# PROCESSING AND ANALYZING OF BIG DATA STRUCTURES IN THE FIELD OF JOINING TECHNOLOGY

Workshop
Numerische Simulation in der mechanischen Fügetechnik
2017

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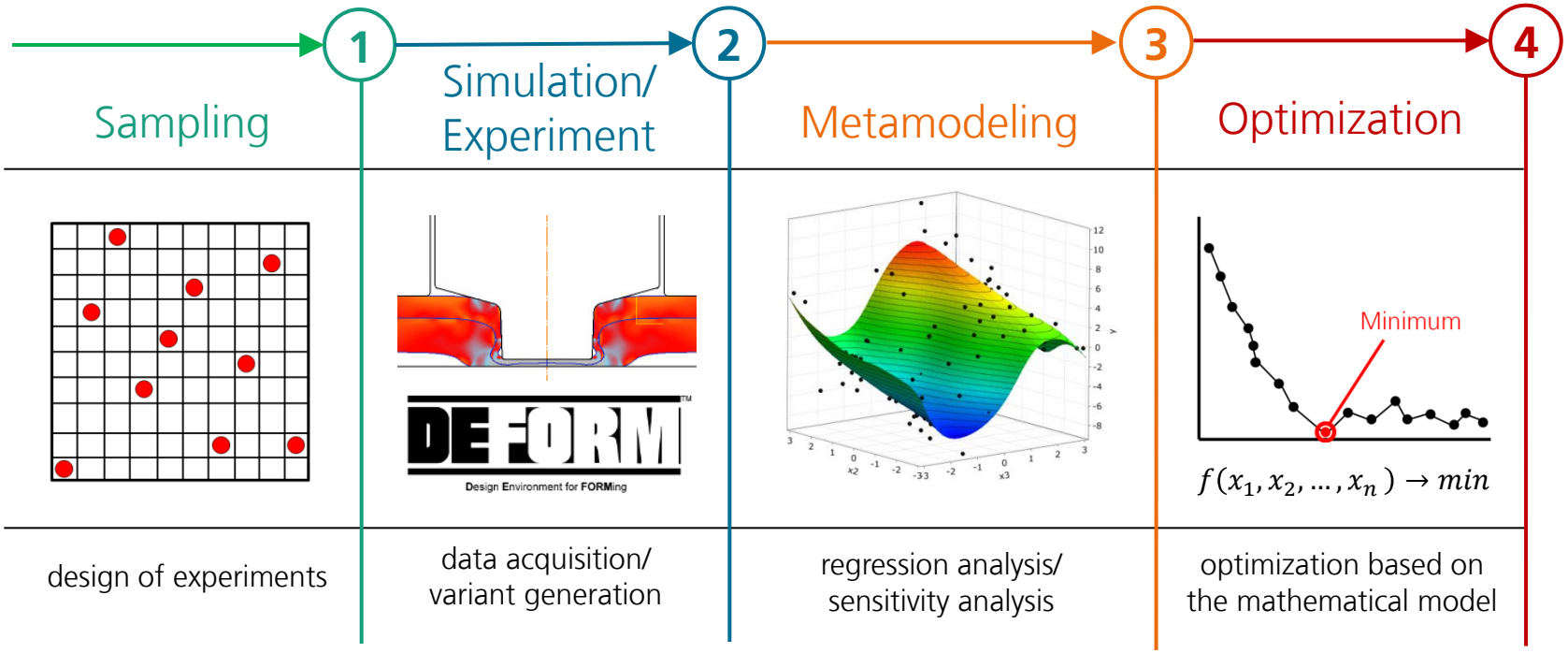
# Agenda

- Motivation
- Principal component analysis – PCA
- Model-based optimization process using PCA-technique
- Example 1: Interactive process optimization for clinching with planar counter tool
- Example 2: Micrograph optimiziation for laser beam welding
- Example 3: Sensitivity analysis of a car body assembly process
- Summary and outlook

# Motivation

## Model-based optimization process





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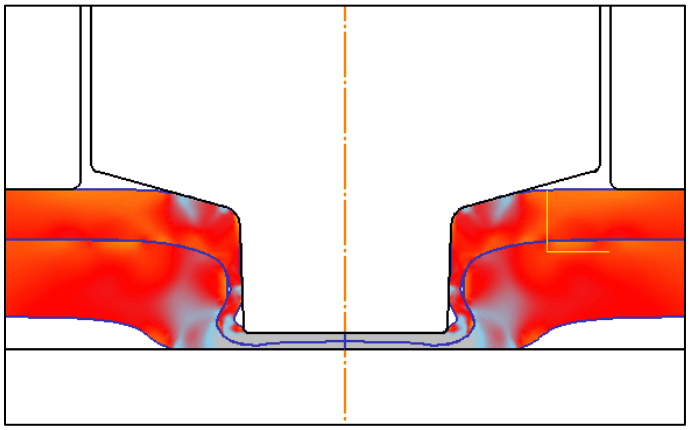
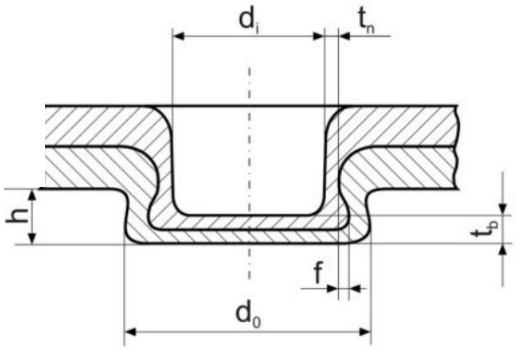
# Motivation

## Quality criteria of clinching with planar counter tool



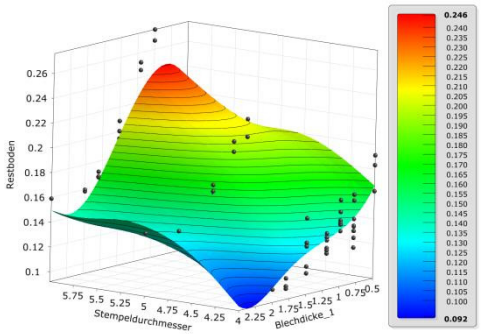
Process sequence of clinching with planar counter tool (simulation)

**Analysis of discrete geometric parameters**

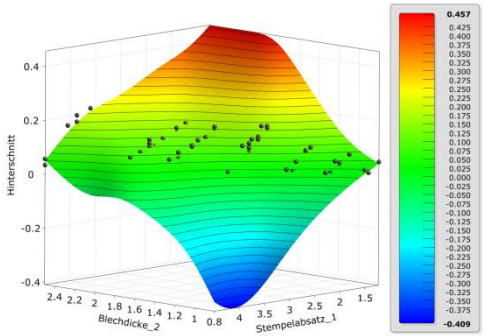



- bottom thickness $t_b$
- interlock $f$
- neck thickness $t_n$
- …

**bottom thickness $t_b$**




**interlock $f$**




**2 objectives = 2 meta models**





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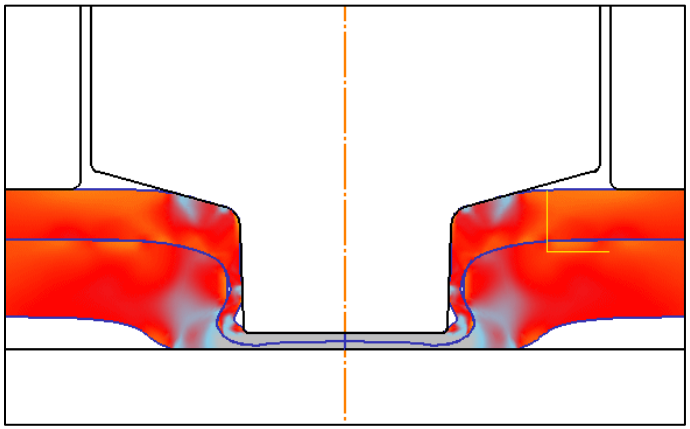
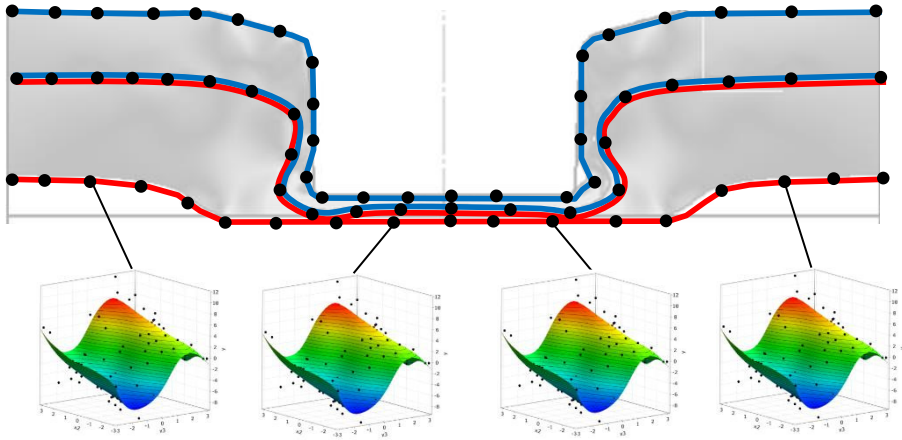
# Motivation

## Quality criteria of clinching with planar counter tool



Process sequence of clinching with planar counter tool (simulation)

**Analysis of the simulated joint contour (e.g. 10.000 data points)**



**10.000 objectives = 10.000 meta models**

dimensionality reduction of the data is necessary

**Principal Component Analysis – PCA**





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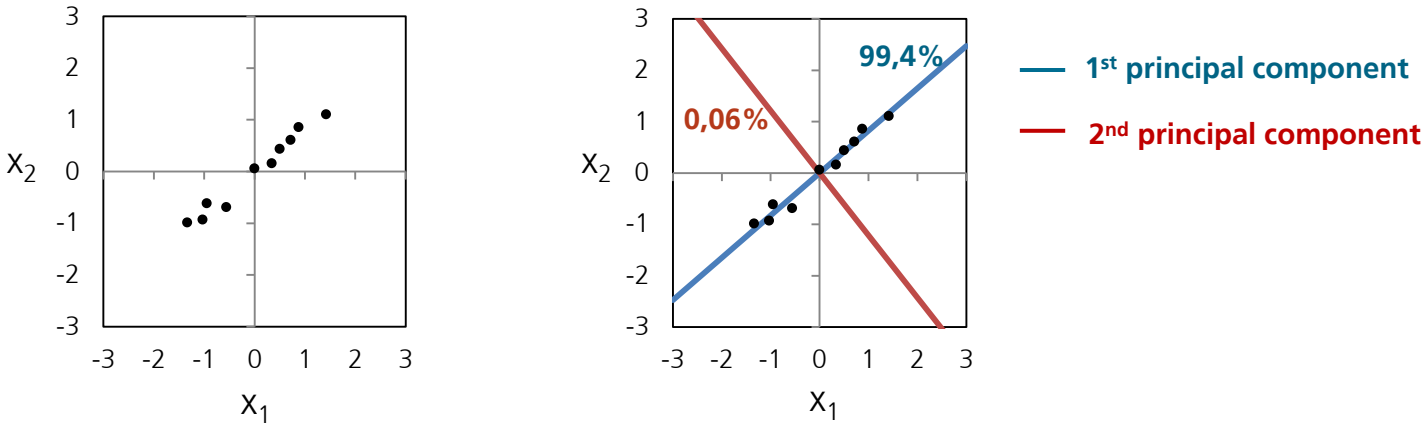
# Principal Component Analysis – PCA

- Principal Component Analysis (PCA) is a **multivariate statistical method** for identifying trends and patterns in **large amounts of data**
- PCA was developed by Pearson 1901 and Hotelling 1933
- The variance structure of high-dimensional data is approximated by a few significant **principal components**
- The **linear projection** of the original data matrix onto the **principal components** results in a low-dimensional projection matrix





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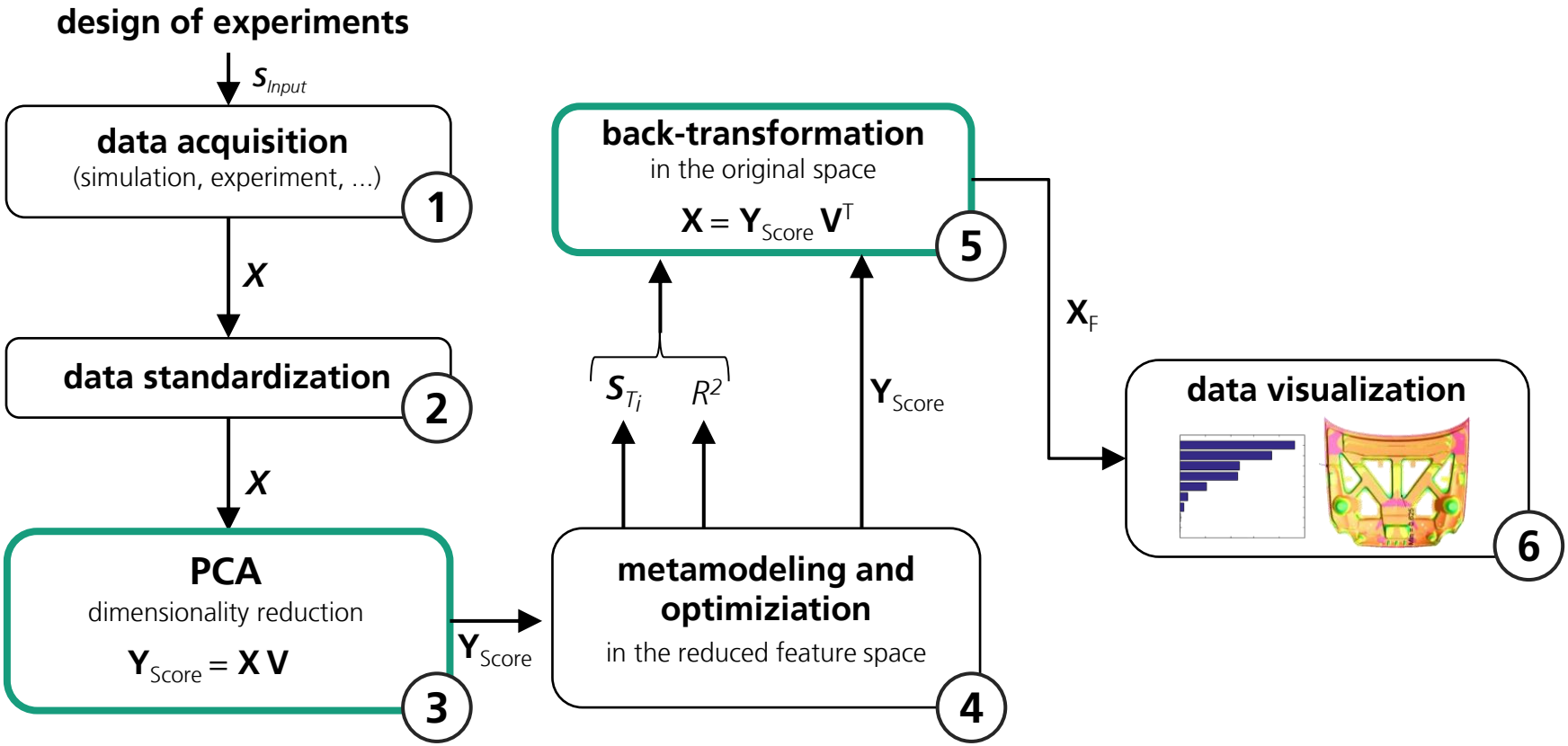
# Model-based optimization process using PCA-technique

## Workflow





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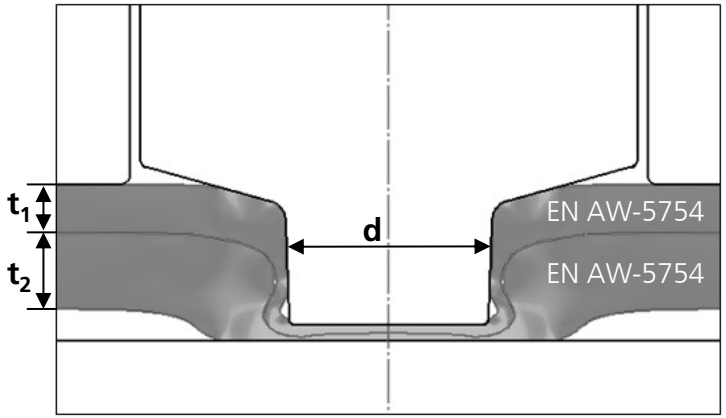
# Example 1: Interactive process optimization for clinching with planar counter tool

- 100 simulations by Deform

**input parameters:**

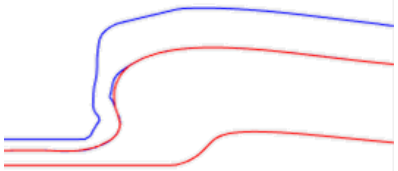
- upper sheet thickness $t_1$
- lower sheet thickness $t_2$
- punch diameter $d$



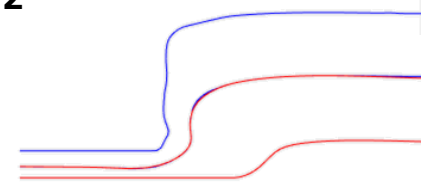

**output parameters:**

- joint contour

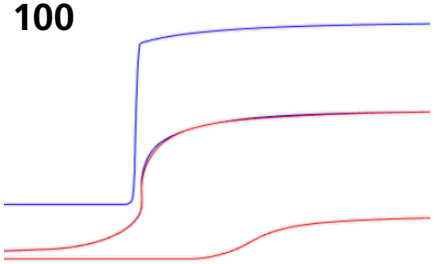
**design 1**



**design 2**



**design 100**







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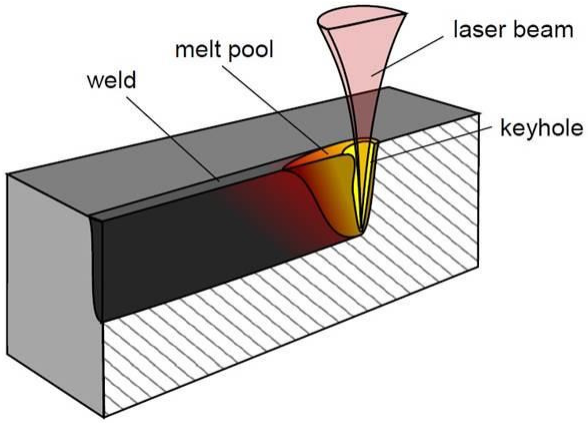
# Example 2: Micrograph optimiziation for laser beam welding

## Input

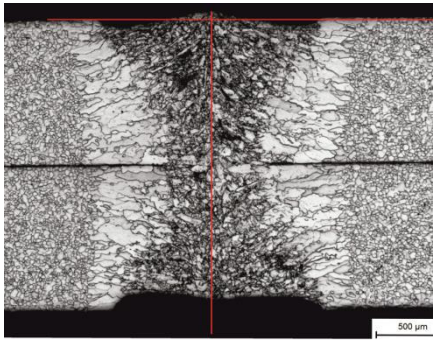
- 3 laser beam welding parameters
  - → focus position ***f*** (-5 to +5)
  - → laser power ***P*** (2000W to 5000W)
  - → laser velocity ***V*** (1m/min to 5m/min)



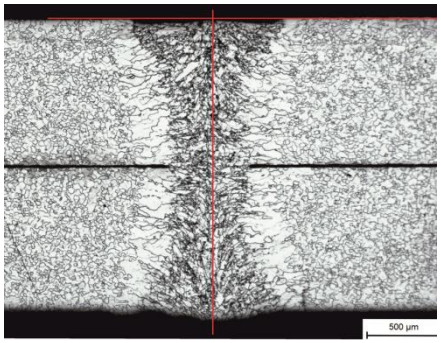

**Laser beam welding process***

## Output

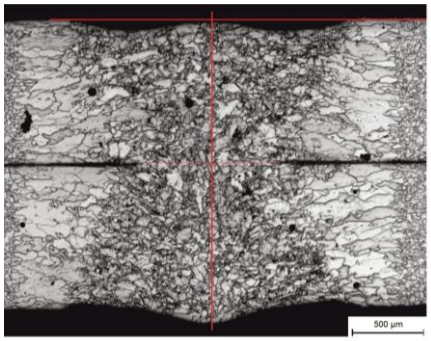
- 12 welding variants are generated experimentally
- Micrograph of the real welding seam geometry



**f = 2**
**P = 2830W**
**V = 2.8m/min**



**f = 0**
**P = 3370W**
**V = 5m/min**



**f = -2**
**P = 3630W**
**V = 1.5m/min**

**→ Functional connection of laser welding parameters with real weld seam geometry**

*Image source: http://www.ionix.fi/en/technologies/laser-processing/laser-welding/





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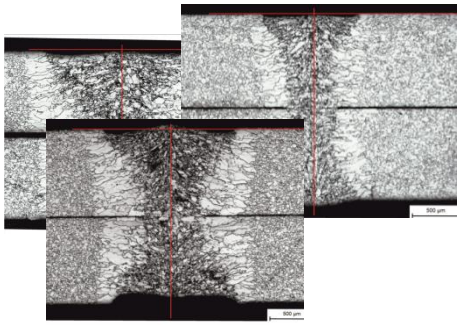
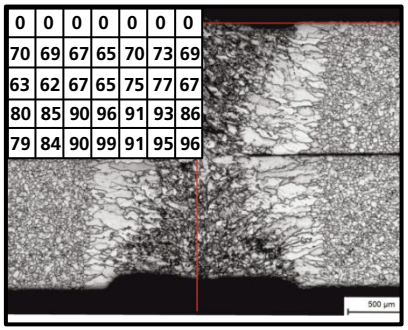
# Example 2: Micrograph optimiziation for laser beam welding

## Functional connection of laser beam welding parameters with weld seam geometry

**1** **12 experimental micrographs**

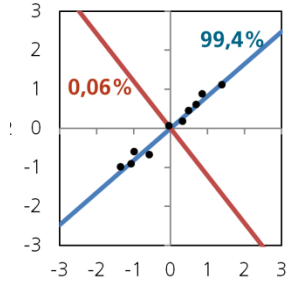


**2** **Analysis of the RGB color map**



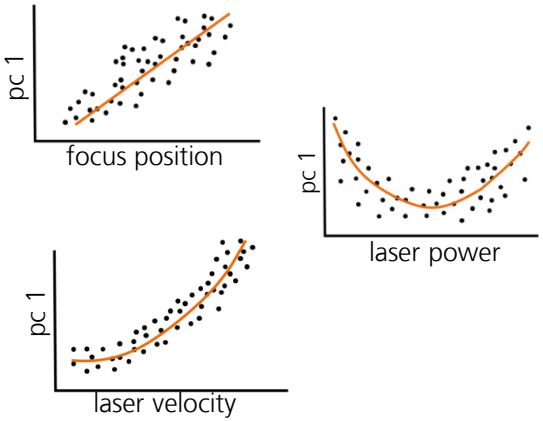

approx. 1,5 million pixel per micrograph

**3** **Principal Component Analysis**

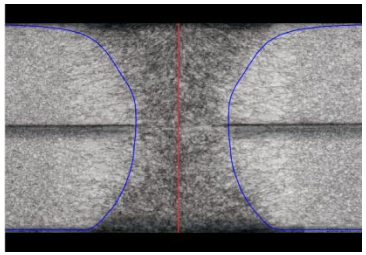



$Y_{Score} = X V$

**4** **PCA-based metamodeling**




**5** **Visualization**



**f = 1.5 P = 3600W V = 3m/min**

interpolated micrograph





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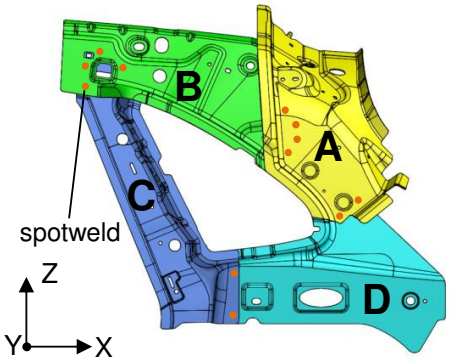
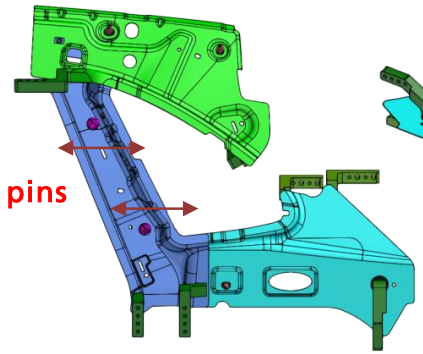
# Example 3: Sensitivity analysis of a car body assembly process

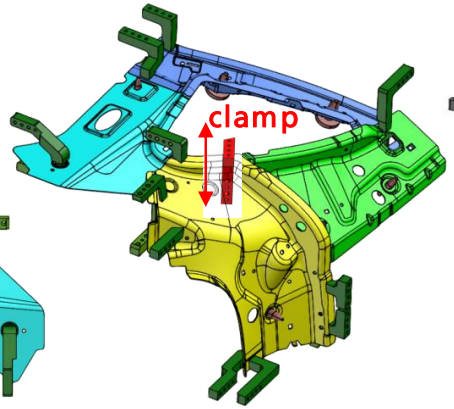
| assembly data | devices |
|---|---|



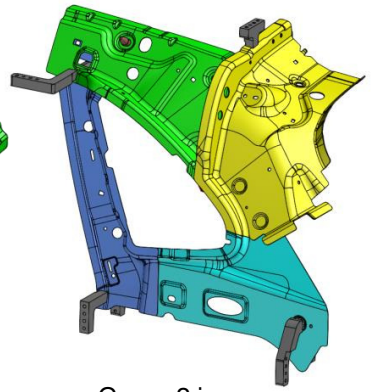

A: 1.75 mm (HX260YD) // B: 1.5 mm (HCT600X)
C: 0.8 mm (HX260YD) // D: 0.8 mm (DX54D)




Group 1 in joining device 1




Group 2 in joining device 2



Group 2 in measuring device

Conditions of the sensitivity analysis

- 50 simulations (PamStamp/ESI)
- 2 input parameters (pin variation + clamp variation)
- Mesh size: ~100.000 elements





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# Summary and outlook

- A possibility to analyze **big data structures** by using **PCA-based metamodeling** and optimization approach was shown

  → **Significant reduction** in time and cost **(up to 99,99%)**

  → **Wide range** of possible applications

  (mechnical joining, thermal joining, car body process, …)

  → Processing of **multi-type data** possible (contours, meshes, pictures, …)

  → Opens the way for a **better process understanding**

- Need of additional research

  → The limitations of the method have to be tested