A novel Deep-Learning Approach for Automated Non-Destructive Testing in Quality Assurance based on Convolutional Neural Networks

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Additive manufacturing process is one of the novel production processes used in industry. Because it is very difficult to evaluate quality and to keep quality standards in a running production system with its many influencing variables, only a solely part or prototype is manufactured. Many experiments and experience are needed to produce such a part or prototype. To reduce the number of attempts and costs new quality assurance methods are needed for manufacturing. Machine learning offers these new possibilities. Convolutional Neural Networks are one of these methods belonging to the state-of-the-art Deep Learning methods, which have already shown very good results in many highly complex application scenarios \cite{1–5}.

In this work, we propose an automated approach for quality assurance of industrial manufactured parts using Convolutional Neural Networks. While typically Deep Convolutional Neural Networks need a large amount of training data \cite{6}, our recognition module is able to identify defective parts in X-Ray images of aluminium casting parts using only little training data. The data used in our study has been retrieved from the GDXray dataset \cite{7} containing 2,727 2D X-Ray images of casting parts. Approaches used by other studies – such as extracting the defects from the original image by extracting cropped patches using human annotated bounding boxes \cite{8} – are not suitable for real-world applications since the defect area is usually not known a priori. That is why we used the entire image without extracting patches, providing a recognition module, which is capable of detecting casting defects in a much more realistic scenario. Based on the Xception neural network architecture and using a Transfer Learning approach our module is able to achieve a balanced accuracy greater than 90\% while precisely detecting the defect within the entire image. Our novel approach shows the potential for fully
automated NDT testing based on X-Ray images, while also showing the limitations of classical texture-based features. In future research, we want to expand the idea towards more manufacturing techniques within additive manufacturing scenarios.

References