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Decoding of PDF417 Barcode in Identity Authentication based on LabVIEW

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Abstract

Two dimensional barcode had widely applied in identity authentication. In this paper, the symbol structure of PDF417 barcode was introduced, and the image processing methods used in PDF417 barcode recognition were researched. A quick and effective method to calculate the width of the unit module in PDF417 barcode was proposed, and a recognition and decoding system of PDF417 barcode based on software development platform of the LabVIEW virtual instrument was designed and implemented. The system could process and analyze the images containing PDF417 barcode collected by camera in real time, and achieve the fast and omnibearing decoding of the barcode.

Keywords*: PDF417 barcode, decoding, image processing, labVIEW*

1. Introduction

With the informatization and digitization of modern society, it requires more hidden individual identity information and more powerful abilities in automatic identification of the personal information. A technology is urgently needed to process and express the identity information and make it not be obtained and utilized easily by other person. The barcode technology could meet the above requirements. It is one of the most widely used automatic identification technology, which mainly researches how to encode the information and convert the data into characters the computer can read. Its applications have greatly improved the work efficiency, and speeded up the data collection and information processing. The barcode has two types of one-dimensional barcode and two-dimensional barcode. The capacity of 1D barcode is limited and its application has to rely on the database. The 2D barcode can express data in two directions simultaneously, which has high capacity, error correction ability, decoding reliability, and the ability of encryption and can express various information. It is very suitable for automatic identification and data collection [1]. The barcode itself is the concealment of identity information, and the characteristic of 2D barcode's encryption can ensure the data more safety. In addition, 2D barcode can encode the image data, the combination of the identification technology of fingerprint image with 2D barcode can enhance the effectiveness of authentication. How to recognize and decode 2D barcode quickly and accurately was the focal point of such research and the key point for wide application.

PDF417 is one of the most widely used barcode in the world. It is a kind of array 2D barcode with high capacity and error correction ability. PDF means "Portable Data File", each symbol character of barcode stands for a code word in code set, which is made up of 4 bars and 4 spaces, and 17 modules in all, so is named PDF417 barcode. PDF417 barcode has multi rows with variable length. Each barcode symbol can express 1108 bytes, 1850 ACSII characters or 2710 numeric information [1]. The structure of PDF417 barcode was shown in Figure 1. Each row has the same starting and termination characters, their bar and space sequence are 81111113 and 711311121 respectively, In order to separate with the right blank area, a module bar is added after the termination character [2].

PDF417 barcode has three data compression and encoding modes (byte coding mode, number coding mode and text coding mode) to convert the original data into code word of 0~928. These three kinds of encoding modes all have high compression ratio to corresponding original

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data. Each kind of mode has an unique code word of identification, through the mode transformation and locking code words, we could use three modes to encode data in a PDF417 barcode symbol [3].

Figure 1. The Structure of PDF417 Barcode

Figure 2. Gray Barcode Image

PDF417 barcode adopts advanced Reed-Solomon error control algorithm to realize error detection and correction of barcode data. PDF417 has nine error correction levels 0~8, each barcode contains two error correcting code words at least. The highest level contains 512 error correction code words, it could correct 50% error codes [3].

In this paper, the identity information included personal name, gender, birthday and fingerprint feature points were encoded into PDF417 barcode, which was printed on a document used for identity authentication. The method of image treatment in the process of recognition of PDF417 barcode and extraction of the symbol characters were investigated.

LabVIEW was exploited by NI company, which is a highly efficient integrated program development environment based on graphic exploitation, debugging and running, it provides many kinds of development tools for specialized application [4]. Our system recognized and read the PDF417 barcode based on its Vision tools module. IMAQ Vision software package is a function library including image processing, which integrates more than 400 kinds of functions into the LabVIEW development environment and provides complete performance for image processing and pattern recognition [5].

2. Barcode Image Preprocessing

There are two methods to obtain PDF417 barcode image, one is scan-based, the other is by the camera. A camera was chosen to capture barcode images and send them into system. Therefore the image quality would directly impact on the performance of the whole system. There are two types of camera, CCD and CMOS. The output of CCD camera is analog single, a specific circuit is must used to convert analog signal to the digital signal that computer can read. While the sequential circuit and the AD transforming circuit had been integrated on CMOS camera, it can convert the simulate video signal into digital signal output directly, without the extra auxiliary circuit. And the digital signal output by CMOS camera can be sent to the computer by USB, serial or parallel port. So we chose CMOS camera to obtain the PDF417 barcode image.

How to recognize and read a barcode quickly and accurately were the key point for its widely application. A barcode that printed on a document may be polluted, and a captured barcode image would be influenced by environmental noise such as nonuniform illumination, which would make the barcode edge fuzzy. Moreover a collected barcode image may be tilted. These would affect the recognition of barcode. Therefore it needs to preprocess the barcode image before decoding to reduce the outside disturbance. The preprocessing steps included graying, smoothing and noise reduction, image binarization and tilt correction. We used Vision Assistant in LabVIEW to realize the preprocessing course.

2.1. Image Gradation

A barcode image collected by a camera was colorized with many color information, its processing and operation were complex. The color image with red, yellow, blue must be converted into gray image only with brightness. Pixel grayscale in grey image is indicated by a 8bit data which is in between 0 and 255, 0 means black, 255 means white. From 0 to 255, brightness increases gradually [6]. The Color Plane Extraction module in Vision Assistant could extract the brightness part from color image directly. A gray barcode image was shown Figure 2.

2.2. Image Smoothing

The gray barcode image did not remove the noise pollution. In order to improve the identification efficiency, it needed to utilize noise filtering technology to enhance image and outstand the useful properties of the image. The image filter are divided into frequency domain method and space domain method. Vision Assistant's filter toolkit contains Gaussian filter, low pass filter, local average filter and median filter. By the contrast, the effect of median filtering was best, shown in Figure.3.

Figure 3. The Image after Median Filter

Figure 4. Binary Barcode Image

Median filter is a local nonlinear filter that could keep image edge clearly when reducing noise. The basic principle of median filter is that all the pixel grayscale values in a neighbor window in which the pixel is centered are ranked from little to large, and the median value of sequence is taken as the grayscale of the pixel [6]. The square window that contains an odd number of pixels was usually selected. In order to reduce the influence on barcode edge, we selected 3*3 minimum window to filter.

In order to reduce the work load of data treatment and lift the speed of barcode decoding, we could convert barcode image to binary that all pixels only have two-value of 0(black)and 1(white). First, a global threshold t in the image was chosen, then all pixels were divided into two parts according to the formula 1, where f(x,y) was the input function of grayscale image, g(x,y) was the output function of binary image.

$$g(x,y)=\begin{cases}1, f(x,y)>t\\0, f(x,y)\le t\end{cases} \quad (1)$$

Thus the grayscale of pixels greater than t is set as the maximum 1 and the grayscale of pixels less than t is set as minimum 0. Binary image inevitable lost some original information, but PDF417 barcode only has black and white colors, so reasonable binarization was beneficial to barcode recognition. During the binary processing, how to select the threshold of the grayscale t was very important. Vision Assistant contains many threshold segmentation methods, local threshold method such as Niblack method and Background Correction method, and auto threshold method, such as Clustering method, Entropy threshold method, Inter Variance method, Metric threshold method, Moments threshold method.

$$t=\frac{k_1+k_2}{2} \quad (2)$$

k_1 was the average of the grayscales of all pixels between 0 and t, k_2 was the average of the grayscales of all pixels between t+1 and 255 [7]. Binary image after binarization was shown in Figure 4. Obviously, the background of the barcode was filtered out, which would benefit the decoding of barcode.

2.4. Tilt Correction

It was impossible to capture absolutely horizontal PDF417 barcode image, which would influence barcode recognition. Before reading the barcode, the barcode image must be corrected and rotated to horizontal position. Barcode edges were extracted and Hough. Transformation was used to detect straight line in the image and calculated its slope to obtain the tilt angle of barcode.

Vision Assistant provides several typical edge detection algorithms including Laplacian operator, Differentiation operator, Prewitt operator, Sobel operator and Roberts operator. Used the above algorithms to extract the edge of barcode respectively and contrasted the results, the Prewitt algorithm extracted the most clear edge of the barcode. Prewitt edge detection operator used two directed templates, one is level, another is vertical, each template approaches a partial derivative, given in the formula 3.

$$P_V = \begin{pmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix} \quad P_H = \begin{pmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{pmatrix} \tag{3}$$

Two operators were used to do convolution with every pixel in the image respectively, and two matrixes were got. By adding the squares of two numbers of corresponding position in the two matrixes, we could achieve grayscale gradient of every pixel in the image. And the image of barcode edge could be obtained through threshold processing [8].

Hough transformation is a kind transformation from the image space to the parameter space. Its basic principle is to build up a “line-point” duality between the two spaces, so that the problem of straight line detection in the image space could be converted to the one of points detection in parameter space, and then the slope of the line would be achieved by the accumulation of those points [8]. Vision Assistant used the Geometry function in its image module to rotate tilt barcode image to horizontal position, which effect was shown in Figure 5.

Figure 5. Barcode Image after Rotation

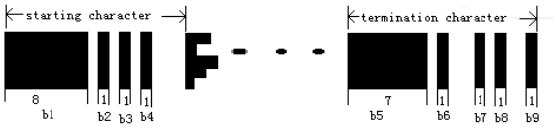

Figure 6. Symbols of Starting and Termination Characters

3. Decoding

At present, there were two kinds of most widely used methods to extract the symbols characters of PDF417 barcode. One was based on barcode’s edge image. The level edge and vertical edge of the barcode image was projected respectively to get the coordinates of divided point, then the symbol characters of the barcode were calculated. Another method was to get the width of unit module in PDF417 barcode, then each barcode layer was divided into separate code words module, from which the corresponding symbol character were calculated [8]. In this paper, the second method was adopted to get barcode’s symbol characters, a quick and effective method to calculate the width of the unit module in PDF417 barcode was proposed.

3.1. The Width of Unit Module

The calculation of the width of unit module in barcode was a key step for barcode decoding. Each row in PDF417 barcode has the same starting and termination characters, their bar and space sequence are 81111113 and 711311121 respectively. In the barcode image, these starting and termination characters both could be regarded as a whole. In the starting and termination characters, except the first bar has 8 and 7 modules respectively, other bars all only have one module. The starting and termination characters were shown in Figure 6.

$$s = \frac{\sum_{i=1}^{9} b_i}{22} \tag{4}$$

So we could use the width of these module bars as the unit module’s width. In order to reduce the error of single measurement, we measured the width of all bars. S stands for the

width of unit module, b1~b9 were the measured width of bars in starting and termination characters, the calculation formula was given in Equation 4.

The particle analysis function in Vision Assistant could detect and analyze particles existing in the image, and output the measurement results. This function would be utilized to measure the width of bars in starting and termination characters, which was shown by the green coil in Figure 7.

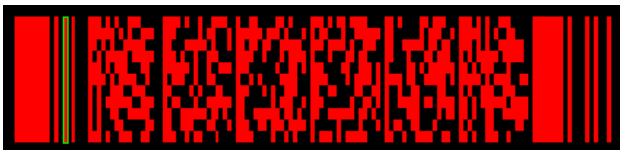

Figure 7. Measurement of the Bar Width

3.2. Data Decoding

PDF417 is a kind of 2D barcode with stacked type, which needs to segment every layer when decoding. The barcode image edge has already been obtained by Prewitt operator. Projected its level edge, the position of barcode level edge could be determined by projection peak. The coordinates of cut-points of barcode layer could be located, which was used to segment barcode image layers directly [8]. The particle analysis function was adopted to measure the width of bars and spaces in every symbol characters. By comparing the width of bars and spaces with the unit module, the bar and space sequence of corresponding symbols characters could be achieved.

By looking up the code word set, bar and space sequence was converted to code word sequence finally. After error detection and correction of the code word sequence, the original identity data were acquired by encoding PDF417 barcode according to the three modes of compression and coding.

4. The Software System and Result

We implemented the identity authentication based on LabVIEW. The system includes barcode image collection, codes reading and data display. We had used a camera to obtain PDF417 barcode picture, written software program on LabVIEW platform to process image, read barcode and show the original identity data. The displayed data included the values encoded into the PDF417 barcode and the time spent to read barcode.

4.1. Capture the PDF417 Barcode Image

Video grab and handle functions in LabVIEW IMAQ Vision module was used to capture the PDF 417 barcode image. The specific program was shown in Figure 8.

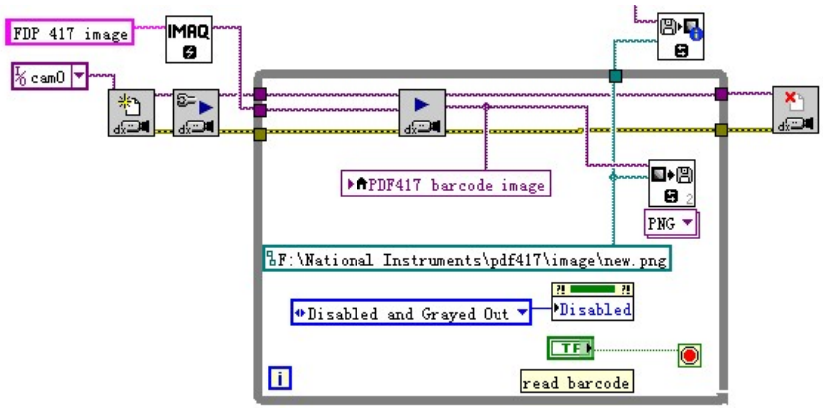

Figure 8. The Program for Capture the Image with Barcode

First, a memory space named PDF417 image was allotted to save video image and IMAQdx Open Camera VI was used to seek the camera connected with computer, and assign the camera a label com0. Second, the IMAQdx Configure Grab VI was utilized to save the video image captured in the buffer. Then program ran into a loop, the IMAQdx Grab VI was linked with a image displaying window named PDF417 barcode image, thus the images saved in buffer can be shown on the window in a real time. Until satisfactory barcode image had been obtained, the reading barcode button was clicked to exit the loop. The collected satisfactory image was shown in the window statically. Simultaneously the image was sent to IMAQ Read Image And Vision Info VI, which could process the image and send the barcode information to the barcode reading VI. The barcode image must be stored in PNG format, because the barcode reading VI could only read an image file with PNG format.

When the video capture was stopped, the IMAQdx Close Camera VI must be used to release the corresponding resources and take back the label that had assigned to camera.

4.2. Barcode Reading

After the PDF417 barcode image was sent into the code reading VI, the IMAQ Read PDF417 Barcode VI in Vision module was mainly used to identify and read barcode. It could read values encoded into a PDF417 barcode and output the data. Our system could achieve the omnibearing decoding of barcode, The specific program for barcode reading was shown in Figure 9.

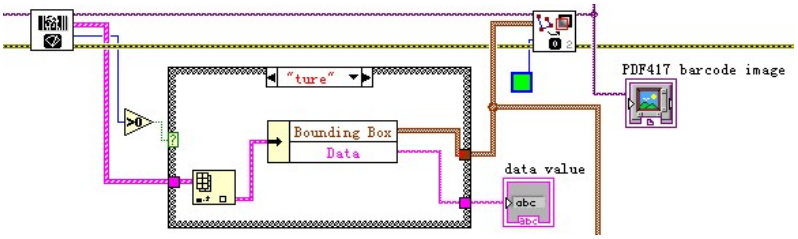

Figure 9. The Program for Barcode Recognition and Reading

After PDF417 barcode in the image being detected, the system entered into true condition selecting structure. Through an index array function, the data values and coordinates of barcode could be separated according to their names. The data values encoded into barcode would be shown on the characters displaying window in front panel. Inputting coordinates of the barcode into the Overlay Multiple Lines VI and choosing certain color line circled out the location of the barcode symbol in image, green line was chosen in our system. If without the PDF417 barcode in image, the program would enter into false condition selecting structure, the system would output error information.

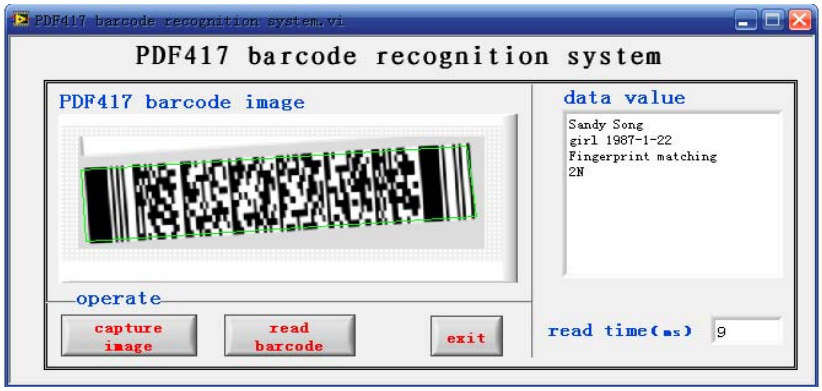

Figure 10. The User Interface of the Identity Authentication System

4.3. User Interface

Frame sequence structure was used in our system. In order to add up the time spent to read PDF417 barcode, we respectively opened a Time Counter in the frame before and after reading the barcode. The difference of two Time Counter in value was the time spent by system to read the barcode, the value was shown in the front panel.

Figure10 shows the user interface of the system. The left is the image collected by a camera, using green lines circling out the FDP417 barcode in image. The right is the original identity data encoded in barcode symbols, under them is the time spent to read barcode.

5. Conclusion

The methods of the image processing and the extraction of symbol characters in the course of PDF417 barcode recognition were investigated, and achieved the identity authentication system based on LabVIEW. For the clear image, the system could complete the recognition and decoding of FDF417 barcode efficiently, and output the user's identify information and the result of fingerprint matching, realizing the identity authentication. LabVIEW also could convert its program to C language and .NET language, which was beneficial to the further research under other development environments.

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