Advanced Science and Technology Letters
Vol.31 (ACN 2013), pp.11-15
http://dx.doi.org/10.14257/astl.2013.31.03

Numerical Recognition in the Verification Process of Mechanical and Electronic Coal Mine Anemometer

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Abstract. In this paper, the digital image processing and recognition technology are applied in the verification process of mechanical and electrical coal mine anemometer. Firstly, using camera to collect the mirror image of the anemometer from a plain mirror which in the wind tunnels. Secondly, the image is processed by secondary mirroring, denoising, the location of numerical display area, binarization, segmentation, etc. Lastly, according to the characteristics of anemometer, which using the LED digital tube to display numbers, the region segmentation scanning method was adopt to recognize the digital characters and the decimal point. The experiments show that this method has high recognition rate, the recognition time is able to meet the requirement for the verification of mine anemometer.

Keywords: electronic anemometer; verification of anemometer; character segmentation; character recognition

1 Introduction

The wind speed is one of the important parameters of coal mine safety [1]. Now, anemometer is widely used in wind speed measurement. According to the types of structure, the anemometer can be divided into mechanical type, electrical type, mechanical and electrical type [2]. Because of the display area of mechanical and electrical anemometer perpendicular to the observable window, it's hard to acquire the numerical values. At present, the research about verification method of mechanical and electronic coal mine anemometer is few reports exist.

There are many recognition methods are proposed about digit recognition, such as template match method [3], statistical decision method, contour polygon method [4], neural network approach [5], etc. Combined with the practical project, this paper proposed a simple effective recognition method and a hardware and software implementation. In the wind tunnel, a plain mirror was placed in the position of 45 degrees of the anemometer's numerical display area. Through the observable window, the camera aimed at the mirror and collected the mirror image of

ISSN: 2287-1233 ASTL

anemometer. The camera was connected to the computer by using data cable. The hardware structure as the figure 1 shows.

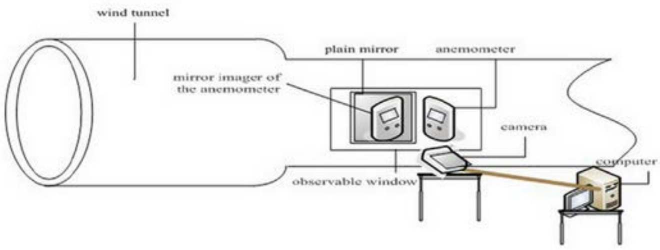

Fig. 1. Hardware structure of the system

2 Image Preprocessing

The image pretreatment stage mainly studies the image secondary horizontal mirror, the image grayscale processing, denoising processing and the image binarization operation. In the verification system, the image collected by the camera is mirror. The mirror image needs secondary horizontal mirror and return to a normalized state. The values of the three components of R, G, B are *R, G, B*, the transformed gray value is *Gray*, The transformation formula is given as follow:

$$Gray=0.299\times R+0.587\times G+0.114\times B \quad (1)$$

The noises would be removed by medium filter, which can remove the isolated points. The OTUS method was used to convert the intensity image to a binary image.

3 Numerical region Location and Incline distortion adjustment

The numerical region can be located base on the color features and the shape features. All the quadrilaterals can be obtained by the edge detection and the specified accuracy polygon approximation. According to the values of the three components of R, G, B, it can determine a reasonable threshold and locate to the numerical region on the color image. The result of location is shown in figure 2(a).

The image photographed by the camera may be produced incline distortion. Incline distortion is adjusted by using the coordinates of the four corners which has obtained from the previous step. The result of adjustment is shown in figure 2(c).The coordinates of the four corners are (x_0, y_0) , (x_1, y_1) , (x_2, y_2) , (x_3, y_3) .The coordinate of any point on original image is (x, y) , after adjustment, the new coordinate is (x', y') .The transformation formula is given as follow:

$$\begin{cases} x' = x + (y - y_0)(x_0 - x_1) / (y_1 - y_0) \\ y' = y + (x - x_0)(y_0 - y_3) / (x_3 - x_0) \end{cases} \tag{2}$$

(a) Location result (b) The extracted image (c) The image after adjustment

Fig.2. The result of Location and adjustment

4 Character Segmentation and Recognition

4.1 Character Segmentation

The vertical and horizontal projection segmentation method was used to segment the Characters in the paper. There are two valleys on the horizontal projection image, and four valleys on the vertical projection image. The positions of these valleys can be used to complete the character segmentation as the boundaries. The results of characters segmentation are shown in figure 3.

F**ig. 3.** The results of character segmentation

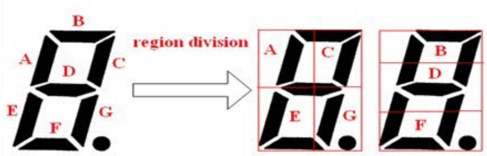

Fig.4. the digital tube region division

4.2 Character recognition

The character image can be divided into seven regions by the position of the digital tube. The results of region division are shown in figure 4. The maximum width and height of the single character image can be obtained and be marked as *MaxWith* and *MaxLength*. If *MaxLength*. >3 *MaxWith*, the character will be recognized as the number 1. Then, find the lighted digital tube. The truth value of the lighted digital tube area would be set to 1; the truth value of unlighted area would be set to 0. The character can be recognized by comparison with the truth table. The truth table is listed in Table 1.

Because of inclined font, it's difficult to separate decimal point from the character image. The length and width ratio of minimum external rectangle and the area ratio between connecting area and external rectangle are calculated in order to judge whether the decimal point exist or not. If the formula 3 and formula 4 are satisfied, the decimal point exists.

$$\varepsilon_1 \le \frac{lheight}{lwidth} \le \varepsilon_2 \tag{3}$$

$$\frac{\sum_{A} S(x,y)}{lheight \times lwidth} \times 100\% \ge \varepsilon_3 \tag{4}$$

A is the minimum external rectangle. *lheight* is the length of minimum external rectangle, *lwidth* is the width of minimum external rectangle. *S(x, y)* is the pixel value of coordinate point *(x, y)*.the upper and lower bound of length width ratio are ε_1 and ε_2, the lower bound of the area ratio is ε_3.

Table 1. Truth table of the digital tube

character	A	B	C	D	E	F	G
0	1	1	1	0	1	1	1
2	0	1	1	1	1	1	0
3	0	1	1	1	0	1	1
4	1	0	1	1	0	0	1
5	1	1	0	1	0	1	1
6	1	1	0	1	1	1	1
7	0	1	1	0	0	0	1
8	1	1	1	1	1	1	1
9	1	1	1	1	0	1	1

5 Experiment results

One hundred real images, which contain three hundred characters, were chosen to carry on the experiment. The results of these experiments are listed in Table 2.The recognition rate of characters is at least 97%. A single test run time is 180ms, which and can completely meet the practical need.

6 Conclusion

The numerical recognition in the verification process of mechanical and electronic coal mine anemometer is a subject worthy of study. The numerical region location method base on the shape and color, which is not influenced by camera position, is feasible and effective. The recognition method base on area scanning, which is no need the thinning and the normalization, improved the identification efficiency.

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