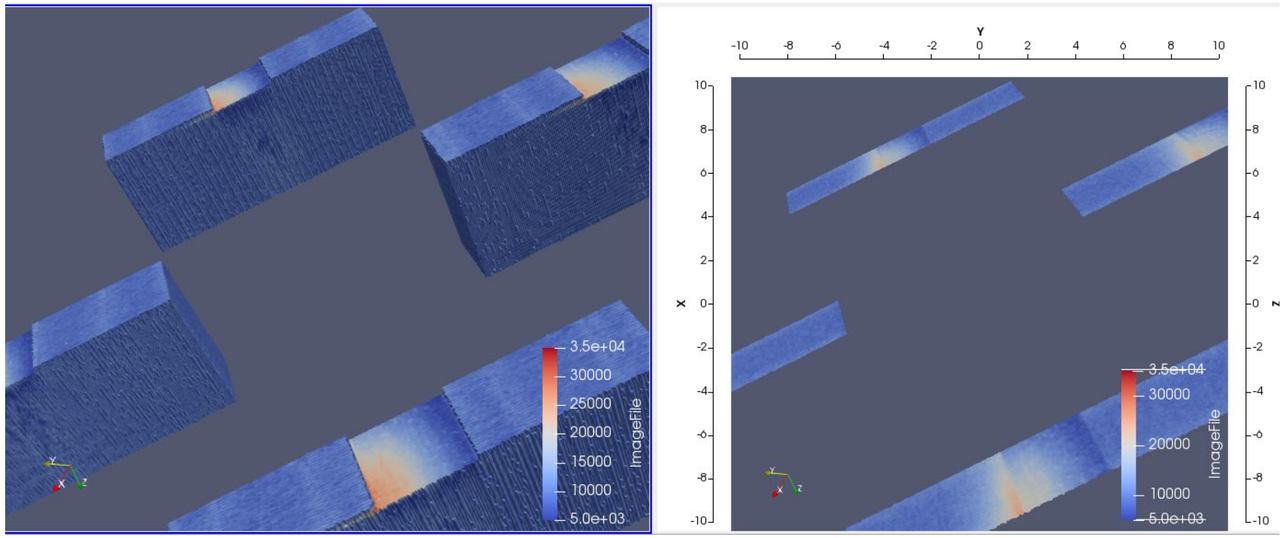
- deep learning gives better results compared to manual inspection
- unsupervised approach also applicable (presentation of OK seams and detection of anomalies)
- models can be trained once or retrained online
- result depends on input data and correct classifications (supervised)

machine learning at plasmo
summary

- dashboard based analysis of production and sensor data (SPC)
  - correlations
  - trend analysis
- modelling OKNOK for different sensors for quality inspection of different joining techniques (laser, TIG, plasma, FSW, …)
- unsupervised clustering of sensor data for all applications
- genetic algorithms for supervised or unsupervised automatic parameterisation of quality inspection systems

machine learning at plasmo
summary

- deep learning for image based analysis
  - analysis of powder bed images (AM) and classification of different defect types
  - unsupervised analysis of image staples (layer by layer) in additive manufacturing



example
3D visualisation of 50 layers
building a bridge (1mm height)

-> up to 10.000 layers (images)
has to be analysed for a real job

machine learning at plasmo
summary

- some tips from our experience
  - don‘t learn existing knowledge
  - keep it as simple as possible
  - 80percent rule: 80% is data preparation, 20% is data analysis

"Inch by inch. Play by play. Until we get there."

Tony D'Amato (Al Pacino) in "Any given Sunday"