Big Data Analytics for Process and Quality Monitoring in Gas Metal Arc Welding of Automotive Parts

Joining Smart Technologies International Automotive Conference 08.05.2019
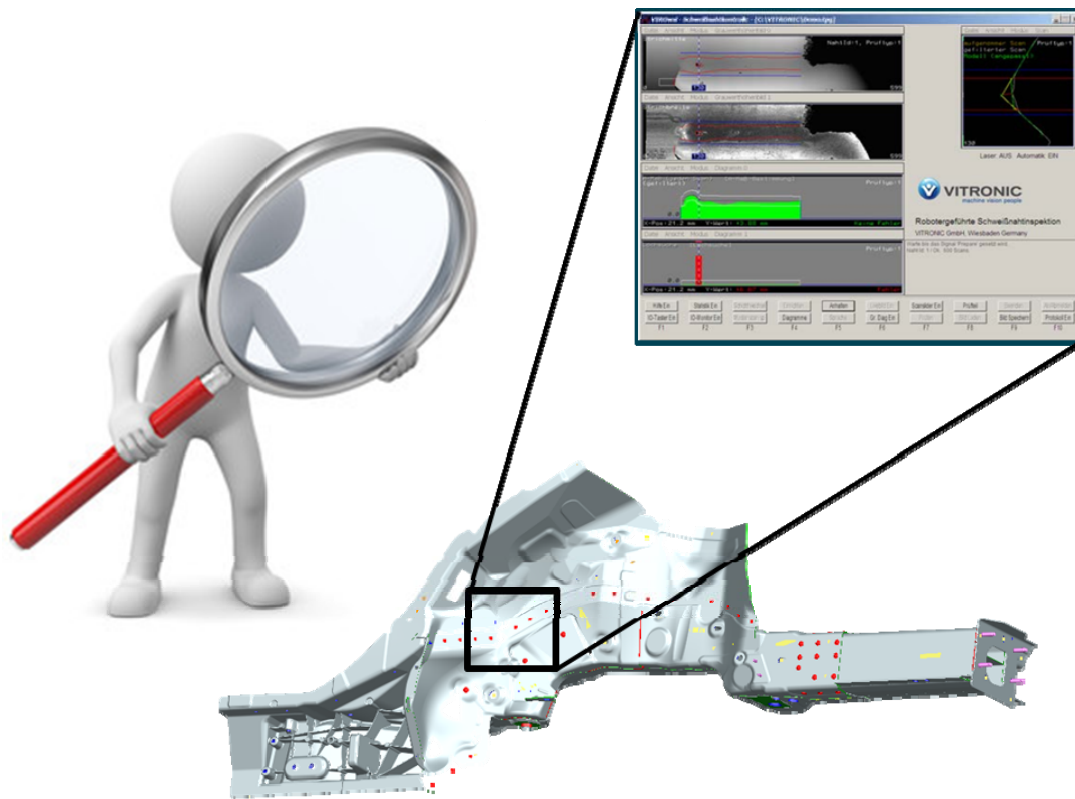
Luttmer, Michael; Thaler, Heiko; Dongus, Jürgen; Process Engineering
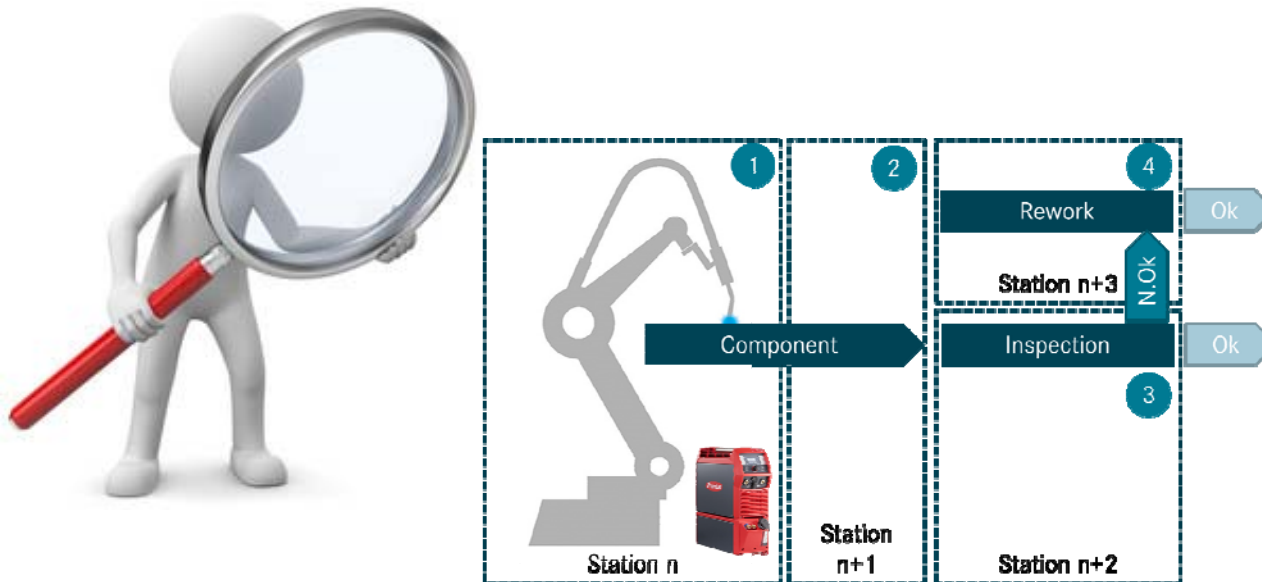
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The best or nothing.

Fully automated optical weld seam inspection systems (e.g.VIRO VSI from VITRONIC)

- Only optical evaluation of the weld seam

- Measuring principle: numerically error based

- Additional inspection station

- No contribution to increase process capability

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Data Analytics on process data to increase weld seam quality and process capability

Fully automated optical weld seam inspection trough systems such as the

VIRO VSI from VITRONIC
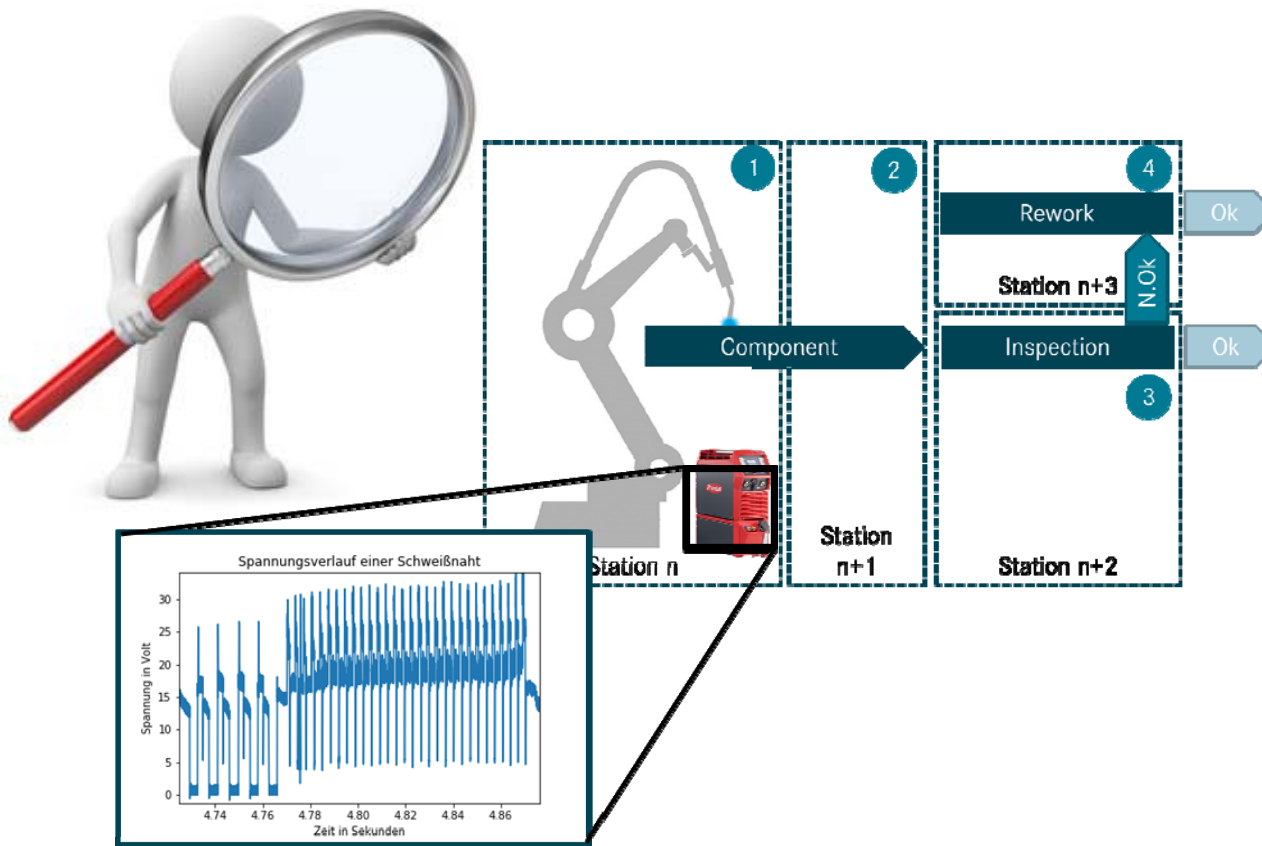
- Only optical evaluation of the weld seam

- Errors based on meassuring principles

- Additional inspection station

- No contribution to increase process capability

Data Analytics on process data to increase weld seam quality and process capability

Approach: Find features with significant correlation to your target

Consumption [ltr / 100km]	10	15
Time [min]	60	45
Distance	Stuttgart - Karlsruhe	

Target → Who was speeding?

Approach: Find features with an significant correlation to your target

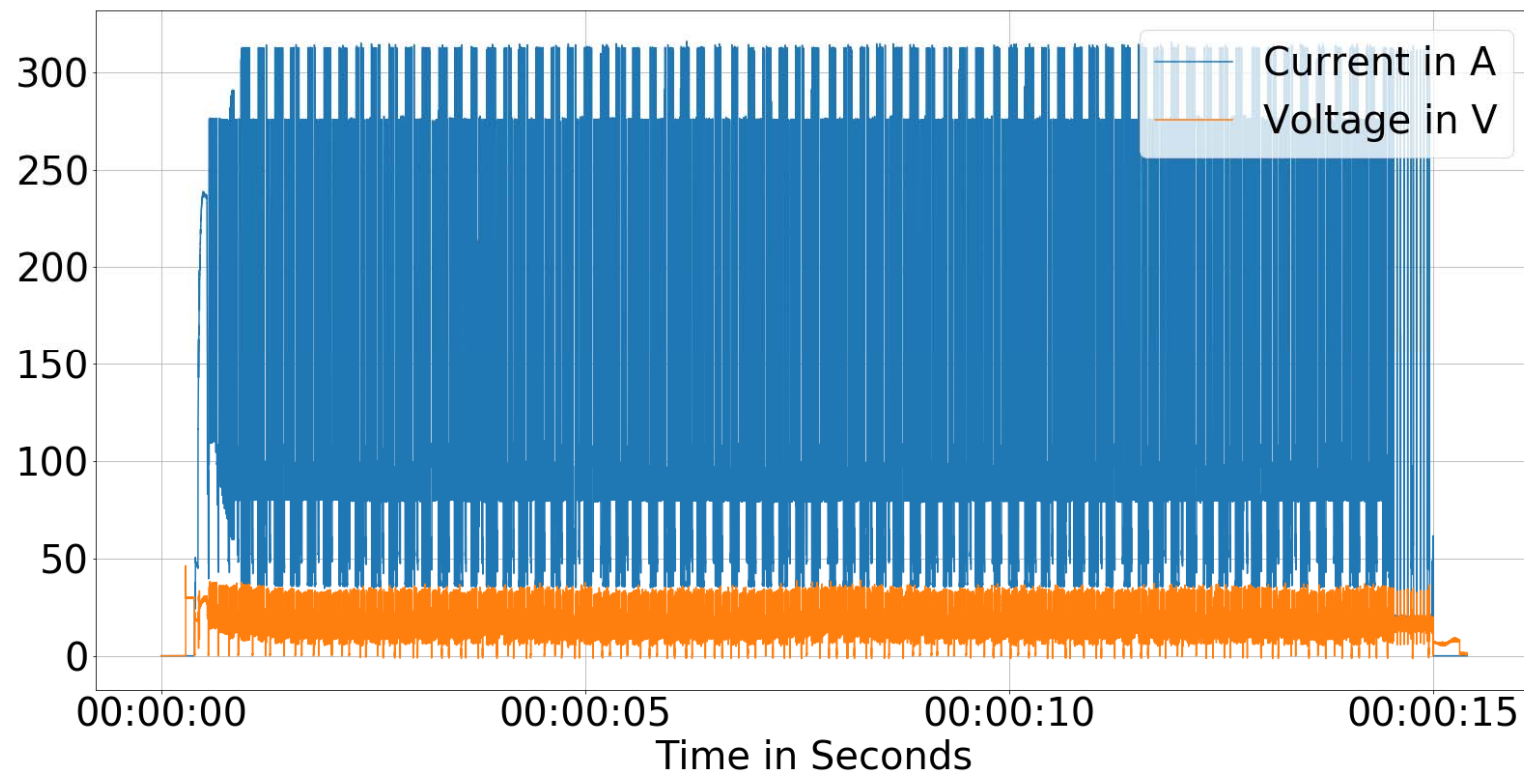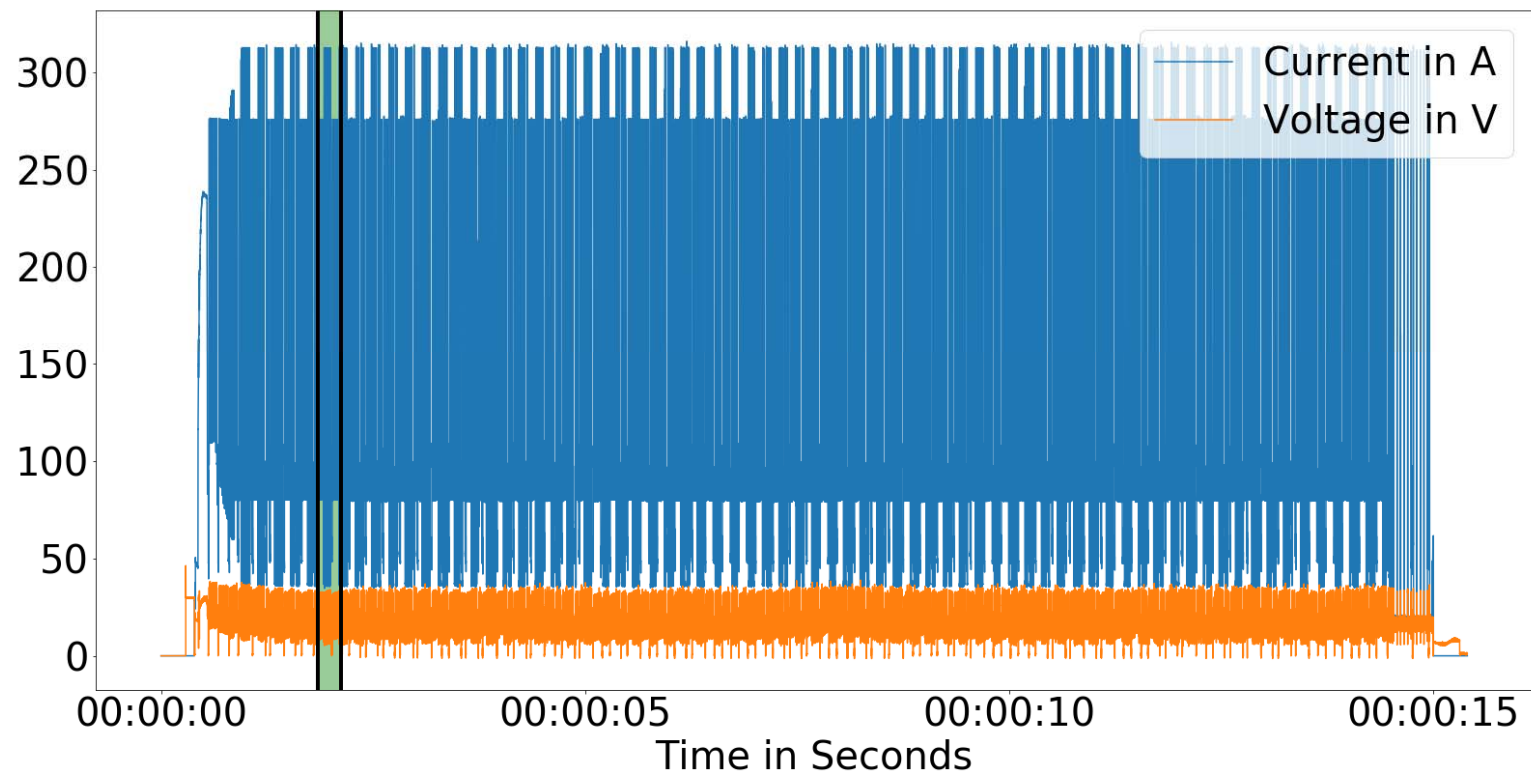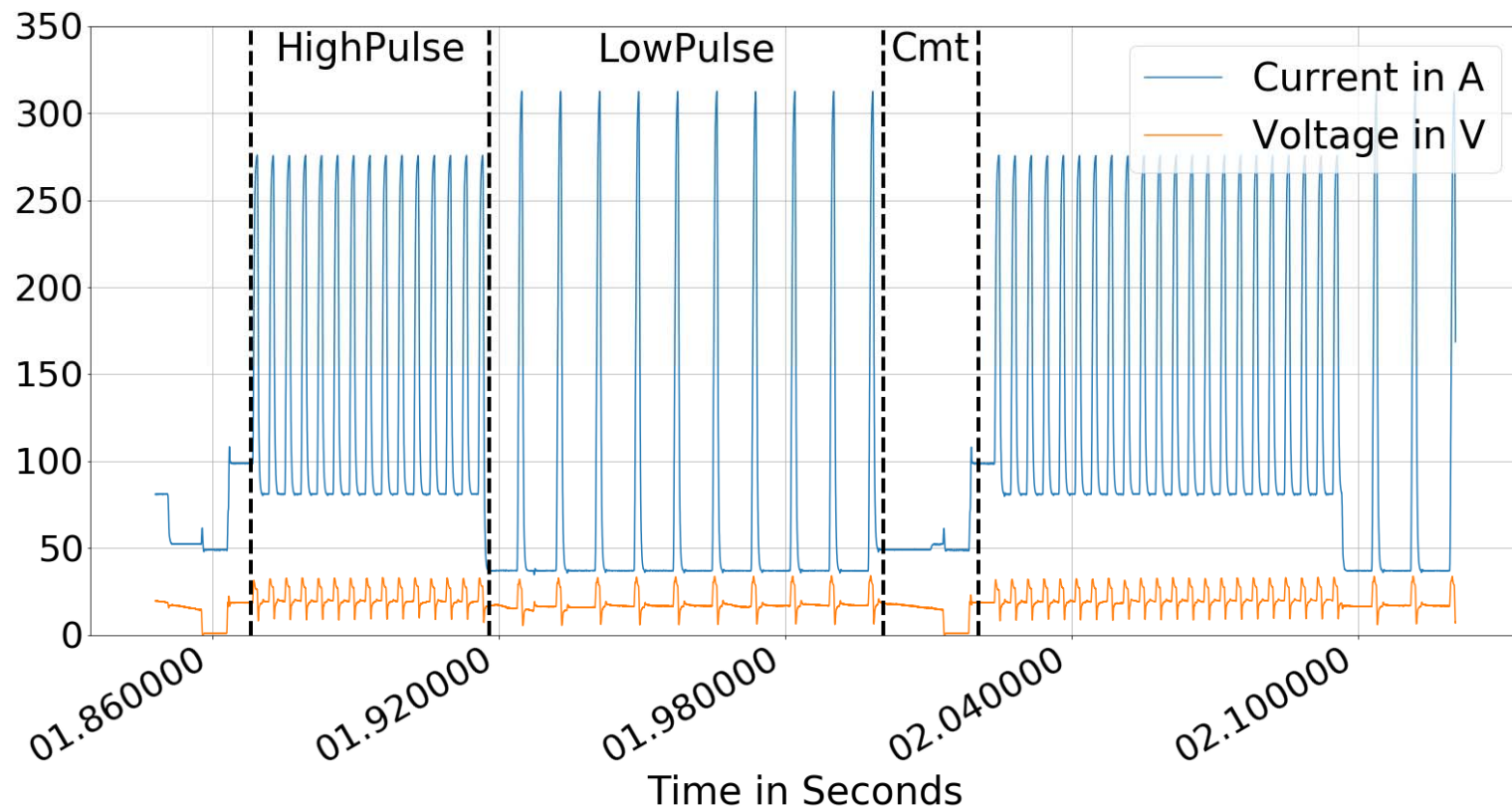| Color | yellow | blue |
| Add-ons | climatronic | bending lights |
| Distance | Stuttgart - Karlsruhe | |

The „modern" gas metal arc welding process is a mixture of different process types

The „modern" gas metal arc welding process is a mixture of different process types

The „modern" gas metal arc welding process is a mixture of different process types

- Controlable heat input

- Stable arc length

- Better gap bridgeability

- Evenly rippled surface

How does our Database look like?

Offset seam

- Pores/Holes
- Undercuts

- Voltage
- Current

- Quality seam

Seam 1120

Seam 1130

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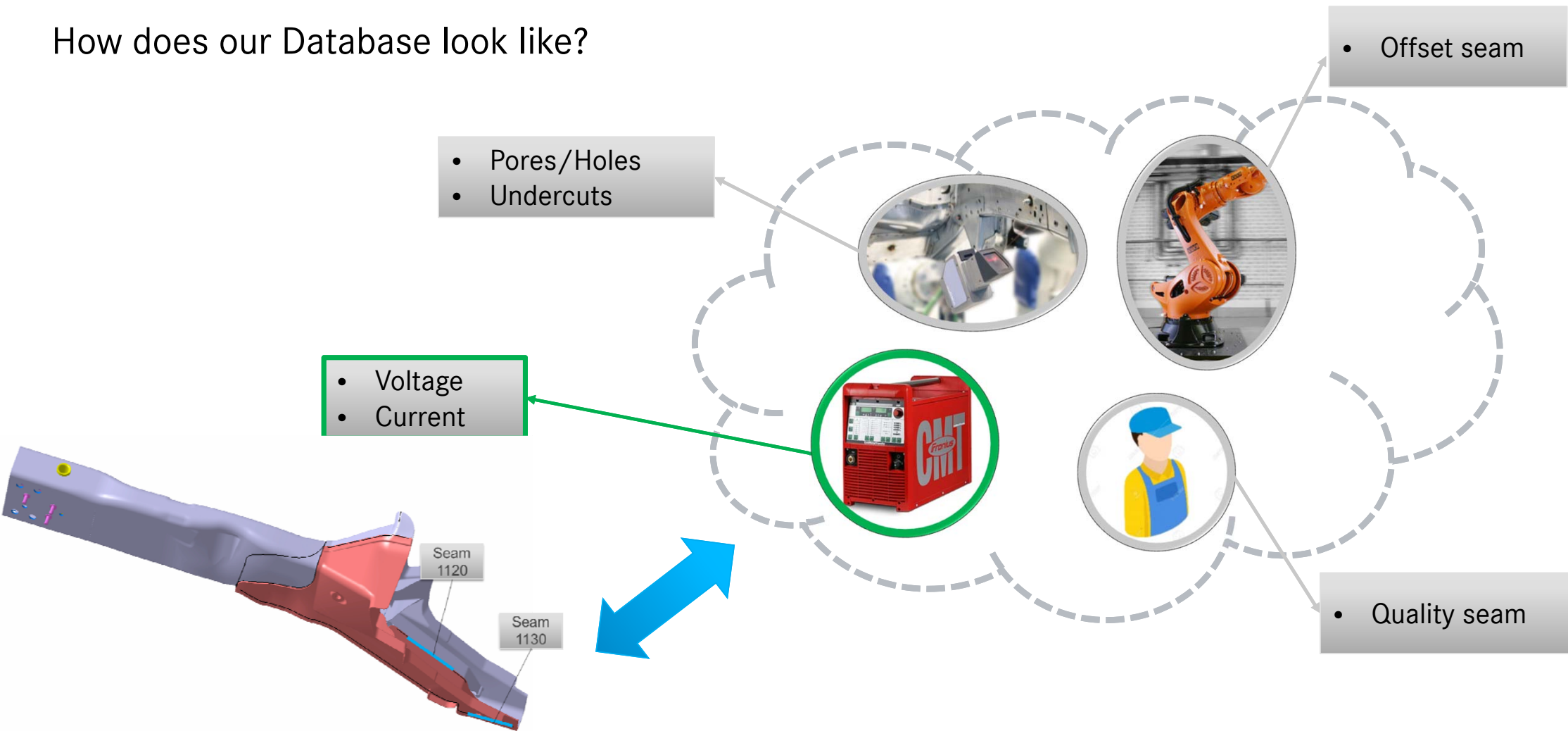
Procedure: From process data to weld seam quality
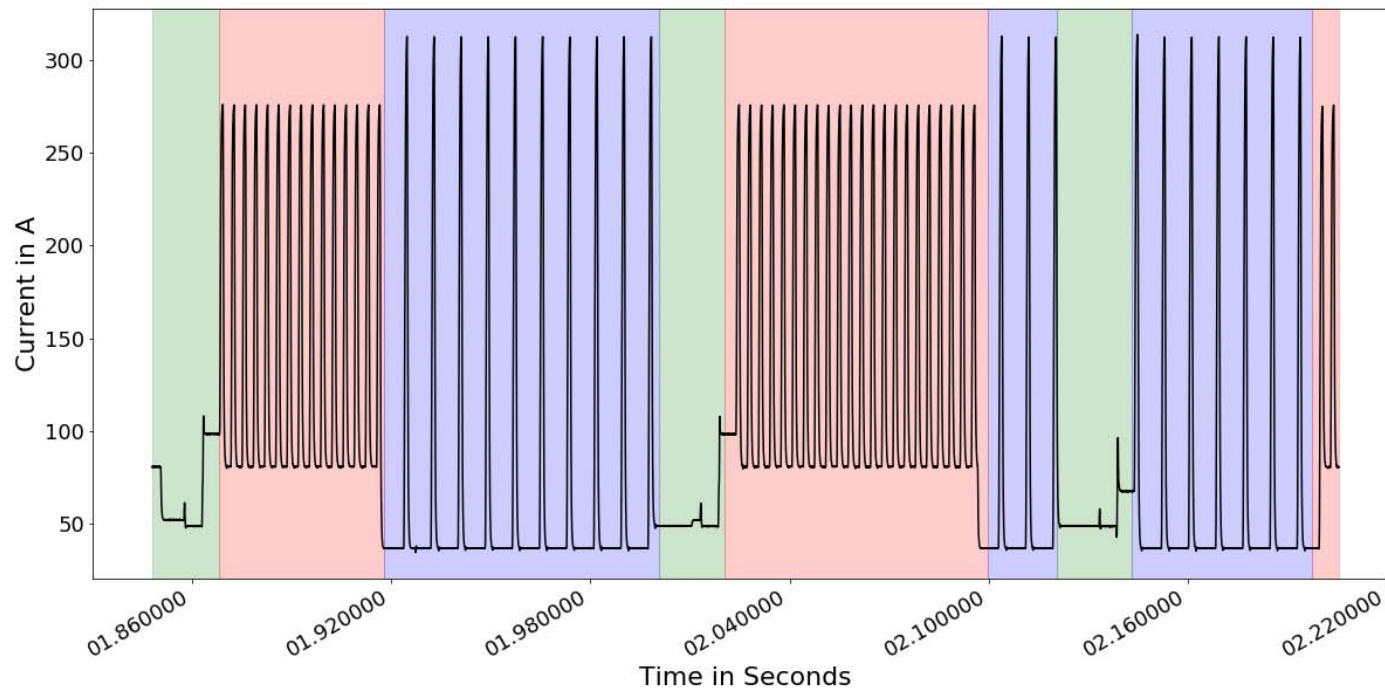
Automatic segmentation of similar process cycles

Segmentation ▶ Classification ▶ Extraction ▶ Correlation ▶ Result

Procedure: From process data to weld seam quality

Classification of the segments with unsupervised learning
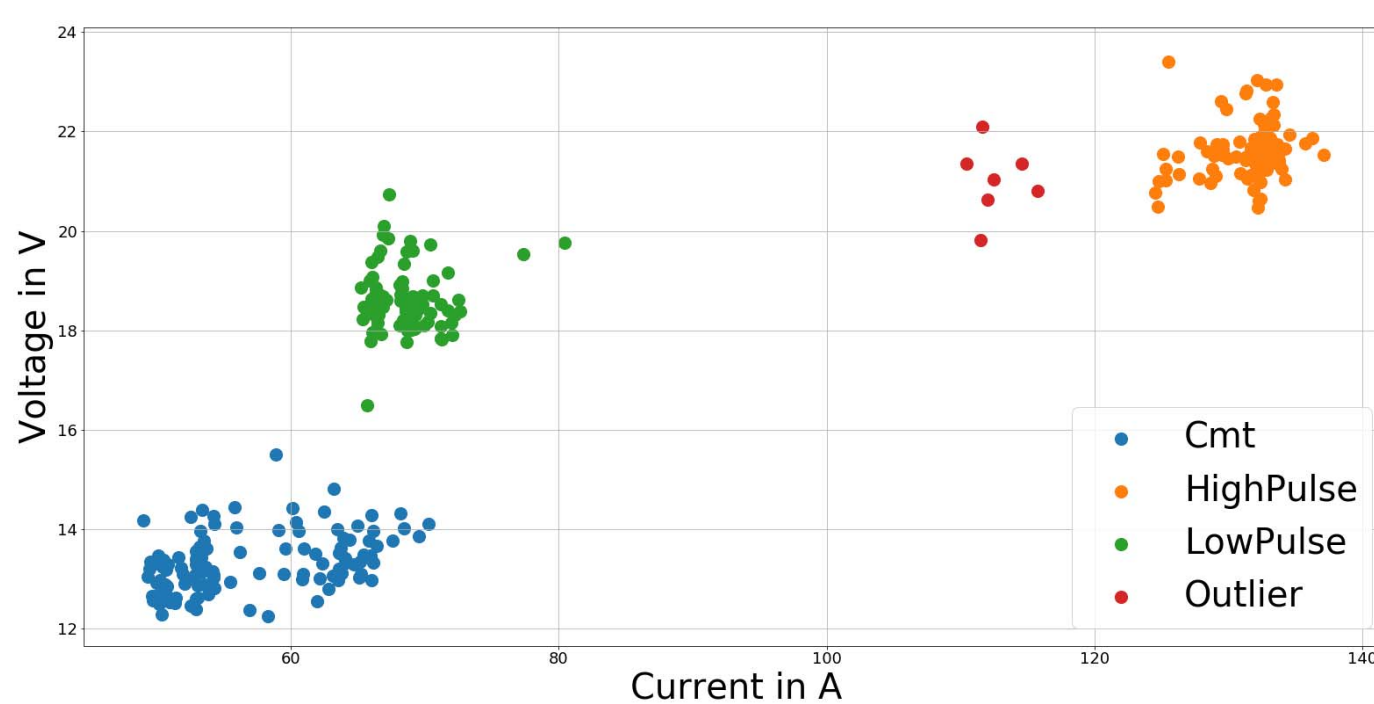
Segmentation	Classification	Extraction	Correlation	Result

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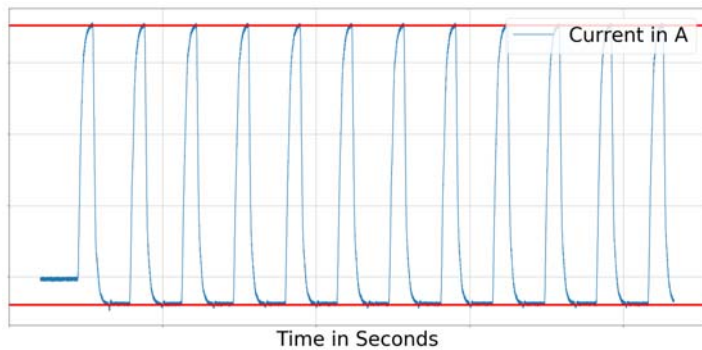**Route:** From process data to weld seam quality
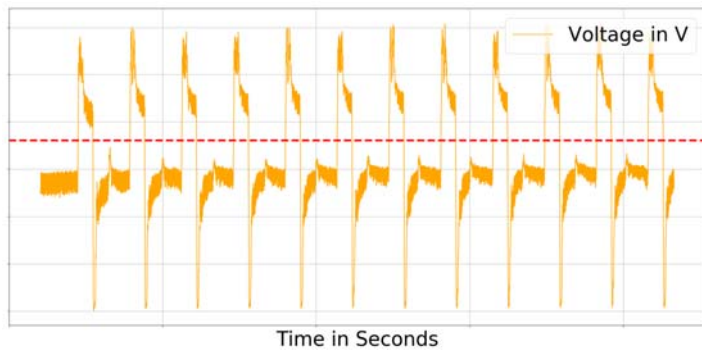
- Mean
- Variance
- Skewness
- Kurtosis

- Base time
- Pulse time
- Base current
- Pulse current

Extraction of statistical and process specific features

Segmentation → Classification → **Extraction** → Correlation → Result

Procedure: From process data to weld seam quality
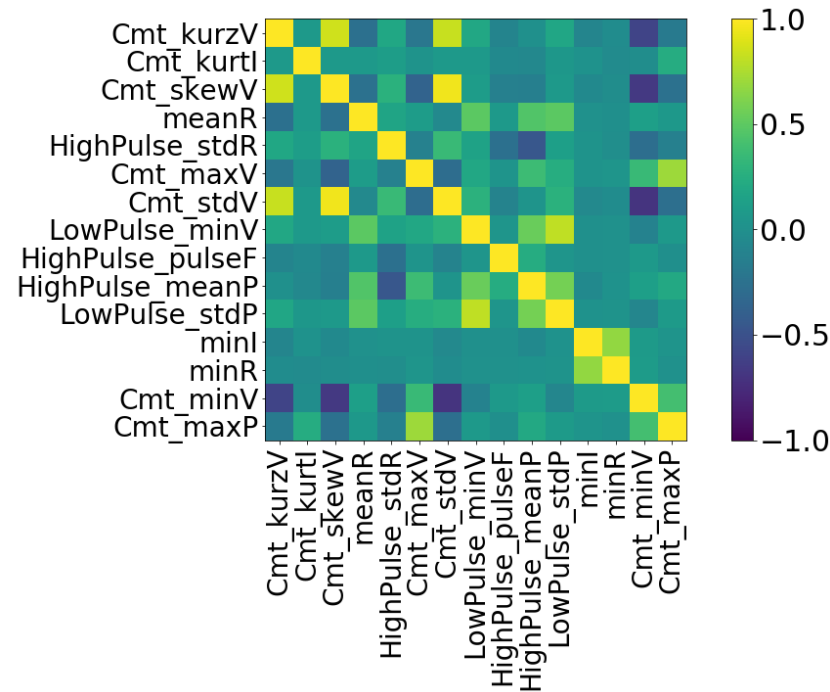
Analysis of correlation between process and quality features

Segmentation → Classification → **Extraction** → Correlation → Result

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Basics: The correlation coefficient measures the relation between features and target

Consumption [ltr/100km]	10	15
Time [min]	60	45
Color	yellow	blue
Add-ons	climatronic	bending lights

Target ➜ Who was speeding?

Basics: The correlation coefficient measures the relation between features and target

Consumption [ltr / 100km]   High

Time [min]   High

Color   Low   Correlation-
                                                      coefficient
Add-ons   Low

Target → Who was speeding?

Basics: The correlation coefficient measures the relation between features and target

Consumption [ltr / 100km]	10	15
Time [min]	60	45
Color	Pink	Blue
Add-ons	parking assistance	bending lights

Target → Which car was driven by a „hipster"?

Basics: The correlation coefficient measures the relation between features and target

Consumption [ltr ∕ 100km]

Time [min]

Color

Add-ons

Correlation-coefficient

Target → Which car was driven by a „hipster"?

Basics: The correlation coefficient measures the relation between features and target

Consumption [ltr / 100km]   Low

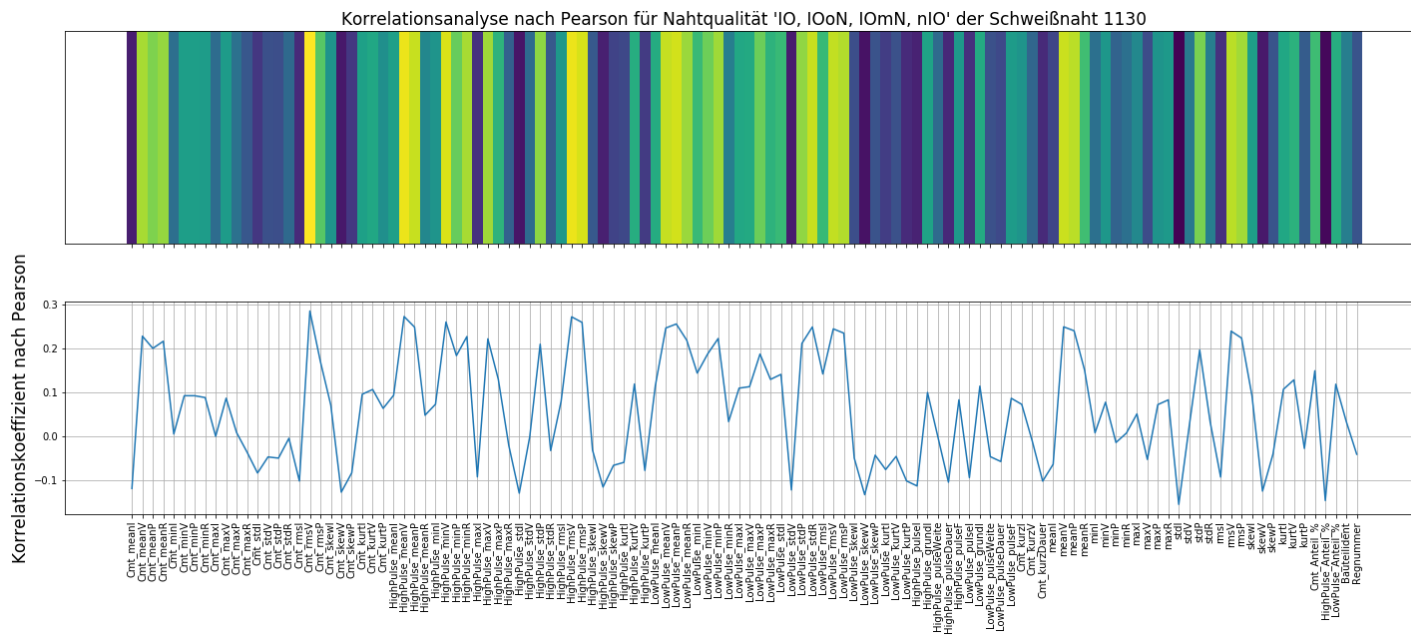Time [min]   Low   Correlation-
                                                    coefficient
Color   High

Add-ons   High

Target → Which car was driven by a „hipster"?

Procedure: From process data to weld seam quality

Korrelationsanalyse nach Pearson für Nahtqualität 'IO, IOoN, IOmN, nIO' der Schweißnaht 1130

Selection of
high coefficient

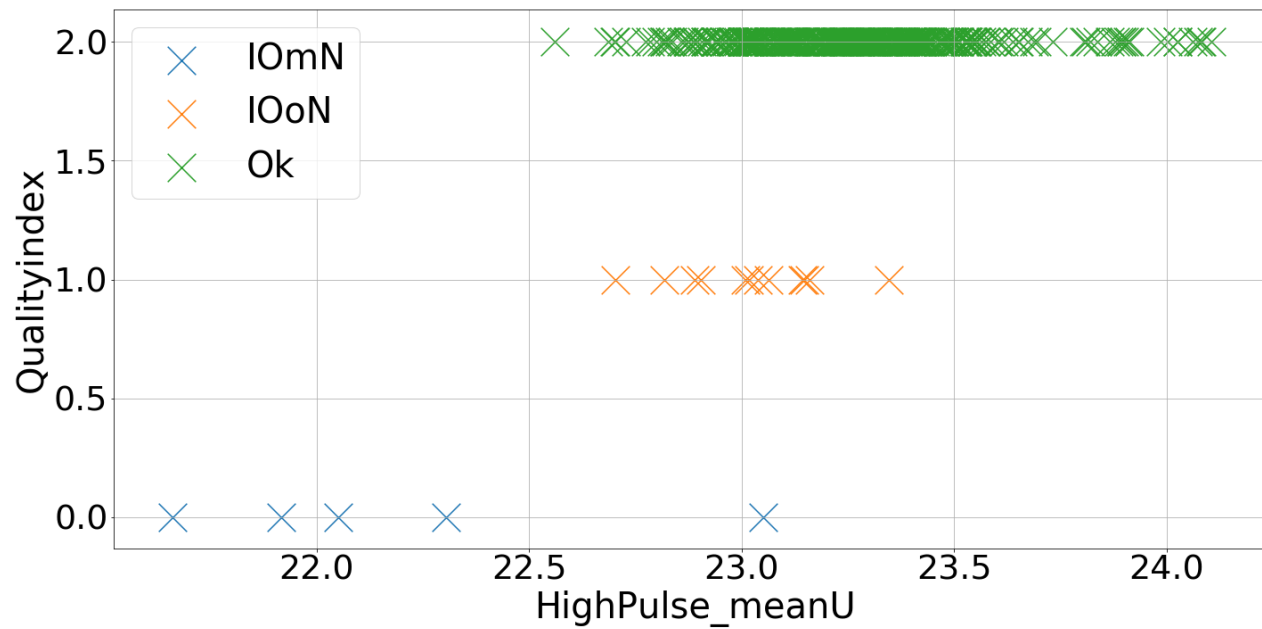| Segmentation | Classification | Extraction | Correlation | Result |

Procedure: From process data to weld seam quality

Korrelationsanalyse nach Pearson für Nahtqualität 'IO, IOoN, IOmN, nIO' der Schweißnaht 1130

HighPulse_meanU
Coef. ~0.28

| Segmentation | Classification | Extraction | Correlation | Result |

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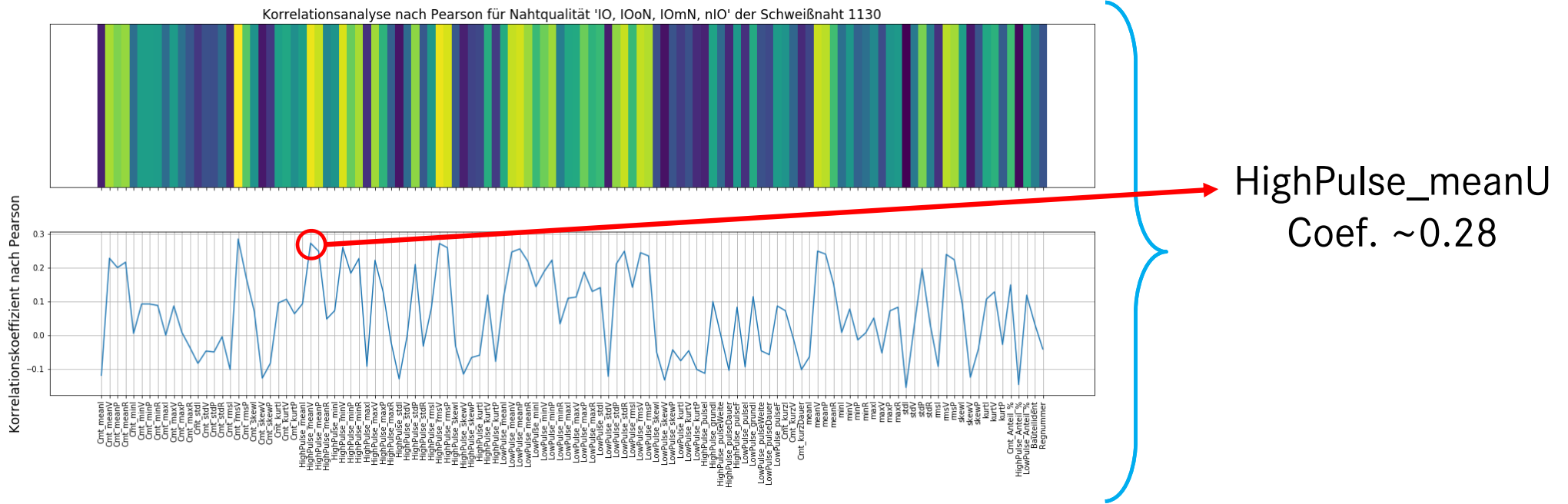
Procedure: From process data to weld seam quality

HighPulse_meanU
Coef. ~0.28

Segmentation → Classification → Extraction → Correlation → Result

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Procedure: From process data to weld seam quality
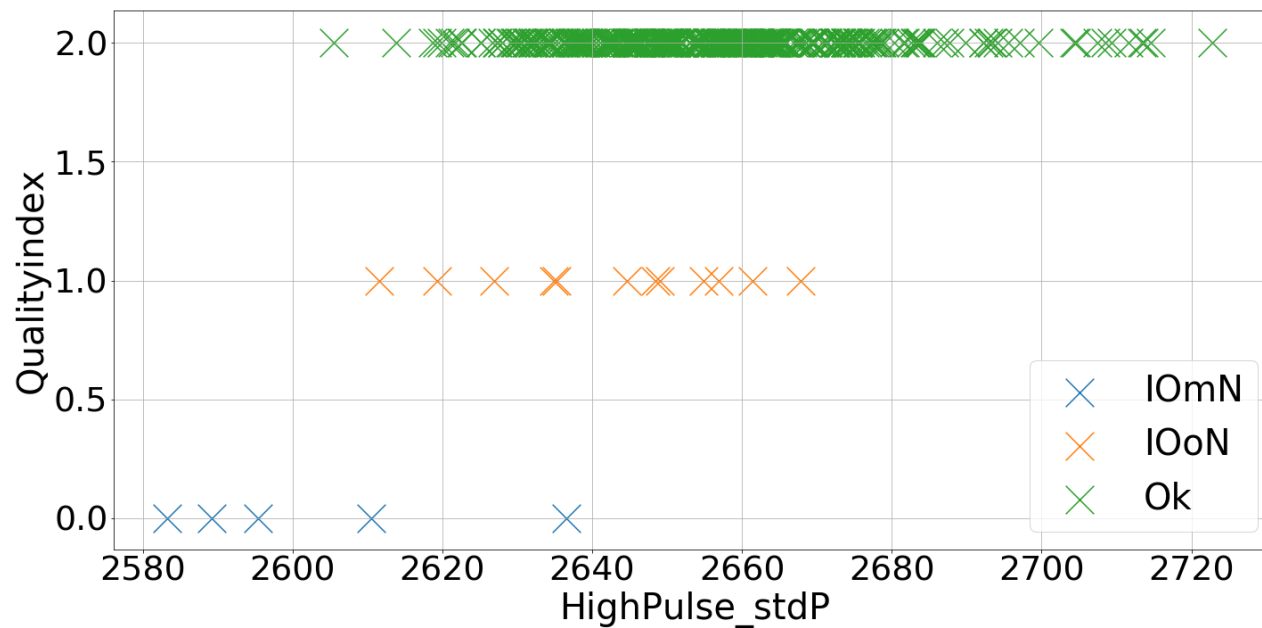
HighPulse_stdP
Coef. ~0.23

| Segmentation | Classification | Extraction | Correlation | Result |

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Procedure: From process data to weld seam quality
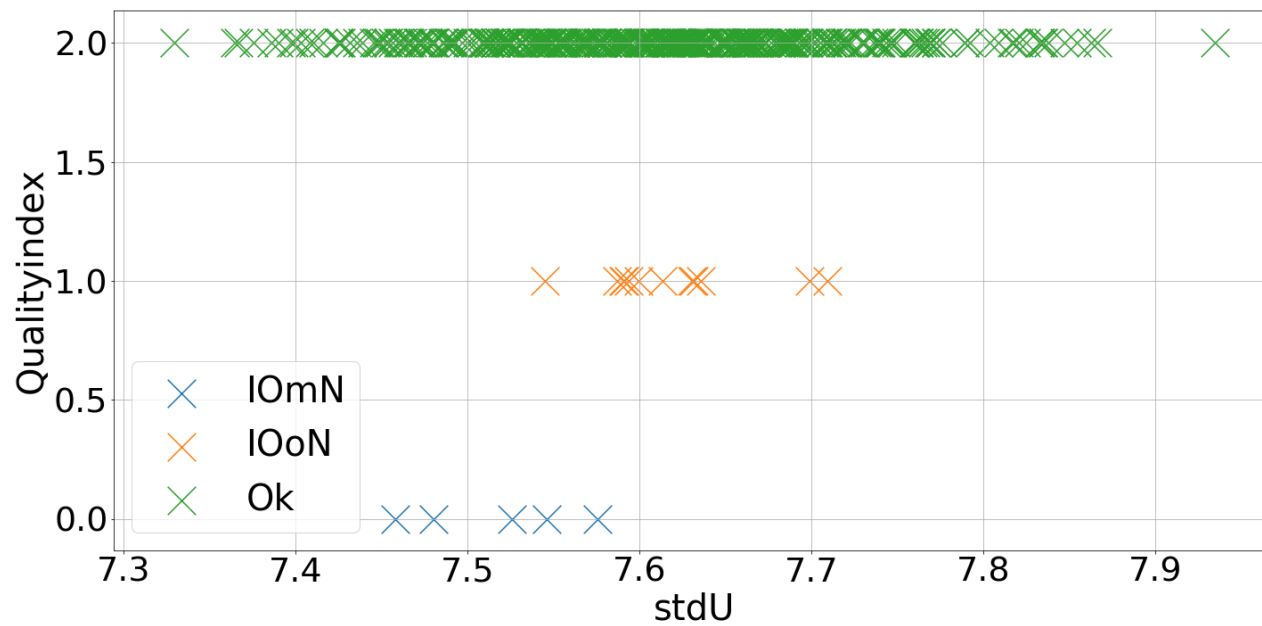
stdU
Coef. ~0.06

Segmentation → Classification → Extraction → Correlation → **Result**

Summary

First steps are done- next ones have to follow

- Feasibility studies

- Features in time domains

- Criteria: IO, IOoN, IOmN

Summary

First steps are done- next ones have to follow

- Feasability studies

- Features in time domains

- Criteria: IO, IOoN, IOmN

- Statistical significance

- Features in frequency domains

- Determination of error types

Outlook

First steps are done- next ones have to follow

• Feasability studies

• Features in time domains

• Criteria: IO, IOoN, IOmN

• Statistical significance

• Features in frequency domains

• Determination of error causes

Bigger data basis, more classified welding errors

Thank you very much for your attention!