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ScienceDirect

Procedia Engineering 188 (2017) 72 – 79

Procedia Engineering

www.elsevier.com/locate/procedia

6th Asia Pacific Workshop on Structural Health Monitoring, 6th APWSHM

Fast and non-invasive surface crack detection of press panels using image processing

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Abstract

The crack detection during the manufacturing process is an important step for quality management of panel products. Traditional crack detection methods are subjective and expensive because they are performed by experienced human inspectors. Therefore, crack detection techniques for automated and accurate inspection are required. In this paper, a crack detection technique based on image processing is proposed, which utilizes the images of panel products captured by a regular CCTV camera system. First, the binary panel object image is extracted from various backgrounds after considering RGB color factors. Edge lines are then generated from a binary image using a percolation process. Finally, crack detection and localization are performed with a unique edge line evaluation. In order to demonstrate the capability of the proposed technique, lab-scale experiments were carried out with a thin aluminum plate and a real sample panel. In addition, the test was performed with the images acquired at an actual press line. Experimental results show that the proposed technique could effectively detect panel cracks with an improved rate and speed.

Peer-review under responsibility of the organizing committee of the 6th APWSHM

Keywords: Pressed panel product, Image processing, Percolation, Crack detection, Edgeline analysis

1. Introduction

Various mechanical components are produced by sheet metals with several manufacturing processes, including press-working. During these processes, including punching, blanking, embossing, materials undergo large deformations in high speed, which may result in manufacturing defects such as cracks, necking and marking lines [1, 2]. In order to detect such defects, crack detection is usually implemented by human inspectors. The detection rate of

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Peer-review under responsibility of the organizing committee of the 6th APWSHM
doi:10.1016/j.proeng.2017.04.459

the method is affected by the skill and the experience of human inspectors. Additionally this method is less reliable and unstable in many cases. For these reason, the development and implementation of an automated and accurate defect detection technique is important during the press-working process. One type of defect inspection technique is to monitor the vibrations of pressure signals of a press line [3, 4]. In these methods, the distortion and/or shape change of pressure signals indicate abnormal conditions of the press line. However, this method has a limitation that it is not appropriate for individual panel inspection. Compared to the methods, image based defect detection methods could provide several advantages over existing methods in the press line because they are non-invasive, accurate, and could be easily implemented in the manufacturing. Thus various studies on image processing for crack detection have been conducted.

Image processing based methods for crack detection enables quick inspection of large area of structural surface. Moreover, stable and accurate inspection is possible with an automated process. Currently, most studies on image processing focused on detection of cracks on large structures such as bridge, building and pavement. Niemueller et al. [5] introduced several methods to detect crack and corrosion on the surface of pipes. Jian and Bunke. [6] developed an edge detection algorithm based on the scan line approximation technique. Abjel-Qader et al. [7] compared and evaluated the performances of the four crack detection methods including Fast Haar Transformation (FHT), Fast Fourier Transformation (FFT), Sobel and Canny filter. The study confirmed that FHT was the most reliable method in crack detection. Fujita and Hamamoto. [8] proposed a robust and automated detection method, targeting crack detection on the surface of concrete structures. In their study, a median filter was implemented to refine the collected images, and cracks were detected based on the image difference method. Meanwhile, Lyer and Sinha. [9] developed a pipe inspection system based on a pattern recognition process.

Defect detection based on image processing is usually applied to inspect large detection area. Thus automated detection and analysis are essential. Also the acceleration of processing speed is critical for real-world applications. Valenca et al. [10] developed an image processing technique to detect cracks in concrete surfaces to monitor the crack initiation and growth in concrete specimen. Yang et al. [11] achieved three dimensional images using two stereo cameras in a real bridge. The deflection of the bridge posts was estimated by tracking grid's movement. Crack region was finally visualized based on the deflection analysis. Zou et al. [12] conducted three image processing steps in order to automatically detect cracks on pavements. In their study, cracks were detected by applying a tree representation and a pruning algorithm to the generated map. To improve the processing speed, Yamaguchi et al. [13] performed the study on the acceleration of the percolation model, which is necessary for crack detection.

Compared to the many studies for large structure inspection, only a few image processing technique were applied to products in manufacturing lines [14, 15]. There are following requirements that image processing for production line must have,

- It could detect manufacturing defects with high accuracy.
- False positive error should be minimized.
- Inspection should be completed in real-time.

This paper aims to develop an image processing technique which is capable of identifying surface defects for pressed panel products. The proposed technique consists of the following steps; i) object extraction from backgrounds, ii) object's shape and edge line extraction, and iii) edge line analysis for crack detection. Several lab-scale experiments are conducted to demonstrate the performance of the proposed technique. Additionally, the proposed technique is applied to a manufacturing press line to detect crack on real panels.

2. Image processing technique for crack detection

Crack detection procedure based on image processing consists of four steps as shown in Fig. 1. First, a new panel images, during the manufacturing stage, is captured using a camera system installed in a press line. In order to extract the target image of interest from various backgrounds, every pixel value is calculated by considering Red, Green, Blue (RGB) color factors and brightness factors. A binary image is then generated with the pre-defined threshold value, as the second step. In the third step, the percolation method is applied to extract the edge line information of the object. As the final step, the extracted edge lines are analyzed for defect detection. Almost all of