The Recognition System of Machine Parts' Characters Based On Stm32

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Abstract:*Intelligent identification of characters is widely used in many ways, such as license plate recognition, train number identification, container number identification and so on. The recognition system of machine parts' characters is an important component of anassembly line, which can greatly increase the production efficiency.In this paper, the system was designed based on an embedded development platform. The machine parts' imageswere acquired by an ov7670 camera, then they were preprocessed by grayscale changing, denoising, morphological filtering, positioning and segmenting. At last, a template matchingmethod was used to recognize the segmented character blocks. The results were displayedon the LCD in real time.*
Keywords:*Character Recognition, Image Processing, Template Matching.*

I. INTRODUCTION

The rapid development of artificial intelligence has brought profound changes to human life, industry and so many other aspects [1].The recognition system of machine parts' characters is an important component of an assembly line, which can greatly increase the production efficiency. In the past, these characters were identified by human workers.Due to the production environment and personnel operating proficiency, mistakes often happen. So it is an urgent need of industrialto have anautomatic recognition systemwith high accuracy.

Image preprocessing is the basis of machine parts' characters recognition. Many algorithms of it have been matured and practical[2,3,4]. With the development of computer vision and artificial intelligence technology, the method of character recognition is more and more diversified and able to recognize the complex characters. The character recognition accuracy is greatly improved, some algorithms of accuracy can even be better than artificial recognition.However, machine parts' characters havedifferentfonts and different sizes.Sometimes they are illegible and the environmentof plantsis changeable.All these mentioned above bring many difficulties for recognition. So it is needed to design the appropriate algorithm according to the actual situation

In this paper, we focus on realizing a recognition system of machine parts' characters based on STM32. The algorithms are running on the embedded platform. The hardware and software of this system are introduced.

II. Hardware Circuit Design

The hardware circuit comprises main control unit, camera control circuit and display control circuit etc. In the main control unit, the MCU STM32f107 produced by STMicroelectronicsis used. The design takes advantage of STM32f107 peripherals specifically suited for embedded applications. TheVarious Interfaces of the STM32f107 support the needs of this system.The STM32f107 family member is anARM-based 32-bit MCU with 64/256 KB Flash.The STM32f107 provides these key features[5]:

•72 MHz maximum frequency, 1.25DMIPS/MHzperformanceat 0 wait state memory access

•64 to 256 Kbytes of Flash memory

•64 Kbytes of general-purpose SRAM

•2.0 to 3.6 V application supply and I/Os

• 3-to-25 MHz crystal oscillator

• Internal 8 MHz factory-trimmed RC

• Internal 40 kHz RC with calibration

• 32 kHz oscillator for RTC with calibration

• 2 × 12-bit, 1 µs A/D converters (16 channels)

• Up to four 16-bit timers

• Up to 14 communication interfaces with pinout remap capability

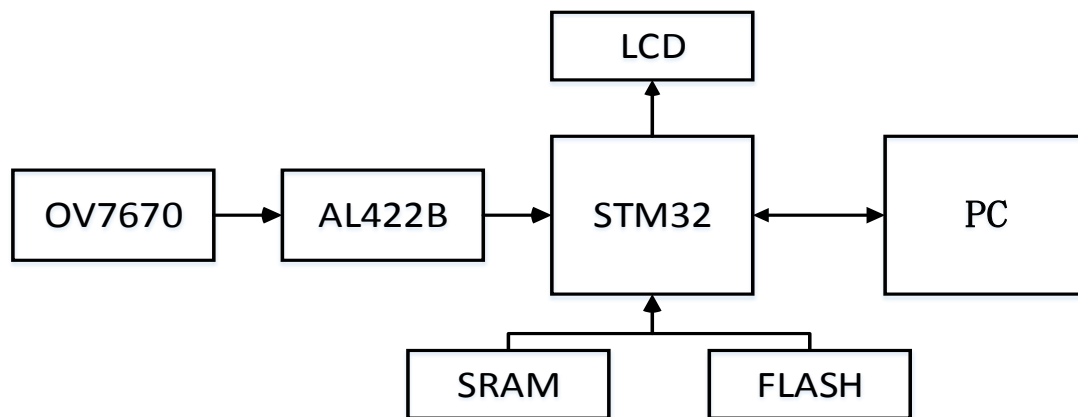The diagram of this circuit is shown in Fig. 2.
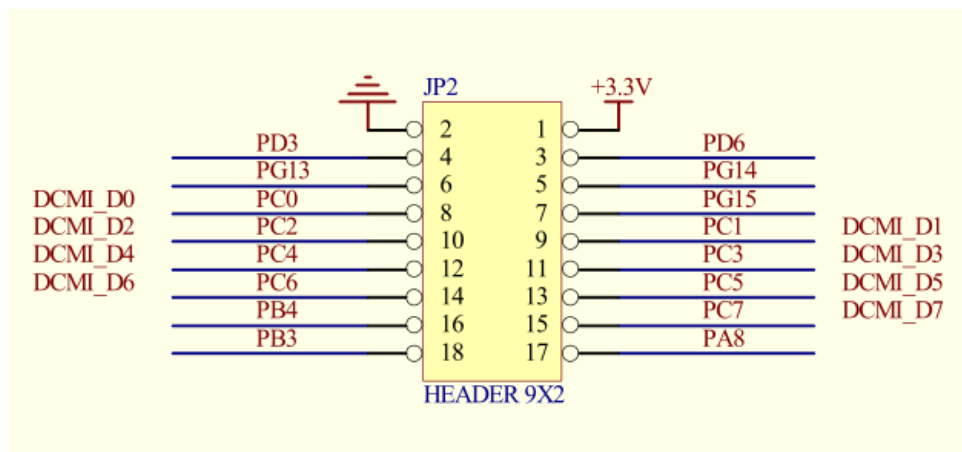

Figure 2. Diagram of circuit

Figure 3. The connection between OV7670 and the main controller

The camera sensor OV7670 has low power consumption and high sensitivity. The main controller can control 8 bits datathrough the SCCB bus, such as the output whole frame, subsampling, and acquisition window. This chip supports RawRGB, RGB (GRB4:2:2, RGB565/555/444), YUV (4:2:2) and YCbCr (4:2:2) output formats and users can fully control image quality, data format and transmission mode. The connection between OV7670 and the main controller is shown in Figure 3.

As OV7670's pixel clock can be up to 24 MHz, it is very difficult to get the image data directly from the IO port of STM3. So the frame buffer AL422B is needed. AL422B is a FIFO memory chip with a storage capacity of 384k * 8bits, enough to store 2 frames of QVGA image data (resolution 320*240). The connectionsbetween OV7670 and AL422B is shown in Figure 4.
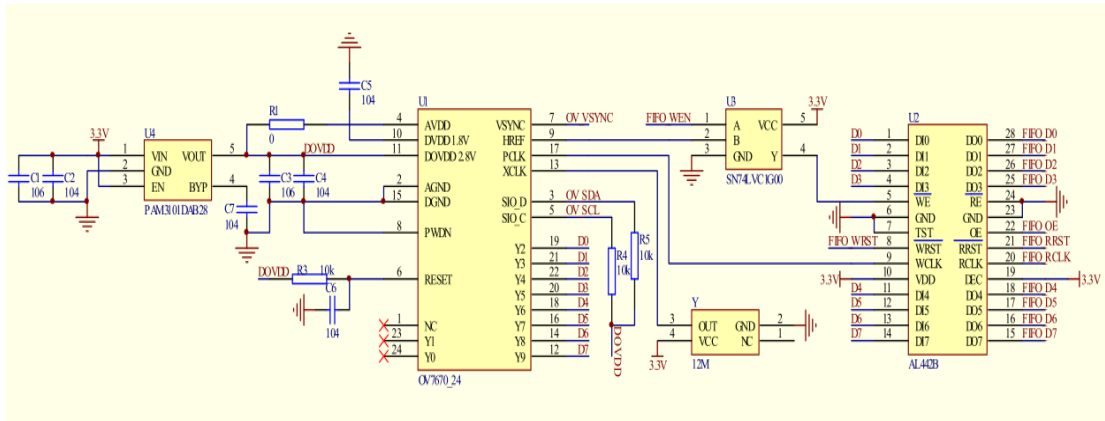
Figure 4. The connection between OV7670 and AL422B

The LCD module was used to display information. It has a 3.2 inch screen, supports 8 or 16 bit data and 320*240 pixels of RGB565. The display circuit is shown in Figure 5.
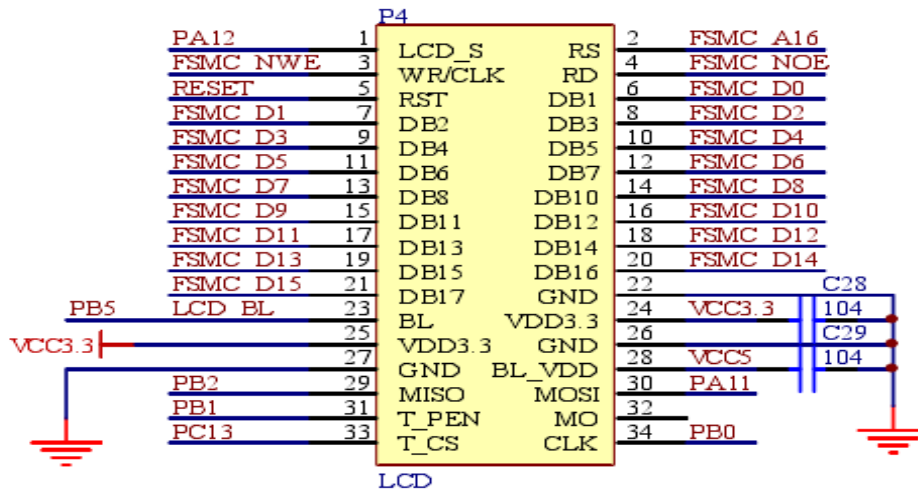

Figure 5. The display circuit

III. SOFTWARE DESIGN

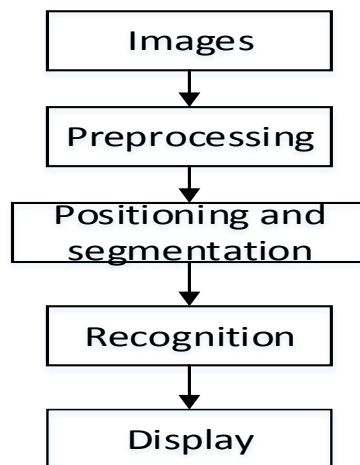The system software includes several modules and the flow is shown in Figure 6.

Figure 6. The softwareflow

Here are a brief introduction to these image preprocessing methods[6, 7].

(1) Image transformation: The image is converted to another space for processing and analysis at first and converted back at last. The commonly used transformations are Fourier transform, wavelet transform, Walsh transform and so on.

(2) Image enhancement: Enhance some interesting features of the image and increase the difference between different features in the image. This procedure can improve the image quality and enrich the information. Image enhancement can be a distortion process with emphasis only on highlighting the characteristics of interest.

(3) Morphological processing: The basic morphological operations of binary images include corrosion, expansion, opening, closing, edge extraction, hit and hit, region filling, refinement, skeleton extraction and morphological gradient extraction.

Image preprocessing is a very important step in the process of character recognition and it will directly affect the accuracy of the following character location, segmentation and recognition.

The OV7670 camera acquires image information in 16 bit color image (RGB565 format) and gets the components of R\G\B separately. For example, the R component takes 5 bits of the 16 bit color data. According to the human eye's perception of different light, the sensitivity of green, red and blue light is reduced in turn. So the algorithm based on human eye perception is used to make grayscale synthesis. This procedure was realized by Formula 1 and 2.

$$Gray = R*0.299 + G*0.587 + B*0.114 \tag{1}$$

$$Gray = (R*76 + G*150 + B*30) >> 8 \tag{2}$$

In the process of generation, transmission and processing, the image quality will be reduced by various noises. The image filtering is the best way to reduce the influence of noise to the target recognition. The spatial domain methods include median filtering, mean filtering, morphological noise filtering and frequency domain methods include high pass filter and low pass filter.In this system, the space domain method is used.

Gray enhancement is to enhance the gray value of the target according to the needs of the target processing. The purpose is to compress the gray value of the background and extend the gray value of the whole image.In this system, the image's overall pixel value is similar with the background. So the pixel difference is enlarged by the method of grayscale stretching. This procedure was realized by Formula 3.

$$DestPixel = 255*(SrcPixel - \min)/(\max - \min) \tag{3}$$

In order to get binary images, different thresholds need to be selectedaccording to the characteristics of the image. Threshold can be divided into global threshold, local threshold and dynamic threshold. In this system, due to uneven illumination in the acquisition environment, local threshold is used.

Because of the influence of parts wear and collecting environment, there are many defects in the characters. It will make the following positioning, segmentation and recognition be difficult.Morphological filtering of the binary images can solve this problem. The selection of structural elements will directly determine the result of morphological filtering.In this system, the structural elements in the open operation should be as much as the number of rows, while the structural elements used for the expansion should be counted as the number of columns.

After getting the character block area, it needs to be positioned and segmented for recognizing. In this system, the improved vertical projection method is used.

Character recognition is the core of this system. The common character recognition methods can be divided into template matching recognition, structure based recognition, and neural network based recognition. In this system, the template matching method was used. Comparing the characters to be recognized with the standard template characters, the most similar template characters are chosen.

The software of MCU is programmed by C in KEIL $\mu Vision5$. The programming IDE is shown in Fig. 7.

Figure 7. Programming IDE

IV. RESULTS

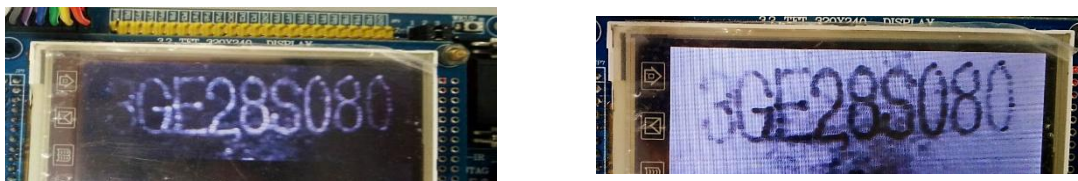The image obtained after the gray level change is shown in Figure 8.

Figure 8. The image obtained after the gray level change

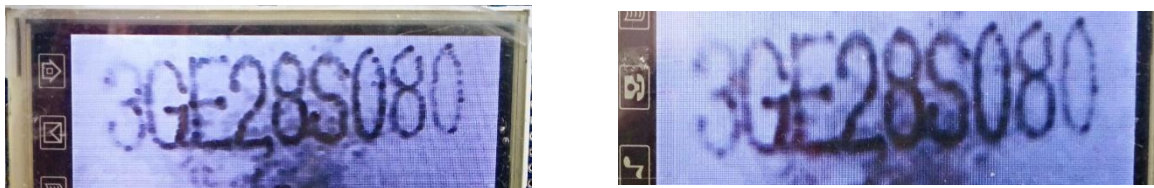The image obtained after average filtering is shown in Figure 9.

Figure 9. The image obtained after average filtering
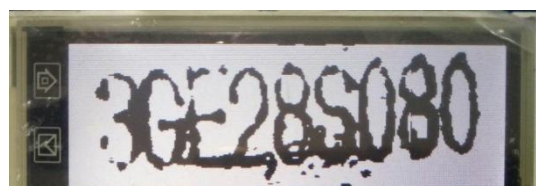
The binary image is shown in Figure 10.

Figure 10. The binary image

The image obtained after morphological filteringshown in Figure.

Figure 11. The image obtained after morphological filtering

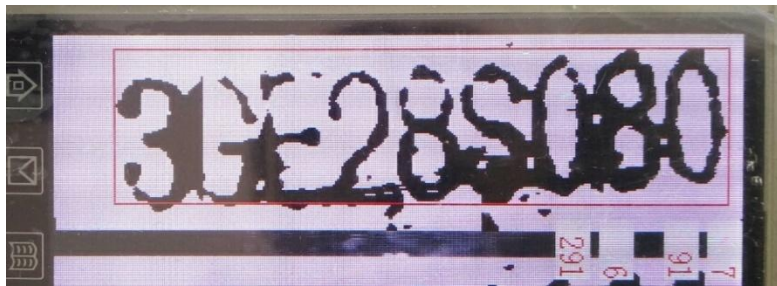The positioning and segmenting result is shown in Figure 12.

Figure 12. The positioning and segmenting result

The recognition result is shown in Table 1.

Table 1. The recognition result

All characters	Right results	Right Ratio
144	142	98.6%

V.   Conclusion

In this paper, the vertical projection method is improved in character segmentation and can accurately separate characters with different size, sticky and broken points. The recognition result shows this system achieved the purpose. Some other algorithms[8] will be tested in this platform and combined with the coding principle of machine parts' characters in order to improve the recognition accuracy.

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