A Reference-free Approach for Pore Detection in CT-Scans of Varying Image Quality Using Deep Learning

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Beam-hardening, image noise, scatter, and other artifacts significantly degrade the image quality of computed tomography (CT) scans. This is particularly evident in in-line scenarios: Here, we are usually constrained by tight cycle times and hence unable to mitigate image artifacts, for instance, by using long exposure times to obtain a clean scan. Nevertheless, the detection of pores, shrinkage cavities, small cracks, and other flaws is a crucial task, not only for safety-critical components. It can be advantageous to identify faulty parts before subjecting them to expensive post-processing procedures. The substantial amount of data generated by a CT scan adds complexity to the task and underscores the need for automated inspection. Existing automated defect detection algorithms often demand either a high minimum image quality or a defect-free reference part (referred to as the 'golden part'). Deep learning-based models offer a potential solution to this challenge by enabling reference-free defect detection in rapid CT scans. Yet, successfully applying deep learning for pore detection presents several challenges: Firstly, there is a shortage of data as annotating 3D voxel data is a demanding process, and companies are reluctant to share their data. Secondly, there is a lack of confidence in this 'black box' technology. Lastly, there is the issue of concept drift during production caused by wear and changes in the imaging system. We address these issues through the following strategies: (i) We employ realistically simulated data for the training process; (ii) We thoroughly evaluate the trained model; and (iii) we monitor the quality of the input before analyzing the data. A synthetic data set of realistically simulated CT scans offers the possibility to simply compute an accurate ground truth and can be generated at any scale. During the evaluation phase, we not only rely on machine-learning-based metrics such as intersection over union – which aids machine learning engineers in supervising the training process – but also on customer-centric metrics like the probability of detection (POD). These customer-oriented metrics foster trust among users. The monitoring process builds upon established methodologies and accepted standards. All these components are integrated into our solution for reference-free pore detection.