Synthetic X-ray Image Generation for Non-Destructive Testing using Generative Adversarial Networks

Rajib Kumar Chanda[1], Thomas Wittenberg[2], Bishwajit Gosswami[3]

[1]Production Monitoring, Fraunhofer IIS, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany,
[1]Department of Computer Science, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany,
[1]Production Monitoring, Fraunhofer IIS, Germany

Developing and optimizing a Machine Learning (ML) based Non-Destructive Testing (NDT) tool for automotive manufacturing can be challenging due to the need for a significant amount of annotated training data. Obtaining such an extent of real X-ray images of different defects can be challenging and expensive. Hence, generating synthetic images with adequate defects is a viable option to fill this gap. This contribution presents a novel approach that harnesses Generative Adversarial Networks (GANs) to simulate industrial X-ray images of specific parts of a car wheel (rim and spokes) with defects and their annotations. The presented method draws inspiration from techniques used in medical healthcare radiography as well as the NDT field for simulating synthetic X-ray images. We propose a novel deep neural network architecture for generating high-resolution X-ray images of size 1024 x 512 pixels with porous defects in specified locations. These images are automatically generated from edge masks of the desired structure. We conducted separate evaluations for both, the generated images and the included defects. To assess the generated image quality, we used image properties and structural similarity metrics. The generated images achieved an MSSIM index of over 0.90. We analyzed the local gray-scale profile of synthetic images to evaluate the quality of generated defects. A state-of-the-art defect detector (ISAR, developed by Fraunhofer EZRT) was used to estimate defect detection based on various IoU thresholds. In conclusion, the presented research demonstrates the feasibility of leveraging GANs to generate synthetic 2D X-ray image data, including defects for training ML-based NDT tools. This approach opens new possibilities for developing and optimizing robust NDT solutions by overcoming the challenges of obtaining real data with defects.