Machine learning based defect detection system for boundary laminated fabric accessories

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The use of automated solutions for inspection processes in the textile manufacturing industry for raw material inspection has been trending in the last few decades to eliminate inconsistencies and inefficiencies in manual inspection. However, it is still prominent in the final inspection of complex garment accessories, such as boundary laminated fabric accessories, which feature a narrow adhesive lamination (a few millimeters wide) along their edges, bonded with a removable backing paper. Since traditional image processing lacks robustness for such applications, while collecting large datasets of defects to train deep learning algorithms is hardly practical, this research focuses on exploring the effectiveness of machine learning for inspection, specifically using a random forest classifier-based semantic segmentation model (RFCSS). The developed defect detection algorithm uses the RFCSS model to segment the input images and uses those segmented images as input for defect analysis. To train the RFCSS model, 17 texture features and 05 colour features were used. The dataset used was comprised of 48 images (training: 38 images, testing: 10 images) having 720 × 1280 pixels resolution, producing over 35 million datapoints for training the model to classify every single pixel into one of the classes from the fabric, background, lamination backing, stains, and yarn damage. Further, a prototype inspection conveyor equipped with a Google Pixel 6A as the input camera, comprising an illumination chamber, was developed to evaluate the real-world performance of the algorithm. A Graphical User Interface was designed and developed using Python and Tkinter to control the inspection process, while providing live footage and a detailed status of each test subject. Regardless of the accuracy of 99.95% produced by the RFCSS model in segmentation of test images, the mean intersection over union (IoU) only reached 82.86% due to the heavy imbalance of the number of pixels corresponding to undamaged fabric portions and the background, compared to small defects like yarn damage (IoU for yarn damage: 38.41%). The defect detection on the prototype produced an accuracy of 77.5% with a recall of 70.96%, and an F1 score of 83.02% in trials carried out using 40 boundary laminated accessories.

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