

# Research of Embedded Handwritten Alphanumeric Recognition System

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**Abstract.** With the growing maturity of Internet of things, more and more hardware devices are developing towards intellectualization. Handwriting plays an increasingly important role in people's lives. However, due to the different writing habits, the character shape varies greatly. At present, the recognition effect scanners, mobile robots and other devices for handwritten characters is difficult to meet the needs. In this context, a handwritten alphanumeric string recognition system based on embedded development platform is developed. S3C2440 development board is selected as the hardware platform. OpenCV is used for image processing, and support vector machine (SVM) classification technology is used to realize the recognition of handwritten letters and digits. The system has the advantages of low power consumption and less memory consumption. It can be transplanted to various embedded devices to quickly identify handwritten alphanumeric strings and provide services for users in many fields such as mail sorting, report statistics and so on.

**Keywords:** Handwritten Recognition; Alphanumeric String; Support Vector Machine; OpenCV.

## 1. Introduction

With the maturity of embedded technology, Image recognition plays a very important role in the construction of smart city. From smart wearing equipment to smart phones, to smart cars, biometrics, traffic security and other applications are inseparable from image recognition technology. Handwritten alphanumeric string recognition is an important branch of image recognition technology. It is a very extensive research field to make the program have memory function by "learning" and make the device complete the task of image classification and recognition instead of human. Because the letters and numbers used in life are different in shape, size and many other aspects, the existing OCR-based system has the disadvantages of high-power consumption, large volume and large amount of calculation, which does not conform to the characteristics of embedded intelligent devices with low power consumption and small memory. In this context, based on machine learning technology, we develop an embedded OCR system.

## 2. System Design

### 2.1 System Architecture

The system mainly consists of five functional modules: input module, image preprocessing and segmentation module, image feature extraction module, training and recognition module, Speech module. The system functional module is shown in Figure 1.

### 2.2 Input Module

According to different usage scenarios, the input module supports handwriting input and picture input. The handwriting input module mainly uses the touch screen of the embedded development board and the driver of the touch screen assembled. This system provides the user with a handwritten input box, the user uses a handwritten pen and other tools to write numeral English alphabet string, after writing, the system will write the writing area in the form of pictures to be saved and handed over to other modules. For the picture input mode, the verification code recognition and the picture

content extraction are mainly designed. Therefore, the function of this module is mainly to provide the human-computer interaction way, and provides the input way.

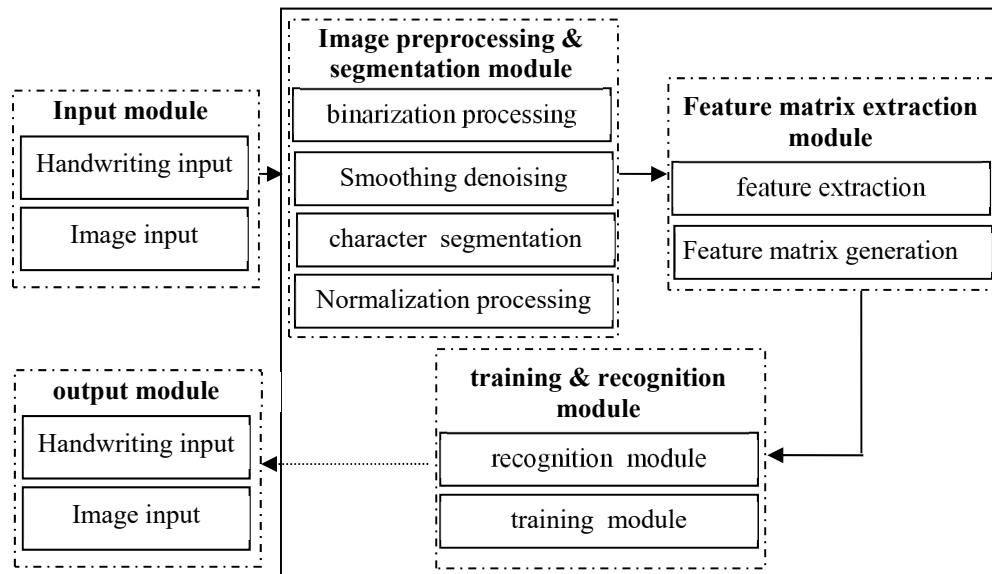


Fig. 1 System function module diagram

### 2.3 Image Preprocessing and Segmentation Module

The image pre-processing provided by the input module mainly includes image bit depth conversion, image smoothing, filtering and denoising, character cutting, normalization and so on, so that it can be more suitable for feature extraction and image recognition. After a series of processing operations, the most representative shape of the image is retained, and the noise that affects the image quality and the small value of the blank area will be removed. After that, the system will use the machine vision library OpenCV to process each image more carefully, including Gaussian blur, threshold processing and so on.

The image preprocessing part is mainly used to deal with the images input by the user, including binarization, smoothing and denoising. After the initial processing, the characters are cut and the pictures are cut into several pictures containing only one character for feature extraction and recognition.

### 2.4 Image Feature Extraction Module

After the image preprocessing and character segmentation are completed, the image feature extraction process is entered. The main method of feature extraction is to extract HOG features from each unit of the image, calculate the eigenvalues for each region, and then connect the HOG features extracted from all regions in series to get the whole image HOG eigenvalue description matrix, which is the feature vector used in the final classification.

After image preprocessing and character segmentation, the invalid blank part of the image is removed, and the size of the image is eventually unified. At this time, the image has met the requirements of qualified samples as feature extraction. The main implementation of feature extraction is pseudo code.

```

begin
Create HOG feature result array
Set the length of the block is 16, the cell edge length is 8, and the calculated direction is 9
while sample != NULL
Create sample matrix for storing HOG characteristics of samples
Calculate feature dimension based on image size
Calculate HOG features of input images
Store the calculated HOG features to the sample matrix
Store the image label value in the tag array

```

```
endwhile  
end
```

## 2.5 Training and Recognition Module

The training function of this system firstly loads the picture information, then transfers the training parameters to the system, including the total number of categories, and then integrates all the training sample eigenvalues according to the extracted eigenvalues of each image and their corresponding labels, and finally saves them in an XML file. The image recognition function first extracts the features of the image to be recognized, and then compares them with the features in the XML file to find the closest value. If the value does not meet the pre-set recognition threshold, the image is rejected.

In order to realize the function of image training and recognition, the SVM classifier should be created firstly, and then the training parameters of the SVM classifier, including the penalty factor and regression parameters, should be determined. The training samples are each feature vector in the feature extraction module's HOG array. The classifier is trained by using the feature vector array and the corresponding label of each feature vector. The training results are saved in the XML file according to the SVM classifier format. After training, the input image can be predicted, where the prediction is usually referred to as recognition. First, the image that the user needs to recognize is read in, and then the image is processed as the same standard as the training image. Then the HOG characteristic matrix is calculated and stored in the same sample array as above. Then the HOG feature can be recognized. Finally, the output of the prediction is displayed on the display screen.

## 2.6 Speech Module

Speech playback function is mainly to play out the results by Speech after recognition, which is another output mode relative to the display screen output. Using audio playback instead of text interface facilitates the user's needs, improves the sense of experience, and makes the system can be extended to other devices to run. The Speech module first finds the corresponding audio file according to the recognition result, and then controls whether to play it or not by the user.

# 3. Experiment

## 3.1 Experimental Environment

The purpose of the system is to design a handwritten alphanumeric string recognition system which combines hardware and software. Compiling and debugging are completed on PC. The final development goal is to run the recognition system on ARM development board.

This development uses the Linux kernel-based sub-system CentOS operating system with a graphical interface. In the CentOS system, we need to install the user graphical interface development tool QT Creator 4 and above, and transplant the machine vision library OpenCV. In order to realize the cross-compilation system, we need to download and install the ARM-Linux cross-compiler. At the same time, we also need to install the Telnet remote login tool and FTP file transfer system. The hardware includes S3C2440 motherboard, display screen, touch screen, stylus and matching data transmission line. The idea of this system is to compile the developed system into binary files which can be executed on ARM development board by using cross compiler on PC, and then connect PC with development board by using network connection line and serial port line, and then compile OpenCV library through ARM-Linux cross compiler to generate library text suitable for ARM development board. Piece. Through FTP file transfer system, the compiled OpenCV library, executable files and resource files needed for running are downloaded to the specified directory of the development board. Then Telnet is used to log on to the development board terminal remotely and run in the mode of loading QT running environment.

### 3.2 Experimental Scheme

In order to ensure the quality of feature extraction, the system needs to do some preprocessing on the image and segment the image containing alphanumeric string into a single character image. The effect of image processing is observed and analyzed, and the image quality before and after processing is compared. The pre-processed image is used for feature extraction, and the extracted image eigenvalue matrix is stored in XML file in a certain format. Check the extracted feature values to ensure the effectiveness of feature extraction.

Training classifier requires a large number of handwritten pictures. The system uses the classic MNIST handwritten picture set. Firstly, a large number of handwritten digits and alphabetic pictures are used in the set of pictures. After the training, a large number of other handwritten digits and alphabetic pictures without training are used to test the system in batches, and the overall recognition rate of the system is obtained.

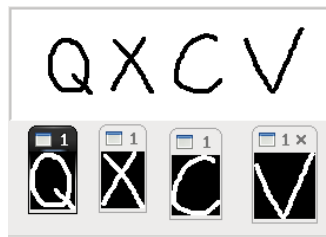


Figure 2. Result of Character segmentation

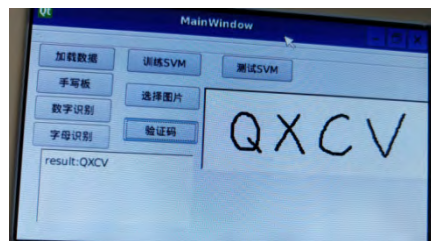


Figure 3. Recognition result of handwritten alphabet strings

### 3.3 Experimental Results and Analysis

For the handwritten string "CVQX", the system after preprocessing and cutting the letter string, the effect is shown in Figure 2. As can be seen from the picture, the picture containing four letters has been changed into four pictures containing only one letter after color reversal, cutting and other processing.

The system can correctly recognize the handwritten alphanumeric string "QXCV" with different line sizes, as shown in Figure 3. By testing 10000 handwritten characters, the correct rate of test is 98%. Correct recognition results are obtained for the handwritten alphabet and numeric strings which are neatly written. For the verification code, pictures with background color are also recognized the correct results, individual character recognition errors, such as the letter O misread the number 0, later need to increase the training library for system improvement.

## 4. Conclusion

Based on ARM-Linux embedded development platform, this paper studies the recognition technology of handwritten alphanumeric string, and designs and implements the recognition system of handwritten alphanumeric string. This system uses an SVM classifier suitable for embedded development platform to cooperate with HOG feature extraction method. This combination method makes use of SVM to compare with other classifiers has the characteristics of small amount of calculation and small sample size. It combines with the advantages of high background and target region recognition when HOG extracts features, and can ensure the recognition rate at the same time.

A large number of tests show that the recognition of handwritten letters and numbers by SVM combined with HOG feature extraction meets the basic requirements of embedded platform.

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