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A Framework for Inline Quality Inspection

Reduction of development time and increase of classification performance by using a Data-Centric Deep Learning Approach

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Portfolio of Miba AG

→ Or products we need to inspect

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ENERGY GENERATION

WIND POWER

SOLAR ENERGY

HYDRO POWER

GAS UND DIESEL GENSETS, TURBINES

FUEL CELLS

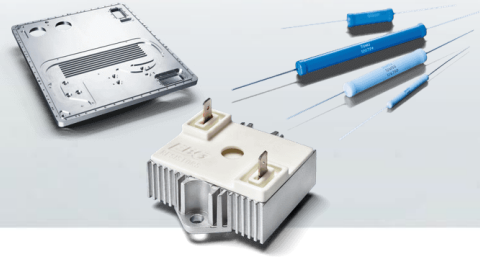
ENERGY TRANSMISSION

EFFICIENT ELECTRICITY TRANSMISSION
(e.g., high-voltage direct current (HVDC) transmission / medium voltage direct current (MVDC) transmission)

SMART GRIDS
(intelligent networkind and control of power grids)

COMPRESSORS AND PUMPS

COMPONENTS FOR CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES



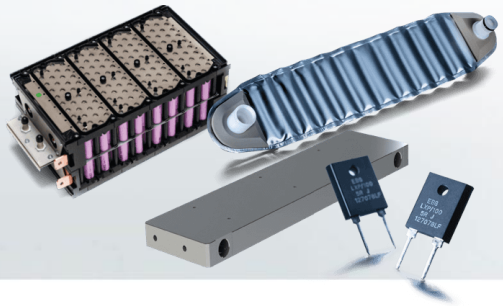
ENERGY STORAGE

BATTERY SYSTEMS AND MODULES

BATTERY COOLING SOLUTIONS

POWER SAFETY DEVICES FOR BATTERIES & FUELL CELLS

COATING SOLUTIONS FOR BATTERIES



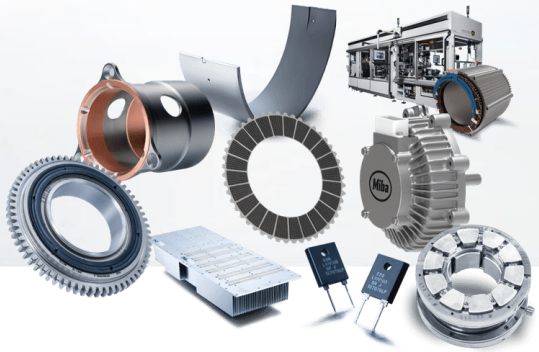
ENERGY USE

HIGHLY EFFICIENT POWERTRAIN TECHNOLOGY:

- CONVENTIONAL DRIVES
- HYBRID DRIVES
- FULLY ELECTRIC DRIVES

VEHICLE APPLICATIONS OUTSIDE THE POWERTRAIN
(e.g. auxiliary drives)

INDUSTRIAL APPLICATIONS



The production of high-quality components and its related productivity and quality goals.

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- → *Automated quality inspection systems are crucial to achieve productivity and quality goals in producing our high-quality components.*
- → *These quality inspection systems enable other automation steps, such as automatic packaging*
- → Conventional rule-based inspection systems have only partially met classification requirements
- → *MIBA developed an own quality inspection system based on a Data-Centric Deep Learning Approach*

The Quality Inspection Framework

Illustration and description of the framework

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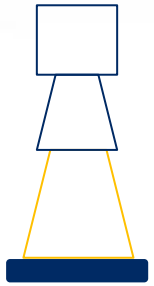
online *Matlab Compiler*

offline *App Designer*

Data & Image Acquisition

Image Acquisition Toolbox



Pre-processing

Computer Vision Toolbox
Image Processing Toolbox

- Filters
- Pose Estimation
- Cut out ‘Region of Interest’ (ROI)
- Feature Extraction

Classification & Reasoning

Deep Learning Toolbox
Statistics and Machine Learning Toolbox

- Classification with Deep Learning Models
- Determining the results (Classes, Distances, …)

Model customization cycle

- Labeling of the Training Data
- Model Training
- Performance Analysis / Validation of Training and Testdata
- Identification of ‘Data Gaps’
- Lean Model Deployment

Data-Centric Model Training

Deep Learning Toolbox
Statistics and Machine Learning Toolbox

Communication

Industrial Communication Toolbox

- PLC (OPC-UA)
- Database
- HMI

The Quality Inspection Framework

Hardware & Software Setup

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Hardware setup:

→ *Focus on seamless integration in the automation.*

→ *Clear definition of requirements (cycle time, environmental conditions, position/movement of components during image acquisition, …)*

Software setup:

→ *Edge Computing (Industrial PC directly integrated into the automated inspection system)*

→ *Deploy the networks and executable directly on the Industrial PC*

→ *MATLAB as backbone of the single software modules*

→ *Fast updating of classification networks via defined processes and automated SW tools*

Our Data-Centric Approach

The workflow

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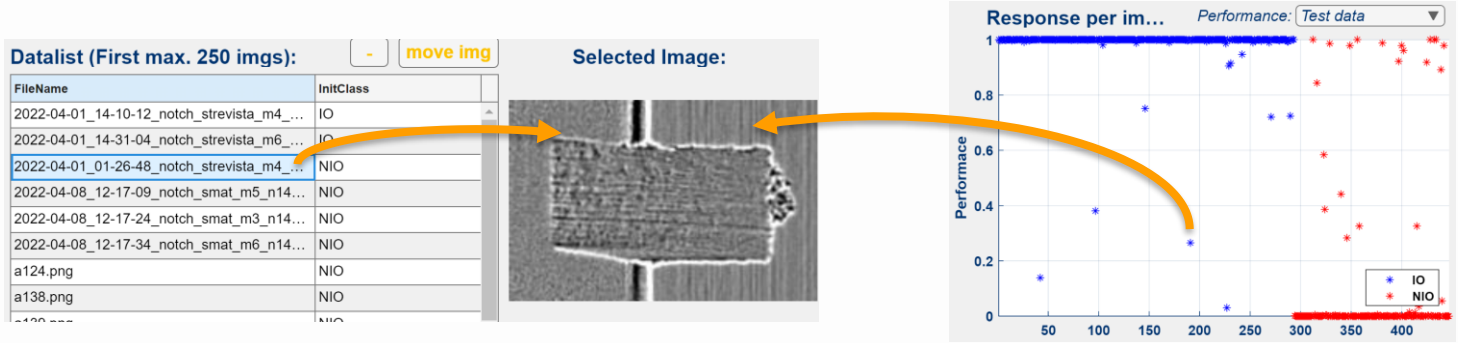
Focus on a ‚Data-Centric' instead of a ‚Model-Centric' approach

→ *Model training and hyperparameter tuning is done automatically using Matlab based guided tool*

→ *Identification of missing data & wrong labeled data*



Continuous improvement of the data base & classification performance

Our Data-Centric Approach

Problem definition & the data

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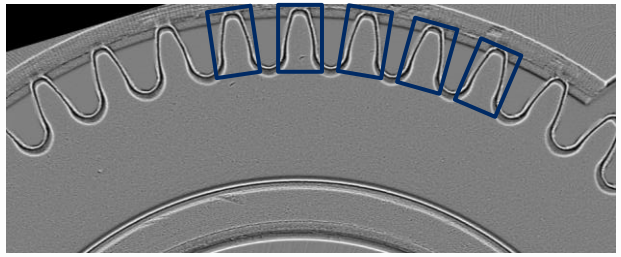
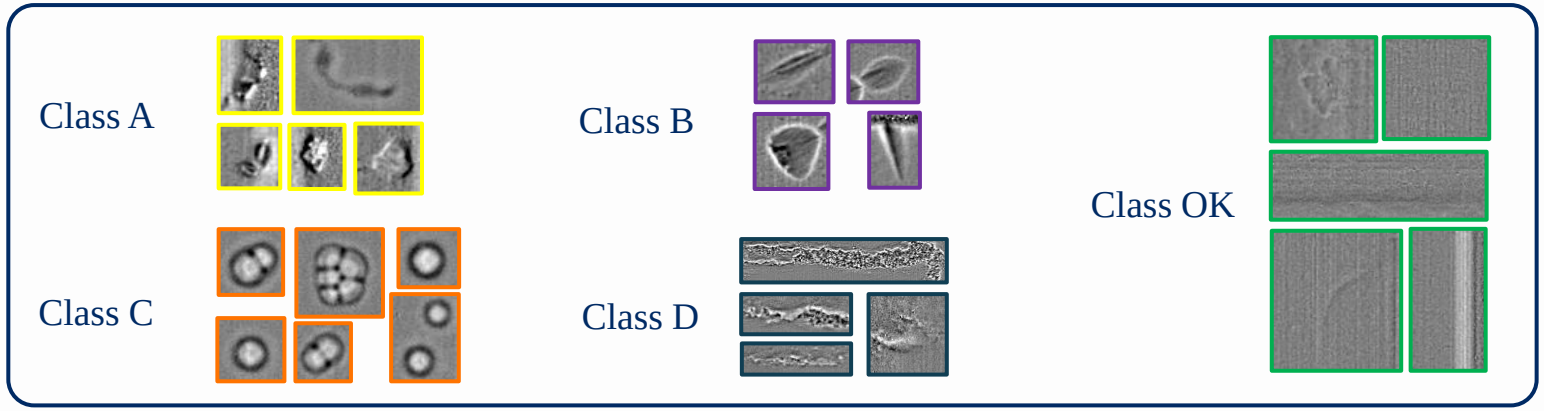
Decomposing inspection challenge to reach higher classification performance with less data

→ *breaking down a problem into few smaller problems that can more easily be addressed*



Subdivision of failure categories to better identify error causes



Results & Discussion

From a production viewpoint

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Successful running systems:

→ *In the first year, the increased use of deep learning and the data-centric approach led to the launch of more inspection systems than in the previous five years combined.*

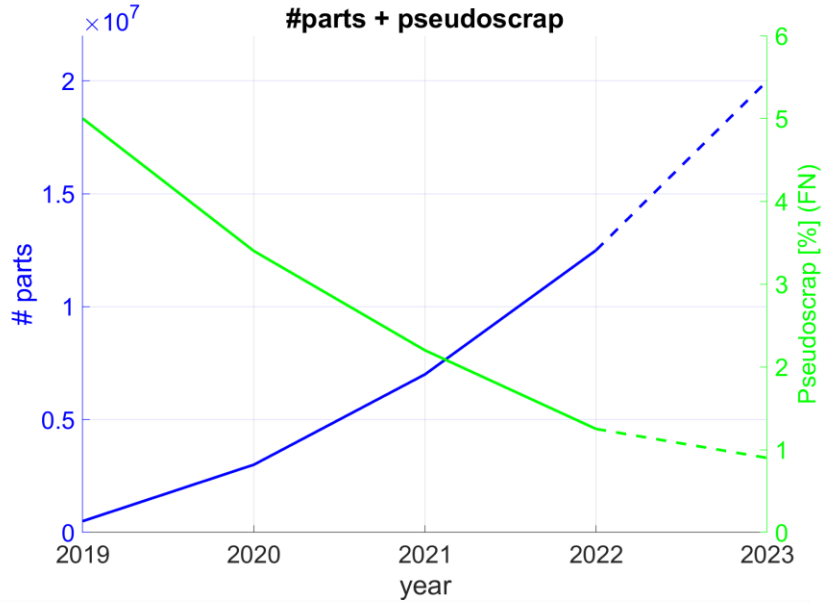
→ *since 2020 more than 10 individual deep learning applications where developed which run on more than 40 inspection stations with over 25 trained networks*

Comparison to traditional rule-based inspection software:

→ *Reduction of the development time by 30-50%*

→ *Significant reduction of pseudo rejects*

→ *short update time (retraining) of the networks lead to higher productivity and less downtime*



Outlook

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Quality Inspection

- *Further generalizations, automation and simplifications of the framework are needed to make it usable for a larger group*
- *Increasing the number of applications and systems as well as continuously reducing the development time and complexity of those systems*

In addition

- *Use the acquired and preprocessed high-quality data more intensively for predictive quality*
- *By leveraging high-value data, we expect to gain a competitive advantage in our industry by making more informed, data-driven decisions.*