Digital Recognition of Weighing Instruments Based on Machine Vision

Nan Dong¹, Yong Zhang², *, Qinjun Zhao³

¹School of Electrical Engineering, University of Jinan, Jinan250022, China
²School of Electrical Engineering, University of Jinan, Jinan250022, China
³School of Electrical Engineering, University of Jinan, Jinan250022, China

E-mail: 837534896@qq.com   E-mail: cse_zhangy@ujn.edu.cn
E-mail: cse_zhaoqj@ujn.edu.cn

Abstract: After image graying, binarization, filtering, corrosion, expansion and other related pre-processing operations, the tilted digits are vertically corrected by searching for the smallest external rectangle of the digits, and then the images are digitally segmented. Finally, the digits are recognized by using BP neural network algorithm, which are all based on the VS Software Platform (Microsoft Visual Studio) of computer and OpenCV Machine Vision Library. BP neural network algorithm has higher accuracy and can recognize different forms of numbers compared with traditional digital recognition methods. However, the processing time of digital recognition is longer, the number of digital samples processed is larger, and the algorithm is more complex compared with the general algorithm. We collect 300 digital pictures for recognition and test, and the recognition accuracy is as high as 97% in the digital image acquisition and recognition system. Finally, experiment shows that the method performs well in recognition accuracy and anti-jamming.

1. Introduction:
In order to judge whether the instrument produced by the company meets the industry standards, it is necessary to send the instrument to the Metrology Institute for testing. The process of digital image acquisition is usually carried out under the condition of EMI (electromagnetic interference) and extreme humidity and temperature, it will do some harm to human body if people are close to the measurement. In addition, people are prone to fatigue when observing large quantities of data, which will reduce the accuracy judgment of the instrument's data identification.

Traditional digital recognition algorithms generally support only one form of digital recognition, which has great limitations and is not conducive to the recognition of multiple forms of digital. The BP neural network algorithm adopted in this paper can recognize many kinds of morphological digits with high recognition rate, but this method is more complex than the traditional method, and the processing time of the digit recognition is longer.

The camera takes the digital pictures on the weighing apparatus display screen and transmits them to the computer. Next, the digital area to be recognized is selected by mouse, which is ROI area. Then gray, binary, filtering and morphological treatment are performed on the image, among them, morphological treatment includes corrosion and expansion. The camera may take tilted digital pictures, which are not conducive to the segmentation of subsequent digits, so it is necessary to vertically...
correct the tilted figures. Finally, the digits are segmented and the segmented digits are fed into the designed BP neural network algorithm for recognition. Fig1 is the overall digital recognition block diagram.

![Digital Image Acquisition of Weighing Instruments](image1)

![Image processing](image2)

**Fig1.** The overall digital recognition block diagram

## 2. Digital Recognition Algorithms

### 2.1. Software and Hardware Platform

The hardware involved computer, weighing instrument, CCD camera, weights, USB gigabit network card converter, etc. The software involved VS software platform, OpenCV machine vision library, camera driving MV_SDK, etc.
2.2. ROI Region Selection

The region of interest (ROI) is selected by mouse to facilitate subsequent digital recognition [1].

2.3. Image Preprocessing

(1) Gray-scale processing

![Gray-scale image]

The color information in the image is removed and only the brightness information is retained. Gray image contains less information than color image, which not only make the image does not lose image information, but also simplifies the process of processing. It will also not affect the recognition accuracy. The image extracted by the camera is colored, and each pixel is composed of three components: R, G and B (red, green and blue).

\[ f(i, j) = 0.30R(i, j) + 0.59G(i, j) + 0.11B(i, j) \]

where \( f(i, j) \) is the gray value of the converted gray image at \((i, j)\) [2].

(2) Adaptive Local Binarization Processing

![Adaptive local binarization]

The binarization process is to transform the image into only two gray levels, which is more conducive to subsequent image processing. There are only two kinds of pixel values in the binarized image with 1 for white and 0 for black. The adaptive local binarization takes the threshold itself as a variable. The threshold is different at each pixel. The adaptive threshold is obtained by calculating the weighted average of the surrounding data and subtracting a constant [3].

(3) Image filtering

Because of various external interference factors, the image obtained by the camera will have noise, which will affect the recognition of weighing instrument numbers, so it is necessary to reduce or even remove the noise.

The median filter replaces the gray value of the pixel with the median gray value of the pixel in the adjacent area. The function window of 3*3 is used to sort the gray level of the pixels in the window, and the middle value is taken as the new gray level of the target pixel. Specific steps are as follows:

1) Arranging the pixels according to the intensity value.
2) The median value of the set of arranged pixels is selected as the new value of the point \((i, j)\) [4].
Fig 7. Median filtering

It can overcome the blurring of image details caused by common linear filtering, and it is very effective in filtering impulse interference and image scanning noise under certain conditions.

(4) Morphological treatment

Expansion or corrosion operations are to traverse all the pixels of the image and convolute the image with the core. The core can be of any shape and size, usually square or circle. Expansion is to find the local maximum. Corrosion operation and expansion are opposite operations.

Fig 8. Corrosion                 Fig 9. Expansion

2.4. Vertical Correction

The camera may take tilted digital pictures, but tilted digital pictures are not conducive to the segmentation of subsequent digits, so it is necessary to vertically correct the tilted figures.

Fig 10. The minimum circumscribed rectangle of tilting figure

Digital tilt correction can be achieved by finding the smallest outer rectangle. Minimum circumscribed rotating rectangle has three attributes: 1) center of rectangle (center of mass); 2) side length (height and width); 3) rotation angle.

The red rectangular box is an outer rectangle of sloping numbers in fig 10. The tilt angles of the four figures are calculated respectively: -81.8699, -87.0643, -85.6013, -83.4802, so the average inclination angle is -84.5039. The rotation matrix is determined by three elements of the rotating rectangle: center of mass, side length and rotation angle, in which the rotation angle is the average of the inclined angle. Finally, the tilting number is rotated according to the rotation matrix.

Fig 11. Vertical corrected pictures
2.5. Digital Segmentation

Fig12: Digital Segmentation results

Digits are segmented by finding the smallest outer rectangle of the digits, and then the segmented digits are normalized to 15*25 pixels.

3. Recognition

The segmented digits are fed into the trained BP neural network [5] squadron digits for recognition. The recognition rate of 8 is 97.0605%.

Fig13: Digital recognition rate

Similarly, the recognition rates of 4, 3 and 0 are 97.294%, 98.2251% and 98.675% respectively. The recognition rate is high with above 97% recognition rate.

4. Conclusion

This paper validates the digital recognition method of BP neural network. Firstly, the image is grayed, binarized, filtered and morphologically processed. Because the inclined digital image that the camera may take will affect the subsequent digital segmentation, it is necessary to vertically correct the digital image by the method of minimum external rectangle, then, the digits are segmented by this method, and the segmented digits are normalized and fed into the trained BP neural network for digit recognition. BP neural network has high recognition rate and good stability, but this method has a long processing time and complex algorithm, which is suitable for the recognition of large quantities of numbers.

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