TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 2124~2130
ISSN: 2302-4046

Printing Detecting Algorithm Based on Maximum Degree of Recognition

Hu Zhang*[1], Feng Guo[2]
[1,2]Key Lab. of Broadband wireless communications and Sensor networks, Wuhan University of Technology, Wuhan, Hubei, China
*Corresponding author e-mail: xxxykyb@whut.edu.cn, guofeng.whut@gmail.com

Abstract

In modern packaging, printing industry, due to effects of the properties of the strip itself and the ambient light, strip background color and the color of the printing line, the low contrast boundaries of the strip on both sides and so on, the traditional digital qualitative detection and control to the correction system does not meet the comprehensive requirements. This paper aims to study the detection of a continuous line, discontinuous line and color dividing line on the strip, and because of low contrast between background color and dividing line, we proposed an innovative solution and implementation. This article discusses a new algorithm basing on maximum degree of recognition and optimal light source search algorithm, and we simulated this in MATLAB, finally, we completed the physical testing of the overall system.

***Keywords**: printing, correction system, degree of recognition, light source search*

1. Introduction

With the continuous development and application of scientific and technological level, the degree of automation of industrial pipeline strengthened. In modern packaging and printing industry, flexible packaging (such as plastic printing, slitting machine, coating machine, printing and dyeing) basic production line nearly finish automation. However, uneven thickness and tension inconsistent made quality deviation and running deviation, therefore strip appears lateral deviation, dislocation and cannot keep a straight line running. Therefore, in order to solve this serious problem affecting the level of automation of modern packaging and printing industry, the need for a corrective control device online tracking and promptly corrected the position of the horizontal direction of the strip during transmission[1].

Corrective control system consists of three components: the corrective position detector, the corrective controller and driver. The corrective position detector in the foremost end of the correction control system, and its main function is to detect the actual position of the strip material needing correction in the horizontal direction. The main function of the controller is to receipt signal from corrector, to determine the strip position and offset to reference position of the direction, and calculate the offset signal. The main function of the execution mechanism is the reception controller of the conditioning signal, completes the correct process for generating offset strip. The main function of the execution mechanism is the reception the conditioning signal of controller, completes the correct process [2-3] .

This paper improved detecting method of existing corrective position, and we proposed printing detecting and correct position algorithm basing on maximum degree of recognition and optimal light.

2. Hardware Implementation

The corrective position detection system diagram is shown in Figure 1, during the corrective image acquisition process, the STM32F103RCT6 module as the core function which is to control the CMOS image sensor and TFT LCD display module. The CMOS image sensor module via a bi-directional transceiver displays an image collecting by CMOS on the screen. In the process, TFT LCD can display the line or edge needs to be identified. STM32 reads image data and converts data into the format of RGB565.

Received January 15, 2013; Revised February 26, 2013; Accepted March 6, 2013

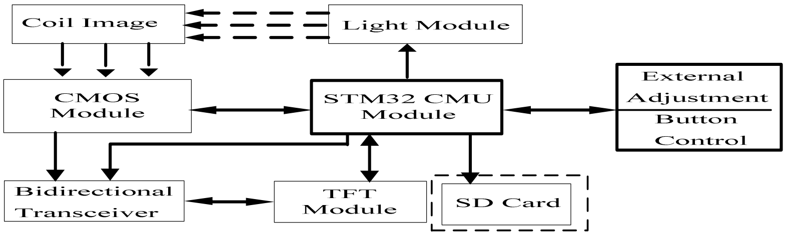

Figure 1. Block Diagram of Corrective Position Detection System

During the process when corrective image contrast is increase, STM32 will analysis of the color contrast, and control the luminous intensity of the light source module. Further, we will find the maximum luminous intensity of the color contrast by a binary search method. Image recognition process, an important task of STM32 is to identify collected image data by some algorithms. In system control aspect, based on recognition result of the image data, through the external conditioning circuitry , STM32 forms standard industrial signal output. External buttons set the corresponding function of the corrective position detection system items. TFT screen display stored volume material information and ID of the corrective position detector.

3. Acquisition of Corrective Image

The corrective image data acquisition overall design diagram is shown in Figure 2.

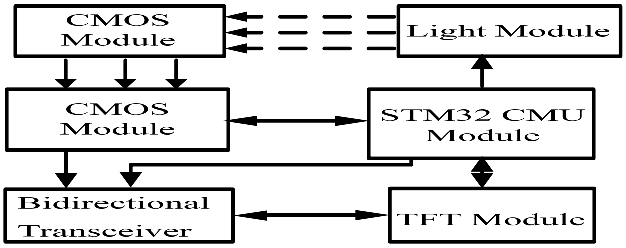

Figure 2. Block Diagram of Image Data Acquisition

Master controller collects color image, the color image in the color of each pixel by the R, G, and B three components decision, each component (255) the values desirable, such a pixel can have more than 1600 million (255 * 255 * 255) of the color range. When master controller during processing, it costs too much computation, thus we will convert color image to gray. Color image converts to gray image needed calculate the effective luminance value of the image pixel, calculating the effective pixels with gray value used by the formula (1) is as follows:

$$\mathrm{Y} = 0.3\mathrm{RED} + 0.59\mathrm{GREEN} + 0.11\mathrm{BLUE} \tag{1}$$

4. Acquisition of Maximum Image Contrast

Contrast is a measurement which represents the brightest white and the darkest black level of different brightness between light and dark areas, the greater the difference in range represents the contrast the greater, the smaller the range of differences behalf the smaller [4].

The corrective contrast of the image is also a reference to the concept above. The core function of corrective core functions of the position detection system is to identify line and edge of corrective image. If the contrast between line of corrective image and background color is small, or contrast color of both sides of the image is small, thus it is difficult to distinguish them[5-6]. Because we will use RGB three primary color LED to achieve the effect of the light mixing, we research the placement of LED. We used placement manner as Figure 3-1 shows, the RGB LED cross placed in the formation of LED dot matrix. It is feasible according to actual light mixing effect. Change the duty cycle of three-way PWM wave can formulate different light.

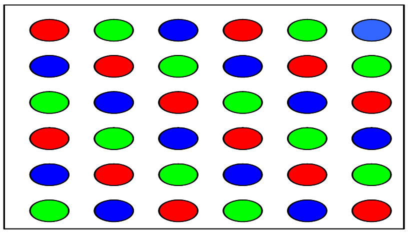

Figure 3. The Placement Way of Led Dot Matrix

We use the volume material pattern as shown in Figure 4 as experimental subjects. The characteristic of the image is a pattern of black lines on a gray background. Figure 5 is the volume material pattern without light source. The black line on the pattern cannot be found prominent, and cannot be identified. Through distributing different RGB component color, we can generate different light. The first light pattern as we use duty cycle to quantify is PWMRED=10%, PWMGREEN=20%, PWMBLUE=50%. The second light pattern is PWMRED=10%, PWMGREEN=20%, PWMBLUE=60%. Under the first light pattern, corrective strip diagram is shown in Figure 6. Under the second light pattern, corrective strip diagram is shown in Figure 7. Compare Figure 6 and Figure 7, we can say that different proportions play important role in black line identification. We can say that Figure 7 has a greater contrast.

Figure 4 Original picture of volume material

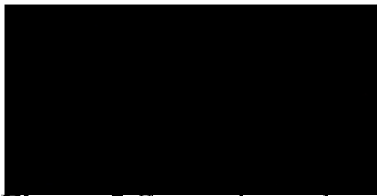

Figure 5 Corrective volume material in dark room

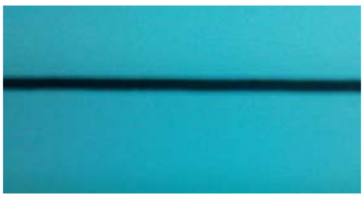

Figure 6 Corrective volume material under light one

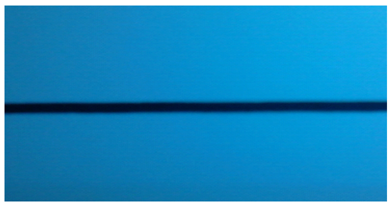

Figure 7 Corrective volume material under light two

Because there are different targets and backgrounds, different scenes need different requirements. Target and background brightness contrast is usually divided into apparent contrast (some literature called the apparent contrast), the inherent contrast (also known as zero contrast) and modulation contrast. Following we will give their definitions.

Modulation contrast: the ratio of difference between the target and background to sum of target and brightness of the background brightness. This definition is often used when the black and white grid test CMOS sensor. Definition formula is shown in Equation (2). Where M is modulation contrast, L_b represents the luminance of the target, L_m indicates the brightness of the background.

$$M = \left| \frac{L_m - L_b}{L_m + L_b} \right| \qquad (2)$$

Apparent contrast: the ratio of the difference between target and background brightness to background brightness, definition formula shown in Equation (3):

$$C = \left| \frac{L_m - L_b}{L_b} \right| \tag{3}$$

Inherent contrast: In apparent contrast test, when use the sky blue as background, the measured apparent contrast called inherent contrast. Definition formula is shown in Equation (4). Where C_0 is inherent contrast, L_s is the brightness of the sky background.

$$C_0 = \left| \frac{L_m - L_s}{L_s} \right| \tag{4}$$

We acquire physical image which contains the boundary into the microcontroller, through digital image processing methods, determine color contrast on both sides of the border. We also call both sides of the border were color blocks, we name them color block 1 and color block 2 respectively. When measure local contrast, we can measure gradation value of color block 1 and color block 2 respectively. Color modulation contrast of color block 1 and color block 2 are shown in Equation (5), also, the average contrast of corrective image:

Where m, b are measured gray scale value of color block 1 and color block 2 respectively.

$$M = \left| \frac{\text{m-b}}{m+b} \right| \tag{5}$$

The contrast calculation method above also applies to the calculating the contrast of line with the background of corrective image. The brightness of the light source is adjusted by adjusting the PWM pulse, the brightness of the LED adjusted by changing the pulse duty. The three components of R, G, B determines the different colors of visible light, and each component of the 256 types of values. So that can be a total range of more than 16 million colors (256*256*256). This not only increases search time, and actually produce such a wide variety of light, far beyond the speed of 32-bit microcontroller. Therefore, we should reduce the variation range of color can be drawn to 250 kinds of illumination level. We need find out an optimum light in the 250 kinds of illumination level, which makes maximum corrective contrast of the image. Search algorithm is as follows: [7-11]

1) In the first round we set a maximum lookup value as 250, the smallest value as 0, stepping value is 26=64, we can determine the scope of the first round samples R=[0, 63, 126, 189, 252], G=[0, 63, 126, 189, 252], B=[0, 63, 126, 189, 252]. There are 5 values for each component, a total of 5*5*5 = 125 combinations.
2) Calculate contrast of each combination, there are 125 values. Compare the contrast values, calculate the maximum contrast value is△max1, corresponding to the sample values are R=R1, G=G1, B=B1.
3) In the second round, set maximum R is R1+64, minimum lookup value is R1-64; maximum G is G1+64, minimum lookup value is G1-64, maximum B is B1+64, minimum lookup value is B1-64, stepping value is 25=32, scope of the samples are R=[R1-64, R1-32, R1, R1+32, R1+64], G=[G1-64, G1-32, G1, G1+32, G1+64], R=[B1-64, B1-32, B1, B1+32, B1+64], determine the value of the element, discard the value of which is less than zero;
4) Calculate contrast of each combination, compare the contrast values, calculate the maximum contrast value is△max2, corresponding to the sample values are R=R2, G=G2, B=B2。
5) In the third round, set maximum R is R2+32, minimum lookup value is R2-32; maximum G is G2+32, minimum lookup value is G2-32, maximum B is B2+32, minimum lookup value is B2-32, stepping value is 24=16, scope of the samples are R=[R2-32, R2-16, R1, R2+16, R2+32], G=[G2-32, G2-16, G1, G2+16, G2+32], B=[B2-32, B2-16, B1, B2+16, B2+32], determine the value of the element, discard the value of which is less than zero;

6) Calculate contrast of each combination, compare the contrast values, calculate the maximum contrast value is △max3, corresponding to the sample values are R=R3, G=G3, B=B3。
7) Fourth round, fifth round, sixth round and seventh round use stepping value 23=8, 22=4, 21=2, 20=1 respectively, determine a sample value for each round, compare the contrast under each of the set of sample values, thus can get maximum contrast value of R, G, B.

The ratio of RGB for selected different light is shown in Table 1, percentage express as the duty cycle of the PWM wave which controls each component.

Table 1. RGB Percentage of 10 Kinds of Light

Kind / Percen	1	2	3	4	5	6	7	8	9	10
R	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
B	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Further, we can get contrast value of 10 flights as Table 2 shows.

Table 2. The Contrast Under Different Kinds Of Light

Kind / Contras	1	2	3	4	5	6	7	8	9	10
△	0.9870	0.1879	0.2150	0.2990	0.3872	0.4990	0.5870	0.6550	0.7352	0.822

5. Recognition of Corrective Image

Corrective position detection system is used to detect the degree of membrane deviation of the horizontal position in the course of transmission. In order to detect the position of the offset, we select unique iconic image pattern to track during corrective. Therefore, recognition of corrective image does not need to recognize the entire image, only volume material pattern on the lines or edges to be identified and tracked. Resolution of a corrective image collected by the master controller is 320*240, the original image is 565RGB format, and then undergo gradation processing. Corrective image identification is based on the gray value of each identified pixel. As shown in the simulation result collected corrective image, we can extract characteristics of corrective image [12]-[14].

Line feature on corrective image is shown in Figure 8. Assuming that the location of the black line is the 160th column and the width of the black line the same as the width of one pixel point. We observe pixels in one row, from 1st to 159th column, pixel gray value is not change. From 159 to 160 column and 160-161 column the gray value mutate. From 161-320 column, gray value remains unchanged. The feature of corrective image can be represented as Figure 4-2, in the position where the black line undergoes positive mutation.

Figure 8 The line on corrective image

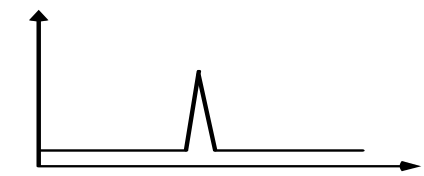

Figure 9 Positive mutation of corrective image

We see Figure 4-3, assume side boundaries 160th column. We observe pixels in one row, from 1st to 159th column, pixel gray value is not change. From 159 to 160 column and 160-

161 column the gray value mutate. From 161-320 column, gray value remains unchanged. The feature of corrective image can be represented as Figure 4-4, in the position where the black line undergoes negative mutation.

Figure 10 The border of corrective image

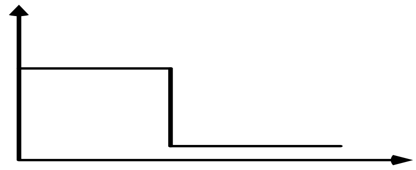

Figure 11 Negative mutation of corrective image

We can identify and track according to this feature gray value mutation of line or edge.Assuming orders of a corrective image grayscale as Table 3 shows. Its resolution is 320*240, we use two-dimensional matrix to descript it as $F_{320\times240}=[f(x,y)]_{320\times240}$, $f(x,y)$ is the gray value of (x,y), and $f(x,y)\in\{0,1...,255\}$, 0-255 is the total number of gray level of the image.

Table 3. Corrective Image Gray Value Arrays

f(1,1)	f(1,2)	f(1,3)	f(1,4)	……	f(1,317)	f(1,318)	f(1,319)	f(1,320)
f(2,1)	f(2,2)	f(2,3)	f(2,4)	……	f(2,317)	f(2,318)	f(2,319)	f(2,320)
f(239,1)	f(239,2)	f(239,3)	f(239,4)	……	f(239,317)	f(239,318)	f(239,319)	f(239,320)
f(240,1)	f(240,2)	f(240,3)	f(240,4)	……	f(240,317)	f(240,318)	f(240,319)	f(240,320)

6. Results and Conclusion

Figure 12 shows the corrective page of system, we can see the corrective image and observe the actual position of the volume material line or edge.

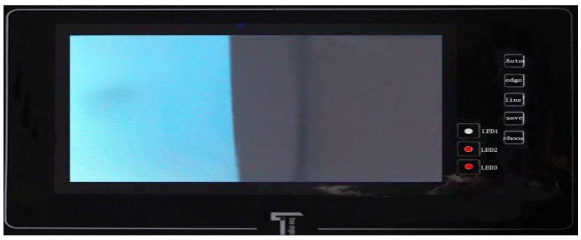

Figure 12. Corrective Page Of This System

For testing convenience, assume that the edge is in the center position of the TFT screen when the volume material does not deviation, as shown in the Figure. Obtain points at the edge as marks, divide the screen into 10 parts in the horizontal direction. Move the volume material edge, make it coincident with marks. When the edge is coincident with the 1st mark, we measure the output signal voltage VOUT of the corrective position detection system by a multimeter. Then moving volume material edge match mark 2, mark 3 ...... mark 10 respectively, measure signal voltage VOUT at that time. Record the ten groups of values, as shown in Table 4 below.

Table 4. Border Position of and Output Voltage

Boundary position	0	1	2	3	4	5	6	7	8	9	10
VOUT(V)	0.005	1.02	2.1	3.22	4.08	5.05	6.12	7.21	8.03	9.1	9.9

Polyline graph is shown in Figure 13.

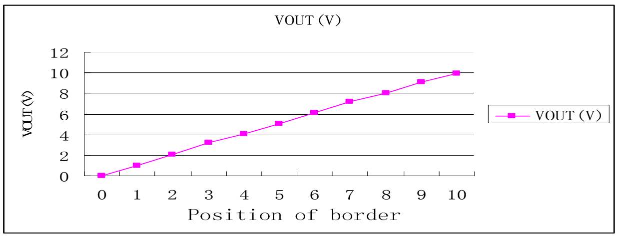

Figure 13. Polyline Graph Of Boundary Position And The Output Voltage

From above figures we can say that system can track the edge of volume material and has a good linearity. Setting the mark 5 is volume material's center place, if VOUT(x)<VOUT(5), the volume material offset to the left; if VOUT(x)>VOUT(5), the volume material offset to the right. According the value of VOUT(x), the controller can control the drive's operation, change the lateral offset distance of volume material, and thus achieve correction effect.

References

[1] Pan RuoMing. The steel strip corrective control system. Harbin: master's degree thesis of Northeastern University. 2006; 1-10.
[2] Niu QingJun. Strip correction and control system. *Non-ferrous metal processing.* 2003; 32(3): 2-4.
[3] Chen DeChuan, Tao Hongbin. A new type of corrective control system of strip winding process. *The learned journal of Hangzhou University of Electronic Technology.* 2008; 28(2): 74-77.
[4] Yao JunChoi, Shi Junsheng. The explore of color image contrast defined. *The learned journal of Yunnan Normal University.* 2006; 26(4): 49-51.
[5] K Wenze, KLadung AK Samuet. Measurement of Color Defectiv e and Normal Color Visio n Subjects Color and Luminance Contrast threshold Functions on CRT. *Per iodica Lo ly technica Ser Mech Encino l.* 2000; 45(1): 103- 108.
[6] KTM ullen. The Contr ast Sensitivit y Of Human Color Vision To Red Green And Blue Yellow Chromat icGrat ing. *Journal o f Physiology.* 1984; 359: 381-382.
[7] Fang Cheng. An improved binary search algorithm. *Modern electronic technology.* 2008; 5: 163-164.
[8] Kunth DE. The Art of Computer Programing, 3: Sorting and Searching. *Addison Wesley.* 1973.
[9] Santosa PI. Cost and Benefit of Information Search using Two Different Strategies. *TELKOMNIKA.* 2010; 8(3): 195–206.
[10] E Martiana, N Rosyid, U Agusetia. Document Search Enginee Based on Automatic Clustering. *TELKOMNIKA.* 2010; 8(1): 41–43.
[11] Hyafil L. Bounds for Selection. *SIAM Joural on Computering.* 1976; 1: 109-115.
[12] Julez B. A Method of Coding TV Signals Based on Edge Detection. *Belltem Tech.Compression Video Television.* 1959; 38(6R): 1001-1020.
[13] Larkiao J, Mallykoski P, Nylander J. Prediction of Rolling Force in Coldby physical Models and Neural computing. *Journals of Materials Processing Technology.* 1996; 60: 381-385.
[14] Zhou Yi Xiao. *Coating furnace strip correction control system*. Taiyuan: Master's degree thesis of Taiyuan University. 2008; 13-18.