Automatic Crack Detection on Pressed panels using camera image Processing

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Abstract
Panel crack detection during the manufacturing process is an important step for ensuring the quality in the industry. Traditional crack detection methods are subjective and expensive because they are performed by human inspectors. Therefore, implementation of on-line and precise crack detection is necessary during the panel pressing process. In this paper, two image process based crack detection methods are developed by inspecting panel product images obtained by a regular CCTV camera system. The first technique is based on evaluation of the panel edge lines which are extracted from a percolated object image. This technique does not require a baseline image for crack detection. Another technique is based on the comparison between a base and a test image using the local image amplitude mapping. Experiments are performed in the laboratory and in the actual manufacturing lines. Experimental results demonstrate that the proposed method could effectively detect the panel cracks with improved speed.

Keywords: Image processing, Cracks, Crack detection, Camera image, Percolation,

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, imprints, necking, fall-in, marking lines and side-wall wrinkles [1, 2]. Defect detection during the manufacturing process is an important step for ensuring the panel product quality in the industry. Traditional crack detection methods are performed by experienced human inspectors. The detection rate of the traditional method is affected by the skill and the experience of human inspectors. This method is also less reliable and unstable in many cases. Therefore, the development and implementation of an automatic and precise defect detection technique is necessary during the press-working process.

One type of defect inspection technique monitors vibrations of pressure signals of a press line [3,4]. Because signal distortions or shape changes are generated by abnormal conditions of a press line, defect occurrence is detected by monitoring signal changes. However, this method has a limitation that it could not inspect individual panel product.

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 line for crack detection. [5]. Image processing techniques are developed in order to detect surface damage on panel products, including rails, PCB panels, printed materials and LCD panels. Defect detection techniques based on image processing could be categorized into two types. One does not require base image for defect
detection. Another type of techniques uses the differences between a base image and a newly acquired image. Toshiyuki et al. [6] derived eigenvalues of every local window and compared each value to find out the relative changes in local areas. In their study, they are able to visualize a certain area which is considered to contain a defect. Yang et al. [7] utilized two stereo cameras to achieve 3D movements of a large structure such as a bridge, and measured the strain of a target area. Based on analysis of strain measurements, the crack location and intensity was identified. Meanwhile, image processing techniques using base images usually utilizes differences in images to detect cracks or defects. Kim et al. [8] designed a high speed image acquirement system and conducted a statistical analysis of acquired images for inspection of steel coil products. First, the image difference is generated by subtraction between the base and the test images. Then the difference is converted to a binary image after applying a threshold method. In this study, the value of threshold limit was determined based on the image histogram. After the binary image generation, various features are extracted and used to detect defects on the coil product. Peng et al. [9] studied the detection of defects on printed materials using image processing techniques. In order to improve the detection rate, they considered three color factors (R, G, B factors) and edge lines were extracted and eliminated to overcome problems of false positive errors from the fact that printed materials are not precisely arranged while each image is acquired. Kim et al. [10] conducted a study on gas leak detection using image processing. In their study, gas leakage was detected by monitoring the histogram values of the image difference between present and previous images.

In this study, we developed two image processing techniques for surface crack detection for pressed panel products. One technique uses the percolation process to extract the shape edge line information, and cracks are detected by conducting a unique edge line analysis. This method does not require a base image for defect detection. The other technique uses both the base and test images. In order to alleviate false-positive errors caused by mis-arrangement of panel products in the press line, a method referred to as a local image amplitude mapping was developed and implemented. Several lab-scale experiments are implemented to demonstrate the performance of the proposed techniques. Additionally, the proposed techniques are applied to a real press line detect cracks on real panels.

2. CRACK DETECTION METHODS BASED ON IMAGE PROCESSING

2.1 Crack detection technique without base image comparison

The first detection technique does not require the base image for crack detection. This technique consists of four steps depicted in Fig. 1. First, a new panel images, during the manufacturing stage, are captured using a camera system which is installed in a press line. In order to extract the target image of interest from various backgrounds, every pixel values are calculated by its color factors (R, G, B 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 used to extract the shape edge line information of the object. Finally, the extracted edge lines are analyzed for defect detection. Almost all of edge lines of panels contain smooth variances of angle in the edges. When a crack occurs in a panel product, there is sudden and acute variance of relative angle, as shown in Fig. 2, which could be used as an indicator of the presence of crack. Therefore, the relative angle variances of each line are evaluated for detection and localization of cracks.
Figure 1: Crack detection procedure without base image

Figure 2: Edge line analysis for crack detection
2.2 Crack detection technique with base image

Crack detection using base images also contains four steps as described in Fig. 3. The first step is the same as the previous one that every panel image is acquired using the installed camera system, which is then converted to gray scaled images for fast image processing. In order to reduce noise components caused by the shadow and light effects, a wiener filtering is first conducted. Wiener filters normalize the value of certain pixels based on neighborhood pixels. A Sobel mask is applied next to extract the edge line from the image. If objects of the base and test images are not precisely arranged, there will be large errors in the image difference after subtraction, which may result in false indication. In order to overcome this problem we apply the local image amplitude mapping process to the base image and the test image. By comparing the local window, instead of comparing every pixel, the false indication could be significantly reduced. Finally, the presence of cracks is visualized by subtracting the test mapping results from that of the base image. During the mapping process, the size of local window is determined after considering the size of crack to be detected and the maximum mis-arrangement value of images.
3. EXPERIMENTAL RESULT

Several experiments were performed to demonstrate the performance of the developed techniques. As shown in Fig. 6, a cell phone camera was used to capture the image of panel (washing machine) in a real press line. The camera is placed 1-m above the convey belt. During the press process, each panel is produced at every 10 second. The images are taken form 13 minutes, and a total of 78 panel images are collected. The image acquisition area was approximately 70 x 45cm, which corresponds 750 x 400 pixels to be analyzed.
3.1 Crack detection results without base image

During the experiment, no defected product was identified. Therefore, simulated cracks, with the size in the range of 1 x 7 cm, 0.5 x 4 cm, 0.5 x 2 cm and 0.2 x 2 cm, are introduced at various locations as shown in Fig. 7. In order to speed up the crack detection process, the resolution of the initial image was lowered by three times than that of the original image. As the results shown in Fig. 7, it was possible to detect various sizes of cracks with the very high accuracy. Even with the presence of sharply created holes which look similar to cracks, no false positive error was reported. This is due to the fact that hole’s edge has rectangular shape and is considered to be smooth by the edge curve evaluation algorithm. It takes less than 8 second to complete the detection process after an image is acquired.

3.2 Crack detection results with base image

In this technique, the extracted panel image shown in Fig. 6 was used as a base image. The same cracks in Fig. 7 (a) and (d) were used and the second algorithm. This algorithm uses the comparison between a base and a test image, and the local amplitude mapping is applied to detect the cracks. Crack detection was conducted with various window sizes (75 x 40 pixels, 50 x 26 pixels and 38 x 20 pixels) and the results are compared in Fig. 8 and 9. The computational time was greatly reduced as the size of window increased. With 38 x 20 pixels
of the window size, the detection procedure took 7 seconds, while it takes less than 4 seconds with a 75 x 40 pixel window size. The window size also affects the accuracy of crack detection. For example, if the size of crack is small as shown in Fig. 9 (b), a false positive error could happen with a relatively large window size. From the results, it is apparent that a stable and accurate crack detection is possible with an appropriate size of window and the use of local image amplitude mapping.

![Figure 8](image1.png)

![Figure 9](image2.png)

4. CONCLUSIONS

This paper proposed two image processing techniques for fast and automatic crack detection for pressed panel products. The first method does not require the use of a base image for crack detection. Instead, cracks are detected and localized with the unique edge line analysis,
proposed in this study. Crack detection with base image uses the image differences between a
stored image in an undamaged state and a tested image. Noise components of the image are
reduced by applying a winner filtering. Edge lines are generated by operating Sobel mask.
The local image amplitude mapping is performed to the images in order to minimize the error
when objects are not precisely arranged in the same position. After the mapping process,
crack occurrence and location are identified from the subtracted mapping result. For
experiments, we collected panel images from a real press line. Through experiments on real
produced panels, we have shown that both proposed image processing techniques are able to
detect crack defects with reasonable accuracy and speed. In order to handle real-world
applications, our study focuses on increasing the speed of overall signal processing and
reducing the false positive errors. Also combining both techniques are being carried out to
improve the crack detection capability.

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