Title: Optimising Welding Process by Detecting Early Irregularities through Deep Learning Practices

Virtual generation and detection of welding defects in cross-sections using AI-based algorithms

Introduction:

The aim of this research project is detecting the irregularities on steel metal by implementing deep learning techniques from error generation to identification of welding errors. Accurate implementation of such practices in industrial settings can lead to significant cost reduction and enhance the product development process.

The aim of the work is the detection of defects that occur in welded steel components using an AI-supported evaluation based on micrographs of the weld seams.
Since the targeted and reproducible production of weld seams with defined defect patterns is extremely difficult both in research and in industry, a method is to be developed within the scope of the work to specifically introduce different defect types into cross-sectional images.
Based on the images developed from this methodology, an AI-supported analysis tool is to be developed to recognize and evaluate weld seam defects in these images.
The enormous advantage of such software for the industry is the significantly reduced scope of real tests to generate data sets and the difficulty of specifically introducing certain types of defects. As a result, development times and costs can be significantly reduced.

Objective:

- Develop a neural network for error generation
- Evaluating the existing object detection model or algorithm and implement the best suited for our application using Python and OpenCV.
- Evaluate the model performance on baseline >= 75 mAP 0.5 0.95
- Asses the potential application in real world scenario

- Literature research and familiarization with the defect types of weld seams based on current standards and data sheets.
- Development of a methodology for the virtual introduction of welding defects.
- Development of AI-based analysis software for the detection and evaluation of welding defects.
- Summary of the results and written elaboration.

Methodology:

1) Knowledge Acquisition: Understanding and selecting welding errors according to European Standard DIN EN ISO 5817
2) Data Collection: Gather data with web scrapping for error generation. Later, train and validate the application

3) Data Pre-Processing Pipeline: Involve two datasets and multiple steps like Image enhancement, normalization of images, Annotation, and Data Augmentation.
4) Model Selection: Choose an adequate deep learning model and algorithm, considering computational efficiency, accuracy, and availability.
5) Performance Matrix: Carry out evaluation process, based upon baseline criteria >= 75 mAP 0.5 0.95. And leveraging the company's industrial environment for real world implementation.

1. Literature research and familiarization with the different types of defects in weld seams. The basis is DIN EN ISO 5817.
2. Based on the results of the literature research, additional data on defective weld seams will be collected by means of web scraping. Based on this data, a suitable methodology will be developed to incorporate the identified defect types into defect-free cross-sectional images. It may be necessary to develop different procedures for the respective defect types.
3. The methods developed in (2) are implemented in an algorithm and cross-sections with defects are generated based on defect-free images. The data generated in this way is analyzed and discussed with experts from the field of welding technology and checked for plausibility. An iterative adjustment in close coordination with the experts should lead to the desired result.
4. Based on the virtually generated cross-sections, which contain welding defects, an AI-supported method is to be developed to detect these. To this end, extensive research will be carried out into suitable algorithms in the field of computer vision.
5. The algorithms with the greatest potential identified in (4) are to be implemented and validated.

Significance:

This research holds significant relevance by creating a dataset without contributing to resource wastage in real world like metal and energy. Later, the welding error detection helps in cost reduction by early error detection. It also holds the significance to the company by positioning itself as welding leaders of tomorrow.

Expected Outcomes:

We envision to establish a successful implementation of deep learning practices in industrial settings. Deep learning practices are proven to be beneficial in minimizing and early detection of errors and in our case welding errors; thus support optimal utilization of resources such as steel, time, and energy.