

# Detecting process anomalies in the GMAW process by acoustic sensing with a CNN for Classification

M. Rohe<sup>1</sup>, B. N. Stoll<sup>1</sup>, J. Hildebrand<sup>1</sup>, J. P. Bergmann<sup>1</sup>

<sup>1</sup>Production Technology Group, Technische Universität Ilmenau, Gustav-Kirchhoff-Platz 2, 98693 Ilmenau, Germany

## Introduction

Today, the quality of welded seams is often examined off-line with either destructive or non-destructive testing. Weld irregularities are often caused by process anomalies, such as a absence of shielding gas due to air turbulence. In manual welding, experienced welders are able to detect process anomalies by listening to the sound of the welding process. The emitted audible sound during GMAW can be used to detect such process anomalies. Existing research uses methods like descriptive methods to characterize the sound or using machine learning applications to identify weld penetration degree. In this research a Convolutional Neural Network (CNN) is used to classify different shielding gas flow rates during robot welding.

## Data Processing & CNN

Beads on plate in a housed experimental setup were performed with varying shielding gas flow rates to reduce side effects from environmental noise or influences of multi layer beads. The different shielding gas flow rates were used to simulate process anomalies. After acquiring the emitted audible sound by a condenser microphone, the data was processed in the data pipeline shown in Figure 1.

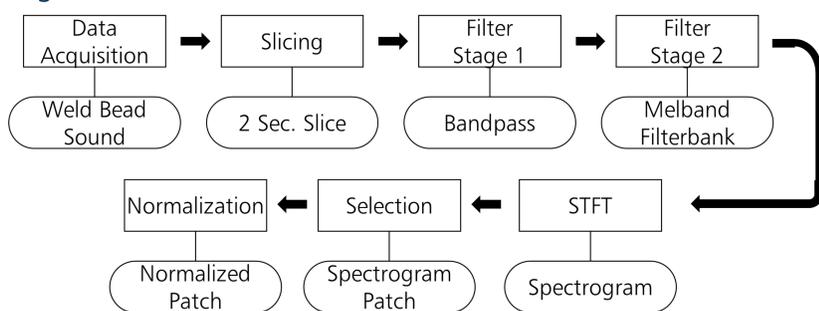


Figure 1 – Data Pipeline for Preprocessing

The processed data was then incorporated to an 2D-CNN for training purposes. To evaluate the developed neural network 10-fold cross validation was applied. The structure of the CNN is illustrated in Figure 2.

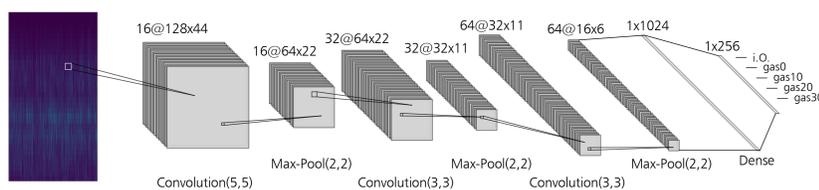


Figure 2 – Structure developed CNN

Additional investigations besides the capability of prediction the right shielding gas flow rate were made. Relevant frequency bands for the classification of the shielding gas flow rate were examined by leaving out certain bands in the training data and the network was trained on these. Differing prediction accuracies are an indices for relevant frequencies.

## Results & Discussion

The CNN was tested with a balanced dataset to get a clear validation. The resulting confusion matrix is shown in Figure 3. It can be seen, that the CNN is capable to distinguish between different shielding gas flow rates during welding. Furthermore the count of type 1 errors were very low. The mean overall accuracy after 10 steps of cross validation is 84 % with a standard derivaton of 1.9 %.

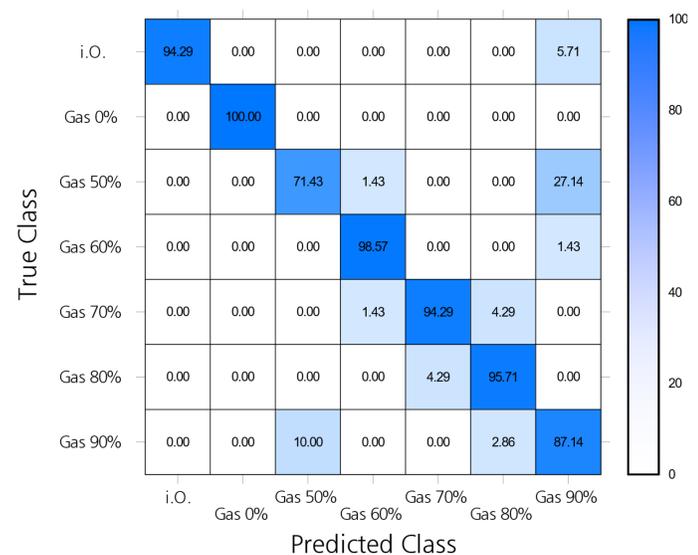


Figure 3 – Capability of CNN to predict gas classes

The relevant frequencies for classification were located in the bands 7.5 to 9.75 kHz, 13.5 to 14.25 kHz and 17.25 to 18 kHz. The prediction accuracy is significantly lower as the mean of all other predictions as presented in Figure 4.

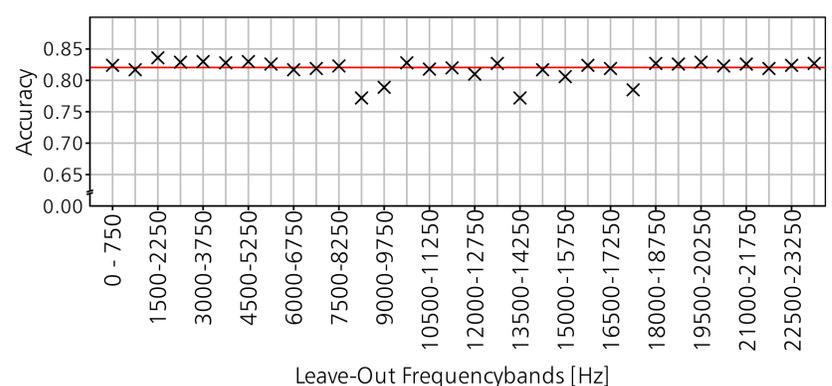


Figure 4 – Accuracies for different leave out frequencies

## Conclusion

The presented approach has shown, that the emitted audible sound during welding can be used to detect various shielding gas flow rates as one kind of process anomalies.