The study of improved binarization algorithm and the design of fingerprint identification system

ZHU Heng-jun¹, GUO Ying¹, ZHANG nan-nan¹, LIANG Hong¹

Abstract. Many domestic enterprises use punch machine for attendance management of coal mine workers, which leads to have some underground hidden danger and have difficulties to confirm the accident personnel and rescue them afterwards. This paper describes the design of a fingerprint recognition system for coal mine workers identity recognition, which can guarantee the safe production. The result of debugging shows that this system can operate stably and reliably, improving the accuracy and efficiency of the security check.

Keywords: mining management; fingerprint recognition; binarization algorithm; optical fingerprint sensor; TMS320VC5509 signal processor.

1 Introduction

In fingerprint algorithm, fingerprint segmentation algorithm is very important for a good fingerprint recognition system. The fingerprint segmentation algorithm typically includes two categories: algorithm based on grey variance and fingerprint segmentation algorithm based on directivity diagram of fingerprint. Each of the two method has its advantages and disadvantages.

This paper has improved the previous methods and puts forward a new method called comprehensive orientation segmentation and variance partitioning, improving the anti-interference ability of the segmented images. At the same time, this paper also uses improved binarization algorithm based on the global iterative method. The software is programmed with C language which can realize fingerprint image acquisition, segmentation, binarization, thinning algorithm and extraction characteristic value of endpoint and bifurcation point to achieve fingerprint comparison and identification. The experimental results show that the false accept rate (FAR) and the false reject rate (FRR) are less than or equal to 1%. It has the advantages of improving the accuracy of fingerprint identification. The speed of the system has raised and the result of the test is satisfactory, which shows that the system is suitable for identity recognition and confirmation of underground coal mine workers.

2 The structure of the fingerprint identification system

In this design, the structure of the fingerprint recognition system consists of four
parts: optical fingerprint sensor acquisition module, DSP processing module, MCU control module and LCD display module. The hardware mainly are: optical fingerprint sensor, DSP data processing unit, peripheral control circuit and LCD display circuit. Fingerprint acquisition and processing system uses TMS320VC5509 made by TI company as the chip of image processing. Use STC89C52 as MCU and LCD12864 as the display chip. Use flash to store the fingerprint data and RS232 interface to communicate with computer, achieving the data transmission between the device and the computer. Use optical fingerprint sensor to realize the fingerprint image acquisition. The overall design scheme of the software system mainly includes: the initialization program design of the system, the design of fingerprint recognition program and the design of LCD display program.

3 The design of fingerprint recognition algorithm

3.1 Fingerprint image segmentation

This paper presents an improved method. This algorithm combines the direction partitioning and variance segmentation, which has improved the segmentation of fingerprint image to a great extent.

This paper uses $9 \times 9$ direction template to perform segmentation. What is shown in Fig 3.2 is the $9 \times 9$ direction map template. The directivity diagram segmentation method separates the foreground and background of the fingerprint. The size of the selected template here is $9 \times 9$. The center of the template is the quasi point. Starting from the horizontal position, we can determine a direction every $\frac{\pi}{8}$, and calculate the DI of every direction and then compare the DI of each direction, finding the minimum value of DI, then I represents the direction of this point. Calculate the mean value first, and then use the formula to calculate the variance of image blocks.

$$D_I = \sum_k \left\| f(i,j) - f_k : j_k \right\|$$

(3-1)

$K$ is the number of the point in the No.1 direction, among them:

$$S = \sum_k f(i,j)$$

(3-2)

$$S_{\text{max}} = \max(S_I)$$

(3-3)

$$S_{\text{min}} = \min(S_I)$$

(3-4)

$S_I$ is the calculation of the pixel gray value in each direction. According to the hypothesis, the central pixel of the window is written as $f(i,j)$, and the attribute of it is
determined by the formula of (3-5) and (3-6).

\[ f(i, j) = \frac{1}{32} \sum_{i=1}^{s} S I \]

(3-5)

\[ \frac{1}{8} (S_{\text{ux}} + S_{\text{mi}}) + \frac{1}{32} \sum_{j=1}^{s} S I \]

(3-6)

It can be proved by the formula (3-5) that: when the gray value of the central window’s pixel \( f(i, j) \) is greater than the average gray value of the pixel in this window, it will be set to foreground, or else it will be set to background. Equation (3-6) has proved that: when the gray value in the direction of \( S_{\text{ux}} \) and that of \( S_{\text{mi}} \) are greater than the average gray value in this window, it will be set to foreground, or else it will be set to background. If the formula (3-5) and (3-6) are combined, we can draw the decision condition (3-7). If the decision condition (3-7) is established, then the point \((i, j)\) is the foreground, or else it is the background.

\[ 4 \left( f(i) + S_{\text{ux}} + S_{\text{mi}} \right) + \sum_{j=1}^{s} S I \]

(3-7)

In order to make the segmentation of fingerprint image more smooth, first we can perform the fingerprint image segmentation using variance method, then we can use the above described decision condition. When this algorithm performs segmentation on the fingerprint gray image, we can obtain a very good result of segmentation, which can get ready for the binarization of the fingerprint image in the next step.

### 3.2 The binarization of the fingerprint image

The selection of threshold of a fingerprint image is too difficult to have an unified method. The threshold is usually set according to experience and other factors. The global iterative method is based on the idea of approximation. The improved binarization algorithm is described as following:

For a size of \( m \times m \) image, if the pixel is \( f(x, y) \) and the gray value of it is also \( f(x, y) \), then the average gray value of this image is

\[ T = \frac{1}{M \times M} \sum_{i=0}^{M-1} \sum_{j=0}^{M-1} f(i, j) \]

According to the value of \( T \), all the pixels of the image can be divided into two categories. The set of pixels which is less than or equal to \( T \) is set to \( S_1 \), and the set of
pixels which is larger than $T$ is set to $S2$. Calculate the mean value of the pixels in $S1$ and $S2$ respectively, and we call them $T1$ and $T2$.

$$T1 = \frac{\sum_{i=0}^{f} ini}{\sum ni} \quad T2 = \frac{\sum_{i=f+1}^{t} ini}{\sum ni}$$

Through observing the fingerprint image we can find that: the prospect region has lower mean value because it contains ridge and valley lines of fingerprint, making the variance of the fingerprint image larger. On the contrary, the background region has larger mean value and smaller variance. Then in the interval $[T1, T2]$, we can use the threshold segmentation algorithm to search the optimal threshold for segmentation, thus avoiding the search for the optimal threshold in the whole gray level.

### 3.3 The thinning of the fingerprint image

The position of minutiae and the relative position between minutiae are very important. This paper uses the Sherman thinning methods and OPTA thinning methods, and these two thinning algorithm are the most commonly used. Therefore, this paper adopts Sherman thinning methods and OPTA thinning methods for fingerprint image processing after binarization. There is no improvement of the above methods in this paper.

### 4 Performance test

During operation, the first step is pressing the button 5 twice, switching to the fingerprint input mode. And then press button 4 to input fingerprint. Press the fingerprint such as the right hand thumb, then the LCD display the recording has succeeded. Then record the fingerprint again. Press the fingerprint on the sensor and the LCD display the recording has succeeded and the number of fingerprint such as 001, the buzzer sounds once at the same time. Press button 5 to switch to the fingerprint recognition mode, and then press the right thumb on the sensor. The LCD display the matching has succeeded and the number of fingerprint-001. If you press the left thumb or other people’s thumb, the LCD will display the matching is not successful, and the buzzer will sound three times. The scheme selects 200 people randomly for the test, and these people are divided to 20 groups. The fingerprint of each people will be recorded twice, and we record the same finger in each group. The results of the test are shown in table 1

<table>
<thead>
<tr>
<th>Testers</th>
<th>Fingerprint</th>
<th>Mode</th>
<th>Display</th>
<th>The number of</th>
</tr>
</thead>
</table>

| Table 1. The performance of fingerprint identification system | 456 |
5 Conclusion

The system uses TMS320VC5509 to complete the fingerprint image acquisition and the matching function. There is some improvement in algorithm, and the accuracy of fingerprint identification is improved, which effectively enhance the operational speed of the system. Internal recognition time using this algorithm is less than one second. It is suitable for the recognition of underground coal mine workers, and it can be efficient, accurate, having good value of practical application.
Acknowledgements. At the end of the paper, we thank sincerely, with great respect, to the leaders of education department of Heilongjiang province who trust us during our research and give us a chance to study the fingerprint identification system for underground miners. This is a meaningful work. We also thank headmaster Mr. Ma li-qun, and dean MS Yao zhong-ming, who also give care and support during our research.

References

2. Lijianpo.:Wireless Fingerprint Attendance System Based on DSP. J. 33.9.29(2012)

Project name: Study of underground personnel positioning method based on the background of the weak signal
Project number: 12541873
Project unit: the education department of heilongjiang province