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Applying Image Processing Technology to Automatically Detect and Adjust Paper Benchmark for Printing Machine

Chi-Ming Chen

Department of Electrical Engineering
National Changhua University of Education
joy.com@msa.hinet.net

Chien-Chih Lin

Department of Electrical Engineering
National Changhua University of Education
u358554@taipower.com.tw

Yu-Sheng Liu

Department of Electrical Engineering
National Changhua University of Education
aie33220@gmail.com

Jin-Xiang Liao

Department of Electrical Engineering
National Changhua University of Education
a2369875@gmail.com

Ming-Tsung Yeh

Department of Electrical Engineering
National Changhua University of Education
jack.yeh@tw.unisys.com,

Yi-Nung Chung*

Department of Electrical Engineering
National Changhua University of Education
ynchung@cc.ncue.edu.tw

Chao-Hsing Hsu

College of Engineering
Chienkuo Technology University
hsu@ctu.edu.tw

Corresponding author: Yi-Nung Chung*
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Abstract. *During the printing machine operation process, the product may be skewed since the system operates for a long time. Usually, people check the benchmark by eyes and adjust the paper position by manual assistance. However, the manual method could not perform the skew correction in real time, therefore it will decrease the amount of printing yield. In this paper, an image processing technology is applied to replace the manual detection. This system will automatically determine whether the printed product is skewed, and it applies PLC system to adjust the correction position automatically. The system can self-adjust the deviation amount, so that it can improve the printing efficiency and productivity without stopping the machine.*

Keywords: Printing machine operation process, Image processing, PLC system

1. **Introduction.** The applications of image processing technology to industrial automation become very popular. The advantage of this technology is that it can reduce manual cost, save processing time, and enhance the productivity. In this paper, the image processing technology is applied to automatically detect and adjust paper's benchmark for printing machine. In image process, a series of images are taken by the camera and then applying the image processing technology to obtain the useful information for the further process. The images may be corrupted by random variations which include the intensity of the light, poor contrast, shadows, and noise. The system applies some methods to remove noise and enhance the image to improve the recognition results. In order to obtain better effect, the image enhancement algorithm is applied also. The computation time will be much if the system considers all the pattern area. Therefore, the unnecessary image needs to be removed. In this process, the system needs to set the region of interest (ROI).

In general, the image is in RGB color space, but the RGB color image may be affected by shadows. In order to avoid the influence effect, this study proposes that let the image in RGB color space transfer to HSV color space [1, 2]. Moreover, in order to reduce the computation burden, the system will convert the color image to grayscale image. The grayscale image converted by original image may contain some background noise. It needs to filter out the noise before applying the edge detection processing. The edgy positions are usually on the object and the background of border, so it can use this principle to detect the edge of the object. In this paper, the Canny edge detection method [3] is proposed to detect the edge of the object because the Canny edge detection method can filter out the noise in pre-processing. This algorithm applies dual hysteresis thresholds, which let Canny edge detection have advantages of filtering and enhancing edges. It has more clear edge detected by using Canny edge detection method.

The rest of this paper is arranged as follows. The system algorithm which includes the technologies of image processing process is presented in second and third sections. The detail algorithm proposed in this paper is described. The operation process is presented in the fourth section. The fifth section is the experimental test. In this section, the experimental results by using the proposed algorithm are presented. The conclusion is presented in the last section.

2. **Image processing technology.** In this application, the system uses a network IP video camera to capture the target image. Since the wide-angle lens will get a fish-eye effect image, so the fish-eye correction is required to eliminate the effect. After the correction processing, the corrected image is obtained. In the image, the region of interested (ROI) need to be selected for later processing. And then, the binarization and morphology process [4] are performed to obtain the part of straight line in the image.

Applying the Hough transformation and canny detection, which can efficiently find the required straight line function. Finally, compare the reference graph with the experimental straight line function and use the difference of the function to infer the experimental results. The flow diagram is shown in Figure 1.

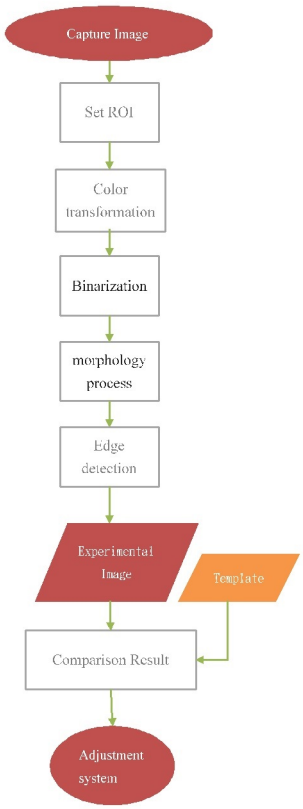

FIGURE 1. Diagram of Image processing

A wide-angle lens is used in this system because it has the characteristics of a short focal length and a larger field of view. But it will have image distortion. It can be changed back to the original projection image by using the correction technology, which is named fish-eye correction [5, 6, 7]. The expansion of the fisheye diagram involves the conversion of various coordinate systems. We may imagine how to expand the globe into a plan view.

When an images is captured, a series of image processing technology is applied to get the information for the further process. At first the pre-image processing was applied to capture the target image, enhance the saturation of complexion, and filter out the noise also. In this system some methods are applied to remove noise and enhance the image to improve the recognition results. In order to obtain better effect, the image enhancement algorithm is applied also. In the process, unnecessary area of pattern in the image is removed. Therefore, the region of interest (ROI) is set in the system.

The image is usually in RGB color space, but this color image sometimes will be affected by shadows. In order to avoid the influence effect, the HSV color space is proposed. In order to reduce the computation burden, the system usually converts the color image to grayscale image. The converted image may contain some noise. The noise needs to filter out before applying the edge detection processing. The edgy positions are usually on the object and the background of border, so it can use this principle to detect the edge of the object. In this paper, the Canny edge detection method is proposed to detect the edge of

the object because the Canny edge detection method can filter out noise in pre-processing. It applies dual hysteresis thresholds, which let Canny edge detection have advantages of filtering and enhancing edges.

Morphology processing is often used in target detection, noise removal, block segmentation and skeleton boundary capture. The operation is to use mask in the image of the pixels as a shift operation. According to different Morphological algorithms do different treatments are done to achieve image segmentation and recognition purposes. Many of the applications of morphology can be deduced and based on these basic operations to perform advanced image processing. In addition, applying morphology to image processing simplifies image data and maintains the basic outline of the graph.

Image subtraction method is a well-known technique to detect the binary images of moving objects. The first frame of the image is captured by the camera as the background, and every subsequent frame subtracts the background frame, the remains is the object to be detected. Usually, this method can be used to remove the noise also.

The edges in the image have vectors in different directions. The Canny method uses four masks to detect horizontal, vertical and diagonal edges. The convolution of the input image and each mask is stored. The maximum value and the direction of the edge vector are marked for each point. In this way, the position and direction of the line segment in the image can be generated from the original image.

3. **Hough transform.** The Hough transform is a feature extraction method [8, 9]. This algorithm is often used in image analysis, computer vision and digital image processing. The Hough transform is used to identify features of objects such as straight lines, circles, ellipses, etc. The process is roughly given for an object, which can distinguish the type of object shape. This algorithm will perform voting in the parameter space to determine the shape of the object. It is determined by the local maximum in the accumulator space. When it analyzes the digital pictures, some simple straight lines, circles and ellipses are detected. In most cases, the edge detector will perform image pre-processing first, and turn the original image to an image with only edges. Because of the imperfect picture or imperfect edge detection, some points or pixels are missing, or there is noise that makes the boundary obtained by the edge detector differ from the actual boundary. However, the detected edges cannot be directly classified into straight lines, circles, and ellipses. The Hough transform can solve the above problems. Through the voting step in the Hough transform algorithm, the parameters of the graph are found in the complex parameter space, and the computer can know which shape the edge is from the parameters. The typical diagram of Hough line detection is shown as Figure 2.

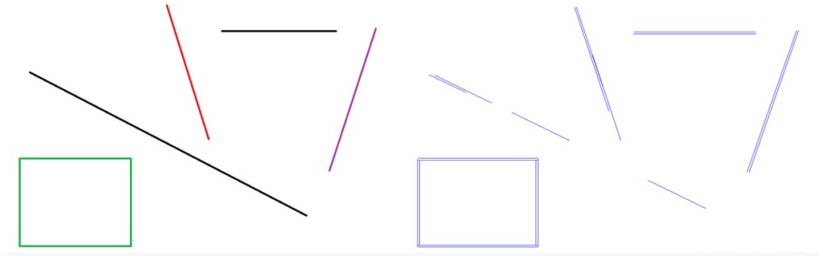

FIGURE 2. The typical diagram of Hough line detection

The simplest Hough transform is to identify straight lines in the image. In a rectangular coordinate system, the equation of straight line is shown as Eq. 1.

$$y = a_0 x + b_0 \tag{1}$$

where b_0 is the intercept of the line and a_0 is the slope of the line. And (m0, b0) can be regarded as a point in the parameter space (m, b). Since Hough transform maps each image point (x, y) to multiple parameter points (a, b), we need use an accumulator to record the number of occurrence points for each group (a, b). The most number of group (a, b) is the most representative straight line in the image space. The process of Hough transform algorithm includes the following steps.
1. Determine all possible feature points in the image space, which are usually edge points or skeleton points.
2. Find a feature point (x, y) in the image space.
3. Find the maximum value of all areas of the accumulator.
4. Map each maximum value point back to image space, which represents each straight line in the image space.

4. **Operation process.** When the system checks the benchmark of paper it only needs to detect a line segment in the image. In order to improve the calculation efficiency and remove unnecessary noise, the algorithm needs to set ROI area which is shown in Figure 3. In the process, after the printing production line of original image is captured by the camera, then the preprocessing and the ROI area are applied. In order to enhance the efficiency of image processing, a gray-scale color space is applied. The image is converted into a binary image, for next step process. And then the subsequent line segment search and deviation calculation are performed.

Since there are not only black lines on the paper but also other patterns or small lines, these residual images will seriously affect the calculation results. So, the connected mark is used to mark the effective pixels in the ROI area, which can take the largest connected area of the target line. It can remove the remaining small pixels, which can greatly reduce the interference of the residual image and accurately detect the target line. After binarization process, the canny edge detection algorithm is applied and the edge of the line segment can be found. After finding the edge, the part of the line segment must be found for subsequent processing. The Hough method can find the part of the line segment very well, and then record the slope and bias after finding the line segment. On printing machine the line segment of the paper and the reference line position are shown in Figures 4 and 5. And then the line slope and bias can be calculated.

5. **Experimental Results.** During the experiment, the image is distorted because of the fish-eye effect, and the image distortion will have errors in the subsequent experimental process. Therefore, the input image needs to do the fish-eye correction to correct the distorted image. The original image is shown in Figure 6. After applying the fish-eye correction algorithm, the skew parameters are corrected. After the correction, it is obvious that the skew and distorted parts of the image have been corrected. In order to improve the calculation efficiency and remove unnecessary noise, the algorithm will set the ROI area and transfer the image to gray-scale color space. The corrected image is shown in Figure 7. The original image input captured by the camera of the printing production line is shown in Figure 8. The line segment image is obtained after the preprocessing and set the ROI area which is shown in Figure 9. And then the subsequent line segment search and deviation calculation are performed.

FIGURE 3. Set the ROI

FIGURE 4. Find the line segment of test paper by using Hough method

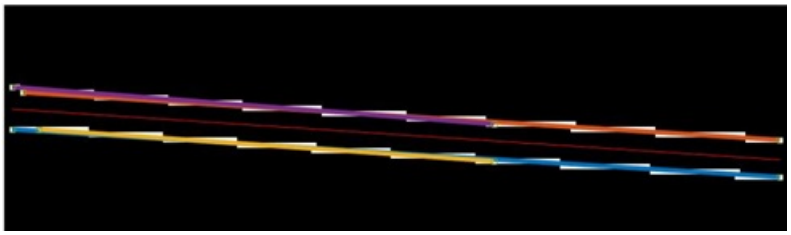

FIGURE 5. The corrected line position of paper

FIGURE 6. The original image in RGB color space

After binarization process, the canny edge detection algorithm is applied to find the edge of the line segment. After finding the edge of line segment, the Hough method is applied to find the part of the line segment. And then, the proposed algorithm will calculate and record the slope and bias of line segment and then it will compare the slope

FIGURE 7. The corrected gray-level image

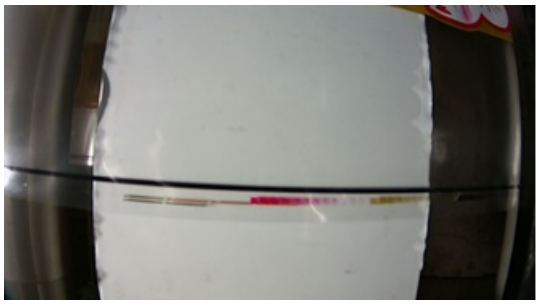

FIGURE 8. The original image of the printing production line

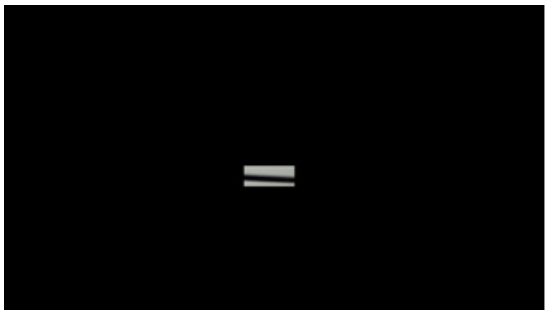

FIGURE 9. The line segment image

and bias of line segment of the paper on printing machine with the reference line position. The slope and bias of line segment of the paper on printing machine is shown Figure 10. The slope and bias of line segment of the reference line segment is shown in Figure 11. The comparison result and position which needs to be moved is shown in Figure 12. After the line slope and bias comparison, the PLC system will adjust automatically.

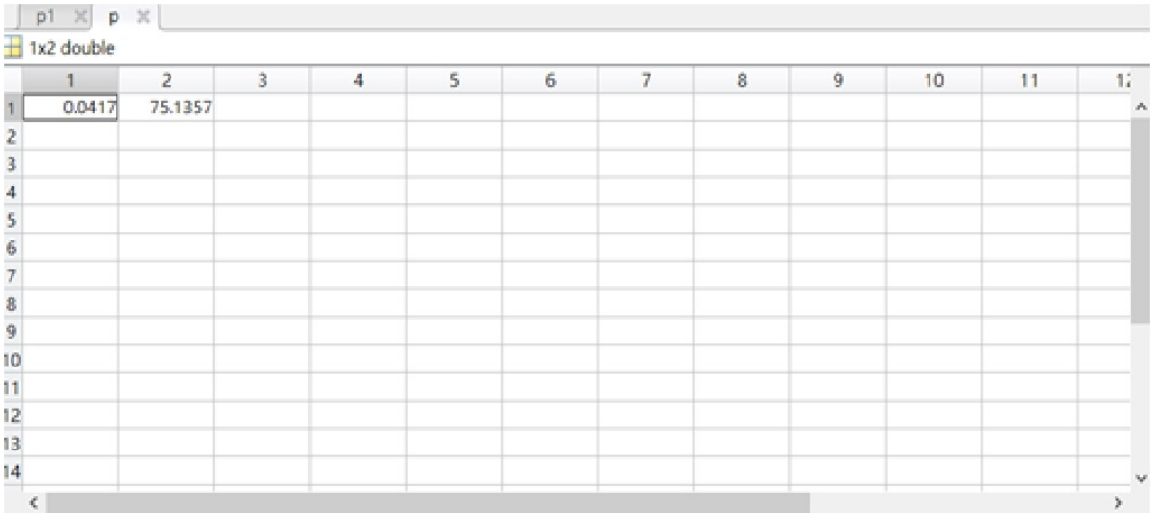

FIGURE 10. The slope and bias of line segment of the paper on printing machine

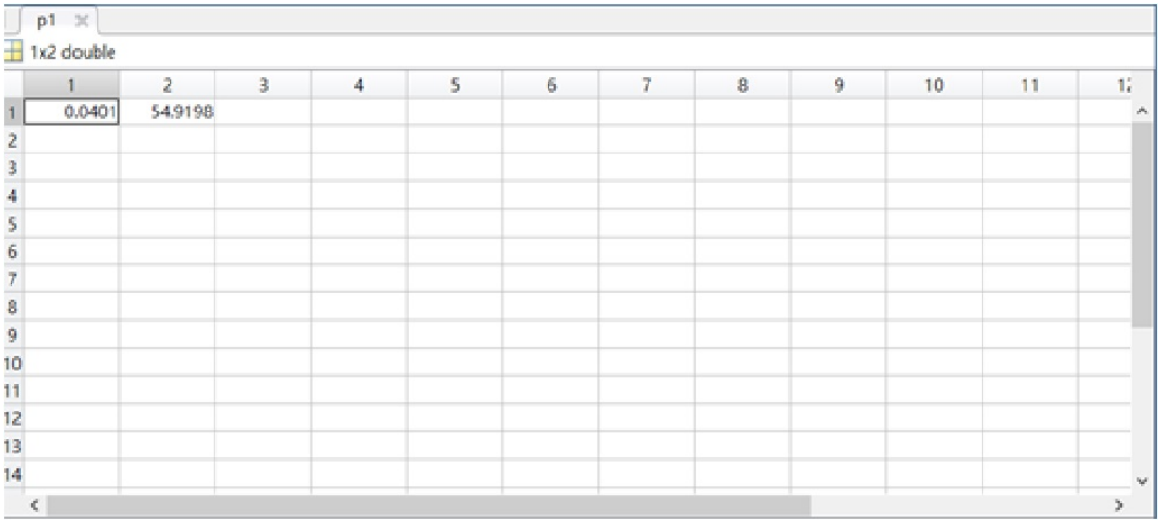

FIGURE 11. The slope and bias of reference line segment

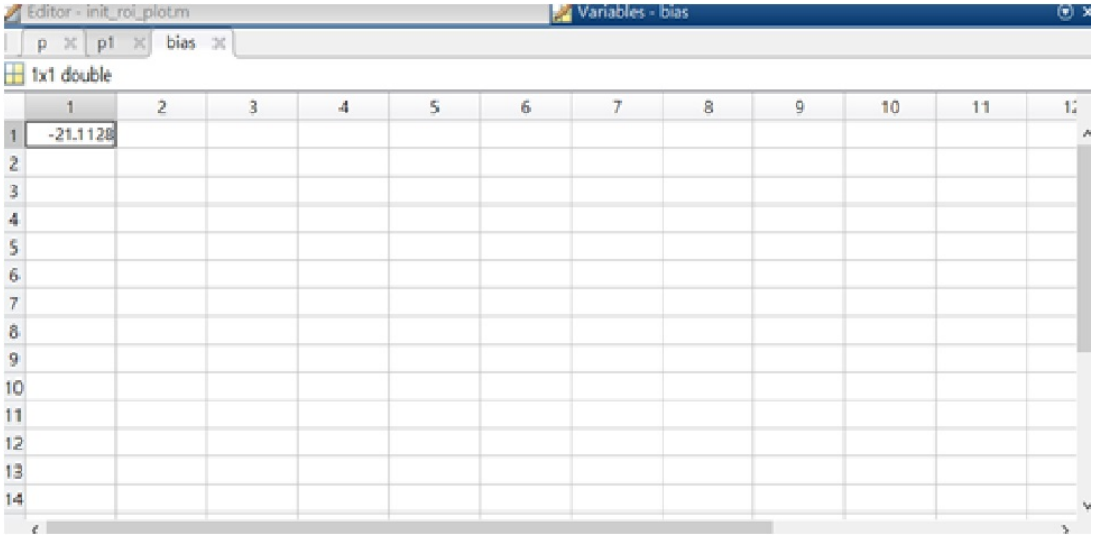

FIGURE 12. The comparison result and position which needs to be moved

6. **Conclusions.** In this paper, an efficient algorithm is applied to adjust the paper position on the printing machine automatically. In this study, the benchmark of paper position can be captured by using image processing technology. After the image preprocessing, the canny edge detection algorithm and Hough method are applied to fine the line segment. And then, the slope and bias of line segment can be calculated. After obtaining the comparison result, the system will adjust the paper position by using PLC system automatically. The system can self-adjust the deviation amount, so that it can improve the efficiency of printing product without stopping the machine.

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