Automated Bounding Box Annotation for NDT Ultrasound Defect Detection

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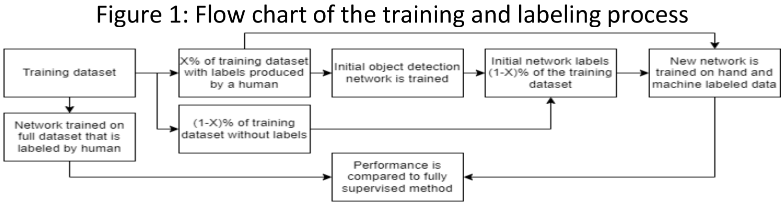
The growing interest in applying Machine Learning (ML) techniques in Non-Destructive Testing (NDT) to assist expert detection and analysis is facing many unique challenges. This research seeks to create an object detection network that would automatically generate bounding boxes around various defects found in Carbon Fibre Reinforced Polymers (CFRPs) through which the quantitative defect size information can be inferred. CFRPs are structurally anisotropic resulting in complex physical interactions between the emitted acoustic waves and the material structure when Ultrasonic Testing (UT) is deployed. Therefore, the structural noise makes the detection of various types of defects, such as porosities, delaminations and inclusions, that are frequently observed in CFRPs [1] even a more challenging task. In order to take a supervised learning approach in the detection of defects, a training dataset must be produced and labelled. Extensive automatic methods for data collection exist, however, in many cases labelling is done manually, which requires extensive use of expert time. Therefore, a method for automatically labelling simple defects could potentially be useful for accelerating the ground truth creation and allowing experts to focus on the detection of more complex defects.

Therefore, the present research a) explores the methods that can efficiently accelerate the labelling process and b) investigates the influence of varying amounts of training data on the performance of trained networks. In other words, with current advances in the field of ML, even small quantity of data can lead to development of great performing networks [2] however, there is a lack of knowledge of how much data is sufficient for training. The aim is to determine the training data quantity that is required to achieve a well performing NDT defect detection network, to evaluate the performance change with different sizes of training datasets, and the effectiveness of models trained on lower data inputs in semi-supervised labeling tasks.

To this end, several inspection data sets in form of ultrasonic C-scan images were generated through simulations in semi-analytical CIVA (EXTENDE) software and experimental scans using an ultrasonic array probe on various CFRP samples containing flat bottom holes as defects. For comparison, the initial network was trained on a smaller subset of training data which was subsequently used for labeling of the remaining available training data. Afterwards, a new network was trained on the data that was labeled by the previous network. Lastly, the performance of the new network was compared against the performance of the network that was trained with fully supervised approach. From initial experiments we observed that proposed approach improves detection performance when low amounts of training samples are used and that such networks could accelerate the labeling process.

Figure 1: Flow chart of the training and labeling process



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