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An Artificial Intelligence Based Defect Detection System for Transparent Substrate

Kai-Yu Lin, Pi-Cheng Tung, Chih-Kuang Lin*
Department of Mechanical Engineering, National Central University
300 Jhong-Da Rd., Jhong-Li District, Tao-Yuan, Taiwan
* t330014@cc.ncu.edu.tw

Extended Abstract

Automated optical inspection (AOI) is widely used in various industries. In a traditional AOI system, digital image processing is applied to design of an algorithm for the inspection. However, because of the limitation of AOI, manual visual inspection is still irreplaceable in certain cases, e.g. in transparent substrates. Pollutions like dust particles and batting could reduce the performance of AOI system for transparent substrates. To overcome that, this study introduced an artificial intelligent technique into the AOI system for inspection of transparent substrates and used a glass substrate as an example to demonstrate the technique. The inspection targets included two types of defects, namely scratch and chip. The goal was to find such defects on the glass substrate of dimensions of 85 mm × 53 mm × 2 mm. In terms of AOI hardware, the image acquisition system was optimized to capture the features of defects with the most suitable light source. For a better image quality, a jig and a black cloth were used to reduce the noise on the image. Such an image acquisition system could provide a high-quality image with defects, so that the image processing algorithm could analyze the information of defects on the specimens and detect defects successfully.

In the image processing algorithm, five YOLOv4 variants were considered for the inspection application, namely YOLOv4, YOLOv4-tiny, YOLOv4-CSP, YOLOv4-P5, and YOLOv4-P6. Custom datasets were built to train these models. In order to have an objective annotation, it followed a procedure to label the custom datasets. After that, 5-fold cross validation was employed to compare each model's performance. According to the validation results of the five models, YOLOv4 was selected for the application in this study due to its highest accuracy and the ability of maintaining a great accuracy when the input image was resized to only 672 × 672 pixels. Then, two approaches were used to optimize the YOLOv4 model, namely fine-tuning and anchor box optimization. The latter successfully improved the accuracy of YOLOv4. The most accurate model was the YOLOv4 optimized by anchor box and trained with the input size of 960 × 960 pixels. It had a precision of 98.4%, a recall of 91.7%, and mAP of 94.52% in the test dataset. Moreover, it could effectively exclude non-defect objects. With these results, the developed inspection system could detect defects as small as a scratch of 0.05-mm width and a chip of 0.1 mm. Furthermore, it could also detect an unclear scratch with only three-gray-level difference.