Research on Methods of Image Recognition for LCD Digit

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Abstract. The old material weighing system using LCD liquid crystal display weighing data, the system intact, but no data export interface. Without affecting the normal use of equipment, the machine vision technology was used to achieve weighing data identification. In this paper, the digital image of LCD liquid crystal display was taken as the object of study, and the methods of seven-segment LCD digital image recognition were studied. 100 LCD display images were collected using the visual system. Two kinds of recognition methods were contrastively studied. One was area feature recognition method. 0-9 character images were obtained through region feature method, and the numbers were identified according to these features. The other was the template matching method. Under the same condition, the results showed that the accuracy of data recognition is 100% for 100 images processing and 94% for template matching. Changing the condition, template matching method could also get the same accuracy. This shows that the regional feature method and template matching method can meet the actual identification requirements.

Introduction

The old material weighing system using LCD liquid crystal display weighing data and the method of manual recording are generally used to achieve the data record. The system intact but no data export interface. In order to achieve the automatic recording of weighing data, without affecting the equipment using normally, it is a good way to use the machine vision technology. Liu Shuang [1](2013) and the members of the group (2013) use the rotation correction method and the positioning method of sliding window gray scale alignment to achieve the displaying digital tilt correction and digital positioning in the instrument. Wang Rongfang [2] and the members of the group (2008) use threading method to achieve digital identification of the seven-segment digital tube, the recognition rate being up to 99%. Gong Yubin [3] (2011) and the members of the group use the gridding dividing to extract the features of the digital image areas, using three-layer BP neural network for digital identification. Li Dan [4] and the members of the group (2007) use the neural network to identify the number, the correct rate being up to 96%. He Hongbo [5] and the members of the group (2007) proposed that the combination of threading recognition and pattern recognition algorithms can greatly improve the recognition accuracy of numbers. Guo Shuang [6] and the members of the group (2012) study the taxi price digital identification, verifying that using threading method and template matching method can get a better recognition effect. Chang Xiaowei [7] and the members of the group (2014) use OCR function in Labview software to achieve digital recognition after enhancing the image filtering and other pre-processing, the recognition rate being up to 99%. Shen Zhonghong [8] and the members of the group (2013) show that the method has good accuracy by statistically analyzing the geometric trajectory characteristics of each target region and matching the existing signature database to realize the digital recognition. Fan, Jianqing [9] and the members of the group (2014) use the grid division seven-segment digital tube, according to degree of the shade in each area of digital tube, identifying the figures displayed.
In this paper, the regional feature recognition method and the template matching recognition method are compared with and the accurate recognition effect is showed.

**Image Acquisition**

**The Machine Vision System**

![Machine Vision System](image)

Figure 1. The machine vision system.

1. Light 2. industrial camera 3. keyboard 4. LCD liquid crystal display 5. control panel 6. computer

The experimental machine vision system section mainly includes industrial cameras, light sources and computers, which gather the image acquisition from the LCD liquid crystal display screen. Besides, the industrial camera is the Basler1300-60gm monochrome camera, resolution 1280 × 1024; lens for 12mmRICOH; objects from the 300mm, LCD display width of 100mm, and height of 10mm.

**Image Collection**

The industrial camera is fixed on the bracket, adjusting the lens focal length and object distance, so that the digital display area basically cover the entire image area, adjusting the position of light source, which makes the imaging contrast is clear. In the case of experiment, the image whose data changes 100 times is recorded by controlling the panel keyboard to display the data.

**Digital Identification**

**Image Preprocessing**

**Filter**

Gaussian filtering is a linear smoothing filtering which is suitable for eliminating Gaussian noise and is widely used in image processing for noise reduction processes. The Gaussian smoothing filter is very effective in suppressing noise from the normal distribution. Generally, \( m \times n \) size Gaussian filter mask is used to linearly filter \( M \times N \) images.

\[
g(x,y) = \sum_{a=-b}^{b} \sum_{t=-b}^{b} w(a, t) f(x+a,y+t)
\]

(1)

Among them, \( a = (m - 1)/2 \), \( b = (n - 1)/2 \), \( x = 0,1,2,...,M - 1 \), \( y = 0,1,2,...,N - 1 \).

**Binarization**

The binary image brings computational convenience to the recognition. Because of adjusting the method of light sources lighting, it makes the lighting tend to be uniform. Therefore, this paper uses a fixed threshold method to achieve image Binarization. The results are shown in Fig2.
Opening Operation

The opening operation can be used to eliminate the noise image and to separate the object at the slim point and change the area at the smoothing the boundary of the larger object not obviously. The image Binarized point can be removed through the operation of the opening operation, which can reduce the roughness of the contour and increase the smoothness of the contour.

The rectangular structure element S is constructed with $h \times i (h = 3, i = 3)$. The image $I_4(x, y)$ is obtained by doing the Opening operation with the image $I(x, y)$ according to the structural element S from the equation (2) (as shown in Fig. 3).

$$I_4 = I \circ S = (I \ominus S) \oplus S$$  \hspace{1cm} (2)

Among them, $\circ$ is seen as the Opening operation, $\ominus$ is seen as the Corrosion operation, $\oplus$ is seen as the Expansion operation.

Template Matching Method

Area Segmentation and Template Extraction

The Binarized image is divided into small area maps according to the width and height of each number, and the 0 to 9 digital images are extracted from the Binarized image as templates to save.

Digital Identification

From the high to the low, the numbers can be identified, according to following by doing the difference operation between the template and the numbers and according to the principle of minimum area of the connected area.
Area Features Method

**Extraction of Regional Feature**

The seven-segment number is divided into seven regions. As shown in the figure, if the large area connecting with each other in the seven regions exists, the area characteristic is judged 1, otherwise 0, according to this method, the features of 0 ~ 9 are classified.

![Figure 6. Area features.](image)

Digital Identification

From high to low, the numbers can be identified according to the number features thereby the identification of the display data is realized.

Result Analysis

The 100 experimental images gathered were processed. From the experimental image, if the light is relatively uniform, the effect is very good. The numerical recognition rate of the data is shown in Table I.
Table 1. Digital recognition correct rate statistics.

| Numbers | Appearance times | Template matching | Area features |
|---------|------------------|-------------------|--------------|
| 0       | 4                | 100%              | 100%         |
| 1       | 85               | 100%              | 100%         |
| 2       | 184              | 100%              | 100%         |
| 3       | 56               | 100%              | 100%         |
| 4       | 74               | 100%              | 100%         |
| 5       | 81               | 100%              | 100%         |
| 6       | 13               | 92.3%             | 100%         |
| 7       | 16               | 93.7%             | 100%         |
| 8       | 122              | 99.1%             | 100%         |
| 9       | 79               | 95%               | 100%         |
| Whole   | 100              | 94%               | 100%         |

From the result compared, Regional feature recognition method for recognizing each numbers have reached 100%, and template matching method has 6 images not correctly identified, which contains 6, 7, 8 of the error 1, with 9 of the error 4. In 100 images, there are 6 maps recognition error and the recognition accuracy rate is 94%.

The interference of the high noise because of the threshold value unsuitably set because the result analyzed when the images are binarized. After the binarized factors and the other pretreatment factors are modified, the result shows the recognition rate of the template matching method is up to 100%.

Conclusion

It is feasible to use the machine vision technology to identify the data shown in the LCD liquid crystal display weighing system of the old material weighing system. In the case of uniform illumination, the template matching method and the regional feature method can obtain accurate data recognition.

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References

[1] Liu X, Cui G G, Liu T H and Yu S C. “Character Recognition of Intelligent Instrument Based on Rotation Correction and Sliding Window Location [J]”, Electrical measurement and instrumentation, 2013, (6): 20-23.

[2] Wang R F, Wang R H and Kang Y F. “Decimal point recognition based on the digital tube machine vision [J]”, Electronic testing, 2008, (11): 17-20.

[3] Li D, Sui C H and Tang Y J. “Study on Digital Character Recognition of Multiple Digital Instrument Dynamic Display [J]”, Journal of Zhejiang University of Technology, 2007, (04): 437-440.
[4] He H B and Kong H C. “A processing method of new digital computer visual recognition [J]”, Electronic Engineer, 2007, (01): 65-69.

[5] Guo S.“Research of digital tube digital instrument automatic identification method [J]”, Communication Technology, 2012, (08): 91-93.

[6] Chang X W. “Multiature instrument character recognition based on machine vision [J]”, Computer Measurement and Control, 2014, (09): 3071-3073.

[7] Shen Z H, Jiang C X, Xu H W, Li Z K, Zhou M Y and Liu J Q. “Automatic reading of digital display instrument based on machine vision [J]”, Electronic Product Reliability and Environmental Test, 2013, (S1): 110-115.

[8] Fan J, Wang A, Gao Y, and Yu L. “Study on the technology of digital recognition in verification process of mechanical and electronic anemometer [J]”, International Journal of Control and Automation, 2014, 7(4): 337-344.

[9] CParsons, D. Williams, The genetic landscape of the childhood cancer medulloblastoma, Science. vol. 331, no., 6016, pp. 435-439, 28 January 2011.

[10] Gong W B, Yang H J, Zhang Y C, Chang G L and Qiu D. “Research on Digital Character Recognition Method of Digital Instrument [J]”, Journal of Shandong University of Architecture & Technology, 2007, (04): 437-4.