

Design and Development of Mobile Terminal Application Based on Android

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Keywords: android, mobile terminal, design and development, OCR application

Received: February 15, 2022

This article addresses the design and development of mobile terminal application based on Android. This paper proposes the design and development of character recognition system application based on Android platform. The implementation process of image acquisition module, image clipping module, image preprocessing module, character recognition, recognition history display module and recognition result post-processing module is introduced in this article. This article presents the method of character training by Tesseract. By using the training tool based on LSTM (long short - term memory) neural network to train the sample set, a specific character training set is obtained, and OCR (optical character recognition) can be used in specific occasions. The function and performance of the system are tested, and the experimental results are analyzed. After the whole OCR system is built and deployed, the operation and completion of the whole OCR system can be understood through the test and analysis of system functions. It can be seen from the test results that the average response time of text images in pure English is the fastest. The response time of text images in pure Chinese is the second, and the slowest is the mixed arrangement of Chinese and English. For pure English text images, the character recognition accuracy is about 90%, and for pure Chinese text images, the recognition accuracy is close to 90%. However, for the mixed arrangement of Chinese and English, the accuracy of character recognition is lower than that of pure Chinese and English. The accuracy of most commercial character recognition software is about more than 90%. Except for the mixed arrangement of Chinese and English, other products can basically achieve the accuracy of general commercial character recognition software. The product has certain practicability and can be applied to recognize text images taken in natural scenes in daily life.

Povzetek: Članek predstavi novo aplikacijo za prepoznavanje znakov na platformi Android. Z uporabo LSTM nevronske mreže in OCR je izboljšana natančnost prepoznave angleških in kitajskih znakov.

1 Introduction

With the growth of wireless network coverage year by year and the continuous increase of mobile terminals, the number of mobile Internet users has increased rapidly. Mobile phones have not only met simple communication functions for people, but also developed into a tool with internet access, music, video, games and other functions [1]. At the same time, with the rapid development of mobile Internet, the amount of data used by mobile clients is gradually approaching the PC end, and the main thrust of this phenomenon should be attributed to the rapid development of mobile app applications [2]. Moreover, the coverage of WiFi has been continuously expanded, which also provides a larger platform for the development of APP applications on the mobile terminal, which has always been a limitation that the PC terminal is difficult to surpass [3]. OCR (optical character recognition), which means optical character recognition, is a process of obtaining text and layout information through a series of decomposition processing of text image files [4]. Specific to the scene, it is to automatically identify and

input your business card, ID card, driver's license and bank card into terminals such as computer or mobile phone through scanning, eliminating the process of manual input. Due to the shift of the consumer market to mobile terminals, more than 60% of the data in the future will come from smart mobile terminals such as mobile phones and tablets. Smart camera has become the main entrance of data acquisition. More unstructured data needs to be transformed into retrievable data at the front and back. This transformation process requires OCR technology to show its skills. However, the fundamental way of the current mobile phone OCR system is to use the mobile phone to capture images, compress the images, transmit them to the background server through the network, recognize characters and return the corresponding results. However, with the improvement of mobile phone performance, the captured images will be more and more fresh, and the image size will gradually increase [5]. If the original image is transmitted directly without compressing the image, it will lead to large traffic consumption and prolonged network transmission; If the image is compressed, some

information will be lost, and the compression algorithm itself has a certain time consumption. At the same time, this method depends on network connection, not strictly mobile phone-based OCR system. The overall process of OCR system is shown in Figure 1. With the rapid improvement of the computing power of mobile intelligent terminal, the feasibility of using the computing power of mobile terminal to complete picture

preprocessing, feature extraction and character recognition at the terminal is gradually improved [6]. In this way, the image compression and transmission process can be avoided, there is no network transmission delay, and it can be independent of the mobile network.

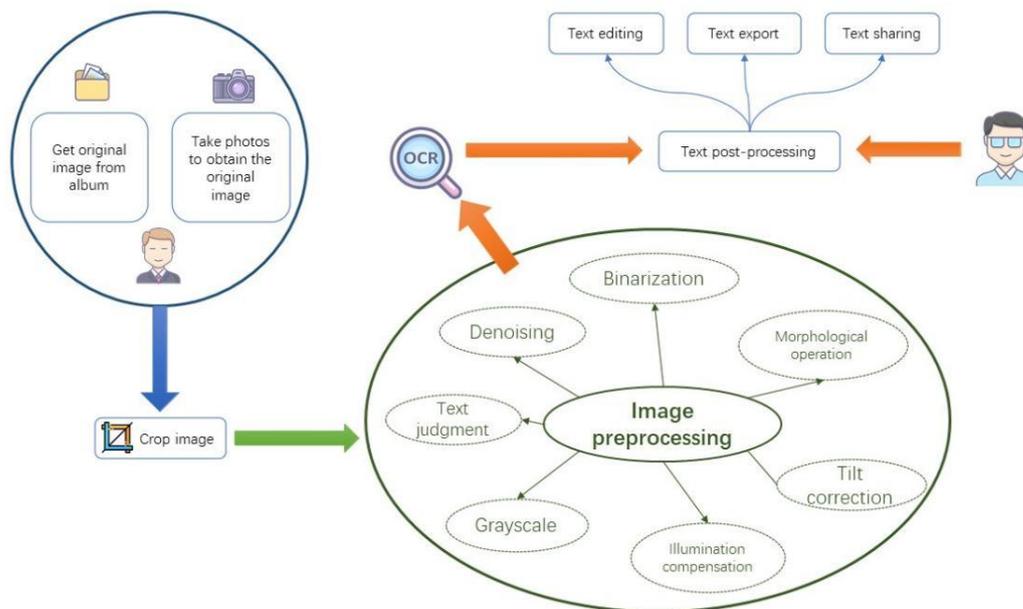


Figure 1: Overall process of OCR system.

At the same time, feature extraction and character recognition are carried out on the original image, resulting in less information loss and higher OCR accuracy [7].

This article addresses the design and development of mobile terminal application based on Android platform by proposing a design and development of character recognition system application. The implementation process of image acquisition module, image clipping module, image preprocessing module, character recognition, recognition history display module and recognition result post-processing module is introduced. The article presents the method of character training by Tesseract. By using the training tool based on LSTM (long short - term memory) neural network to train the sample set, a specific character training set is obtained, and OCR (optical character recognition) can be used in specific occasions. The function and performance of the system are tested, and the experimental results are analyzed. After the whole OCR system is built and deployed, the operation and completion of the whole OCR system can be understood through the test and analysis of system functions. It can be seen from the test results that the average response time of text images in pure English is the fastest. Except for the mixed arrangement of Chinese and English, other products can basically achieve the accuracy of general commercial character recognition software. The product has certain

practicability and can be applied to recognize text images taken in natural scenes in daily life.

The rest of this article is arranged as: Literature review is presented in section 2 and the methods discussing the traditional character recognition algorithm, tesseract recognition algorithm, image acquisition, clipping and preprocessing, recognition and text post-processing is presented in section 3. Results and analysis are presented in section 4 followed by conclusion in section 5.

2 Literature review

To solve this problem, Xu *et al.* studied the design and development of intelligent webcam application based on Android platform [8]. Wang *et al.* found that Android is an open software system containing many source codes. Its system architecture is divided into four levels [9]. The software named wavesecure launched by Feng, is a mobile phone security protection software, which is specially used to backup and restore data on a variety of devices, so that the important data in the user's mobile phone can be fully protected [10]. Cai *et al.* studied a mobile device management solution, which mainly manages and configures enterprise mobile devices and employees' own mobile devices based on roles, and ensures the security of enterprise content stored in the devices [11]. Ameigeiras *et al.* studied and analyzed that text secure is an application software for SMS encryption of mobile terminals, which provides SMS encryption,

SMS session encryption and other functions [12]. Lin *et al.* found that Twitter has opened the source code of the project on git hub. The application uses a combination of symmetric encryption algorithm and asymmetric encryption algorithm to protect the transmitted data, which has good security [13].

Cao *et al.* found that Twitter uses digital signature technology to ensure the non-repudiation of data. Although the application software enhances the security of short message communication between individual users and enterprise users, it can only encrypt short messages and short message sessions, and cannot provide more comprehensive protection for data and devices in mobile terminals. Therefore, it also has limitations that cannot be ignored [14]. Xin *et al.* proposed a file remote data backup system on Android platform based on the research of remote-control technology [15]. Zhang proposed a remote security management model of Android mobile terminal based on RFB (remote frame buffer) protocol, which can support remote opening of camera, recorder, Bluetooth, positioning device, erasing data and other functions. However, this protocol is a thin client protocol, so that the service platform cannot monitor the client status [16].

Based on the current research, this paper proposes the design and development of character recognition system application based on Android platform. The implementation process of image acquisition module, image clipping module, image preprocessing module, character recognition, recognition history display module and recognition result post-processing module is introduced in detail, and the implementation algorithm is analyzed. The method of character training by Tesseract is introduced. The training tool is used based on LSTM neural network to train the sample set, a specific character training set is obtained, and OCR (optical character recognition) can be used in specific occasions. The experimental results show that the system can quickly carry out image preprocessing and character recognition by relying on gradually powerful mobile computing resources, and efficiently complete the character recognition task at the mobile end.

3 Research methodology

This section includes the discussion of adopted methodology of character recognition algorithm and image acquisition and recognition module.

3.1 Traditional character recognition algorithm

Pattern recognition can recognize the target object through two machine learning methods: supervised learning and unsupervised learning [17]. Supervised pattern recognition classifiers need to judge the results based on a priori known conditions, that is, through known labels; The similarity classifier, which does not use a priori known conditions to train the character set, but expresses the results according to a set of feature vectors, is an unsupervised pattern recognition classifier. Template matching is one of the simplest pattern

recognition algorithms. It is often used to find sub image regions that are the same or highly similar to the template image from an unknown image according to the predefined template image in image processing. Therefore, template matching requires two inputs, one template image and the other is the target image to be detected [18]. Template matching uses the calculation method based on image pixel similarity, which is easy to be affected by illumination intensity and object geometric distortion, and has high accuracy only when the brightness and resolution are constant and there is no geometric distortion. The template matching methods based on pixel calculation include the following 6 kinds.

TM_SQDIFF square difference:

$$R(x, y) = \sum_{x', y'} (T(x', y') - I(x + x', y + y'))^2 \quad (1)$$

TM_SQDIFF_NORMEND normalized squared difference:

$$R(x, y) = \frac{\sum_{x', y'} (T(x', y') - I(x + x', y + y'))^2}{\sqrt{\sum_{x', y'} T(x', y')^2 \cdot \sum_{x', y'} I(x + x', y + y')^2}} \quad (2)$$

TM_CCORR relevance:

$$R(x, y) = \sum_{x', y'} (T(x', y') \cdot I(x + x', y + y')) \quad (3)$$

TM_CCORR_NORMEND normalized correlation:

$$R(x, y) = \frac{\sum_{x', y'} (T(x', y') \cdot I(x + x', y + y'))^2}{\sqrt{\sum_{x', y'} T(x', y')^2 \cdot \sum_{x', y'} I(x + x', y + y')^2}} \quad (4)$$

TM_CCORREFF correlation factor:

$$R(x, y) = \sum_{x', y'} (T'(x', y') \cdot I'(x + x', y + y')) \quad (5)$$

TM_CCORR_NORMEND normalized correlation factor:

$$R(x, y) = \frac{\sum_{x', y'} (T'(x', y') \cdot I'(x + x', y + y'))^2}{\sqrt{\sum_{x', y'} T'(x', y')^2 \cdot \sum_{x', y'} I'(x + x', y + y')^2}} \quad (6)$$

3.2 Tesseract recognition algorithm

Recurrent neural network RNN is a kind of neural network used to process sequence $X^{(1)}, \dots, X^{(T)}$, which can be extended to longer sequences. However, the gradient of RNN tends to disappear after many stages of propagation. Even if we assume that the cyclic network

parameters are stable, the difficulty of long-term dependence comes from the weight smaller than the index of short-term interaction. In theory, RNN can deal with long-term dependence problems, and people can carefully select parameters to solve the most primary form of such problems, but in practice, RNN can certainly not successfully learn this knowledge. RNN cannot process sequences with a long distance because the gradient is likely to disappear during training, that is, exponential reduction is likely to occur during training through formula (7), so that RNN loses its ability to perceive distant times [19].

$$\frac{\partial E}{\partial W} = \sum_t \frac{\partial E_t}{\partial W} = \sum_{k=0}^t \frac{\partial E_t}{\partial net_t} \frac{\partial net_t}{\partial s_t} \left(\prod_{j=k+1}^t \frac{\partial s_t}{\partial s_k} \right) \frac{\partial s_k}{\partial W} \quad (7)$$

Because RNN has the problem of gradient disappearance, Tesseract introduces LSTM algorithm as the neural network structure for training and recognition. LSTM (long short-term memory) is a long-term and short-term memory network. It is a time recursive neural network, which is suitable for processing and predicting important events with relatively long interval and delay in time series. LSTM is a special RNN, which can learn long-term dependent information. LSTM has achieved great success in many applications, such as unconstrained handwriting recognition, speech recognition, handwriting generation, machine translation, image title generation and parsing. LSTM is different from a single neural network layer.

The structure of the repetitive network module of LSTM is much more complex. It realizes three gate calculations, namely forgetting gate, input gate and output gate. Each gate is responsible for different tasks, and the forgetting gate is responsible for determining how many cell states from the previous time to the current time [20]. The input gate is responsible for determining how much current time input is reserved to the unit state of the current time; The output gate is responsible for determining how many outputs the unit state has at the current time. In addition to the external RNN cycle, LSTM also has an internal "LSTM cell" cycle. Therefore, LSTM is not a gating unit system with simple affine transformation of input and loop units and element by element nonlinearity. Similar to ordinary loop networks, each unit has the same input and output, but also has more parameters and control information flow. The most important component is the state unit $S_i^{(t)}$. the self loop weight is controlled by the forgetting Gate $f_i^{(t)}$, and the sigmoid unit sets the weight to a value between 0 and 1. The forgetting gate formula is shown in equation (8).

$$f_i^{(t)} = \sigma \left(b_i^f + \sum_j U_{i,j}^f x_j^{(t)} + \sum_j W_{i,j}^f h_j^{(t-1)} \right) \quad (8)$$

Where $X^{(t)}$ is the current input vector, h^t is the current hidden layer vector, and h^t contains the outputs of all LSTM cells. B^f, U^f, W^f are offset, input weight and cycle weight of forgetting gate respectively. Therefore, the internal state of LSTM cells is updated in the way of formula (9), in which there is a conditional self-ring weight $f_i^{(t)}$.

$$S_i^{(t)} = f_i^{(t)} s_i^{(t-1)} + g_i^{(t)} \sigma \left(b_i + \sum_j U_{i,j} x_j^{(t)} + \sum_j W_{i,j} h_j^{(t-1)} \right) \quad (9)$$

Where, b, U and W are the bias, input weight and cycle weight of forgetting gate in LSTM cells respectively. The external input gate unit $g_i^{(t)}$ is updated in a manner similar to the forgetting gate, but has its own parameters, as shown in equation (10).

$$g_i^{(t)} = \sigma \left(b_i^g + \sum_j U_{i,j}^g x_j^{(t)} + \sum_j W_{i,j}^g h_j^{(t-1)} \right) \quad (10)$$

The output h_i^t of LSTM cells (see equation (11)) can be closed by the output gate q_i^t (see equation (12)).

$$h_i^{(t)} = \tanh(s_i^{(t)}) q_i^{(t)} \quad (11)$$

$$q_i^{(t)} = \sigma \left(b_i^0 + \sum_j U_{i,j}^0 x_j^{(t)} + \sum_j W_{i,j}^0 h_j^{(t-1)} \right) \quad (12)$$

Where b^0, U^0, W^0 are the cyclic weight of offset, input weight and forgetting gate respectively. LSTM network is easier to learn and rely on for a long time than simple cyclic architecture, which is very suitable for optical character recognition of long sequences.

3.3 Image acquisition module

The image acquisition module is used to obtain the text image to be recognized. There are two ways to obtain the text image. It mainly completes the task of text image through the two sub modules of obtaining the original image through photo album and photographing. The function of photo album to obtain the original image is realized by the photo album calling interface of Android system. Taking photos to obtain the original image is to obtain the image by taking photos with the camera provided by Android. The image acquisition module is the basis for the operation of the whole software.

After entering the system, the user first needs to select the image acquisition method. The original image obtained from the album of the system is the default interface to enter the system. The text image in the album is loaded in the interface. By selecting the photographing mode in the column at the bottom of the system, the source image can also be obtained by photographing.

Only through the image acquisition module can the next step of image preprocessing and image recognition [21].

3.4 Image clipping module

The original image selected by the user may contain non text areas. The main function of the system is to recognize characters. Therefore, the non-text areas need to be cropped and the text area ROI of interest to the user is selected, so as to reduce unnecessary calculation during later image processing and recognition, so as to improve the accuracy of character positioning and recognition. The implementation part of the system is that the user cuts out the text area manually.

The clipping module mainly includes clipping, image rotation, clipping region scaling and clipping region moving functions. Clipping is used for the user to manually select the text area of interest through block diagram selection [22]. Rotation is used to deal with large angle text tilt. It mainly aims at the image rotation greater than 90 degrees caused by the photographing angle, and realizes the function of 90 degrees rotation of the image after cutting. For the inclined image less than 90 degrees, the image needs to be corrected by tilt correction. The image zoom function is to zoom in and out the image of the clipping area; Picture movement is to move the position of the background original image of the clipping area, and fine tune the user's clipping area through the movement function.

3.5 Image preprocessing module

The input image of the image preprocessing module is the Bitmap image after image clipping by the image clipping module, and the output end is the bitmap format image after graying, illumination compensation, filter denoising, binarization, tilt correction and morphological operation. The function code of the picture preprocessing module is implemented on the recognition page. After the user clicks the character recognition button, the image preprocessing module is called for pre-processing. Because image preprocessing is a time-consuming operation, if it is operated directly on the main identification interface, the system will get stuck and even the program will not respond and crash. In order to solve this problem, the system uses the asynchronous call mode of Handler+Looper+Message Queue in Android to process the time-consuming operation of the image processing module. Asynchronous processing sub threads mainly do some time-consuming operations. After the sub thread completes the operation, it sends a message to the main thread. The system communicates between the sub thread and the handler in the main line through the message circulation mechanism. The specific work is that the sub thread sends a message after completing the time-consuming operation, and the handler refreshes the UI on the main thread after receiving the message, so as to avoid the user interface getting stuck and unresponsive due to the time-

consuming preprocessing process in the background. In this paper, events related to the user interface in Android asynchronous tasks will be handled by the main thread. In the Android system, the UI interface of the system needs to be updated through the main thread. In order to avoid blocking the main thread of the operation interface, this paper processes time-consuming tasks such as image preprocessing and character recognition in the background by opening a new thread [23].

3.6 Image recognition module

The input end of the image recognition module is the output image preprocessed by the background image, and the output end is the structured text information after character recognition. If the identification module is called in the main thread, the system will crash if the waiting time of the main thread is too long. Therefore, the background of the system also needs to adopt the asynchronous call mode of Handler+Looper+Message Queue to deal with the time-consuming operation of the character recognition module. The interface of the character recognition module mainly uses the material design control Floating Action Button, which can easily realize the effect of floating buttons. For floating buttons, you can set the transparency and color of buttons. For the selection of recognition text, this paper uses the spinner drop-down box button to realize the recognition text. The recognition text can choose to recognize Chinese and English.

3.7 Text post-processing module

This module is used for post-processing the recognized text, mainly for correcting the misrecognized text in the source text image. The text post-processing module includes the functions of text original image comparison and correction, text editing, text copying, exporting text, sharing and so on. The proofreading function is to load the processed gray-scale image. In the same activity, the user can edit and change the original image. Exporting the text can help the user export the recognized text into PDF format. The text can be saved on the user's computer and shared with friends to help friends with text recognition. The text post-processing module is developed based on the Android native API. The whole implementation interface of the text post-processing module is simple and easy to use.

The system implementation flow of character recognition module is shown in Figure 2. For the function realization of the core module of character recognition, this paper uses Tesseract recognition engine to realize the function of character recognition, and calls Tesseract through JNI to realize the complete character recognition function of the image in the form of bitmap at the input and string characters at the output.

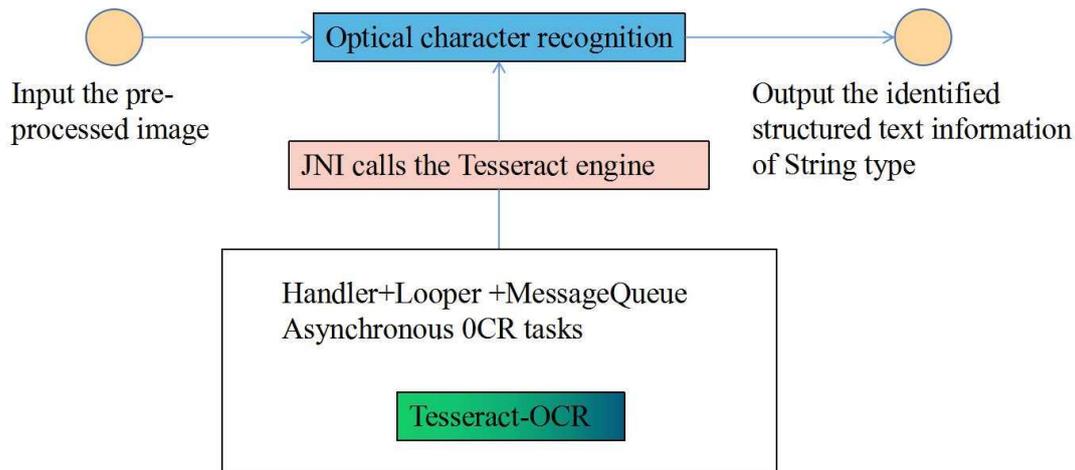


Figure 2: OCR implementation process.

4 Results and analysis

The function and performance of the system are tested, and the experimental results are analyzed. After the whole OCR system is built and deployed, the operation and completion of the whole OCR system can be understood through the test and analysis of system functions.

4.1 System test environment

The OCR character recognition application based on Android needs the support of the camera, so it cannot continue to use the virtual Android machine in the Android Studio development environment for testing. The application needs to support two ways: photo album and photographing to obtain the text source image to be recognized. The application is aimed at ordinary Internet users. The software running environment is determined through analysis, including hardware environment and software environment. The specific test running environment of the system is shown in Table 1.

Software / Hardware	Version / Configuration
Operating system	Android 7.0
Database	SQLite
Image processing	Open CV 3.2
Recognition engine	Tesseract 4.0
CPU	Qualcomm Snapdragon 835
RAM	6G
ROM	128G
Camera	21 00W
Resolving power	1080*1920

Table 1: Test environment

4.2 Function test

The system function test is mainly to verify whether the system can run the application normally and stably, whether each functional module can run normally, whether the data obtained by the system is accurate, and

whether the speed of system image processing and the accuracy of character recognition meet the design requirements. After the development of each functional module of the system is completed, we have deployed the character recognition system in the above operating environment. First, install the character recognition software on the Android system, enter the first interface of the system, run the installed and deployed OCR recognition application, and start testing the main functions of the recognition system. According to the test cases of the system, the functional unit module and system test are carried out for the image acquisition module, cutting module, character recognition module, character recognition history display module and text post-processing module of the system. The test results show that all functional modules of the system operate normally, indicating that the functional modules of the system meet the product design requirements. The UI interface of each functional module of the system is convenient and practical, and the overall layout is reasonable, which is in line with the aesthetics of public users. It shows that the interface effect based on material design style is good and meets the interface requirements of the system.

4.3 Performance test

The main purpose of system performance test is to test the operation effect of the system under heavy load, and then find some possible defects of the system. In this system, the performance test object is mainly to test the system response time in different languages and different text mixing. For the character recognition system, the two key factors affecting the system response time are image preprocessing and character recognition. Image preprocessing and character recognition are functional modules with large amount of calculation. For character recognition, the two main indicators affecting the response time are the working efficiency of the classifier and the size of the character library. The larger the character library, the more character sets the system needs to match, and the more time it needs to consume. System response time is an important index to measure software performance. Through software testing, the

time-consuming of image preprocessing and classification recognition in image recognition is counted. Through detailed analysis of the time-consuming of each small step, the operation bottleneck in the system is found, so as to provide scientific data basis for subsequent optimization of software performance. The test text images used in this paper are 150, 50 pure Chinese, 50 pure English and 50 Mixed Chinese and English, with about 50 characters each. After many tests, the statistical test results are shown in Figures 3, 4 and 5.

arrangement of Chinese and English, multiple recognition is required to determine the text result, and the complex layout will also increase the character recognition time. Therefore, the text type and layout of the original image should not be too complex during character recognition, which can improve the accuracy of character recognition. The total average time of observation and recognition is about 3s, most of the mainstream commercial character recognition software is within 3s, and most of the software using cloud recognition is within 2s.

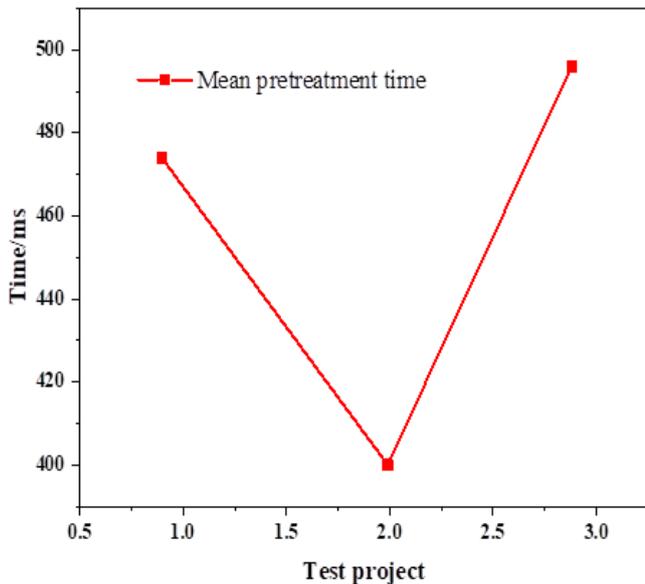


Figure 3: Test results of average response preprocessing time.

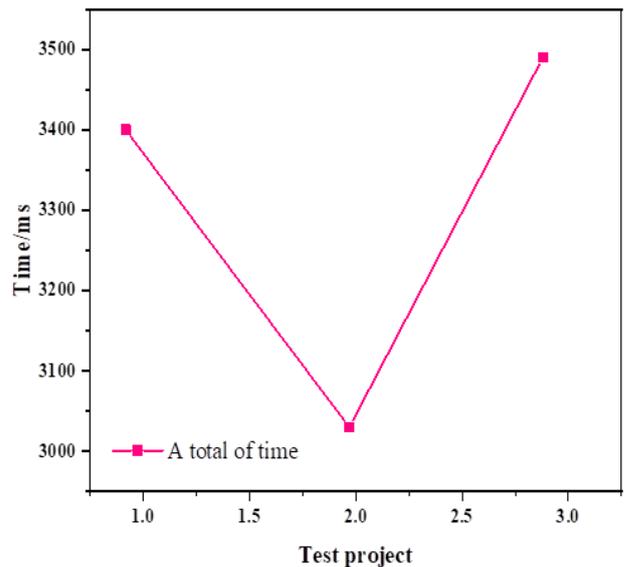


Figure 5: Total response time test results.

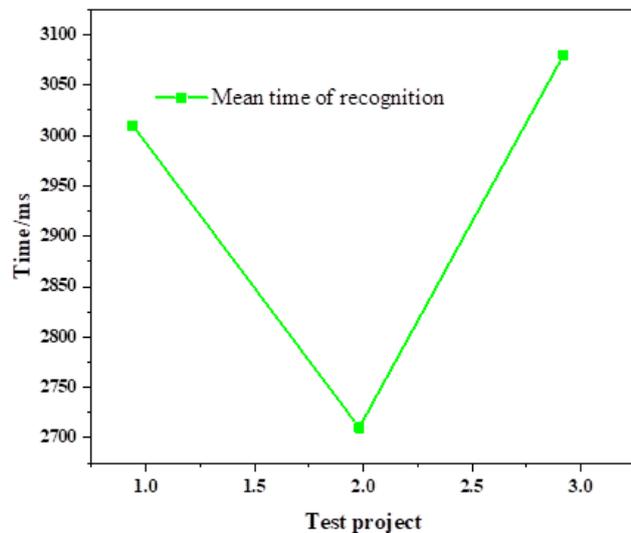


Figure 4: Average response identification time test results.

It can be seen from the test results that the average response time of text images in pure English is the fastest, the response time of text images in pure Chinese is the second, and the slowest is the mixed arrangement of Chinese and English. The analysis results show that because there are more Chinese features than English features and the matching time is longer, for the mixed

The recognition of the system is about 3s in many cases. Therefore, the system can basically achieve the recognition response time performance of the mainstream commercial software.

4.4 Identification accuracy test

After the function test and performance test, the recognition accuracy of OCR system needs to be tested. The recognition accuracy is an important index to evaluate the system. The recognition accuracy directly affects the user experience. The system mainly describes the recognition accuracy of the system through three parameters: correct recognition rate (A), error recognition rate (S) and recognition accuracy (P). Among them, recognition accuracy (P) is an important index to evaluate the recognition effect of a character recognition system. The higher the recognition accuracy, the better the recognition effect of the system. The identification accuracy is expressed by formula, see formula (13).

$$P = \frac{A}{A + S} * 100\% \tag{13}$$

This section also uses 150 pictures used in the performance test, 50 in Chinese, 50 in English and 50 in Chinese and 50 in English. Each picture contains about 50 characters. After many tests and statistical data

analysis, the test results are shown in Table 2 and it is graphically presented in Figure 6.

Table 2: Statistical results of recognition accuracy

	Total number of characters	Number of false identifications	Correct recognition rate A	Error recognition rate S	Recognition accuracy P
Chinese characters (English/Mathematics)	2467	343	86.09%	13.91%	86.09%
Symbols (English)	2345	262	88.82%	11.18%	88.82%
Mixed arrangement of Chinese and English	2656	423	84.07%	15.93%	84.07%

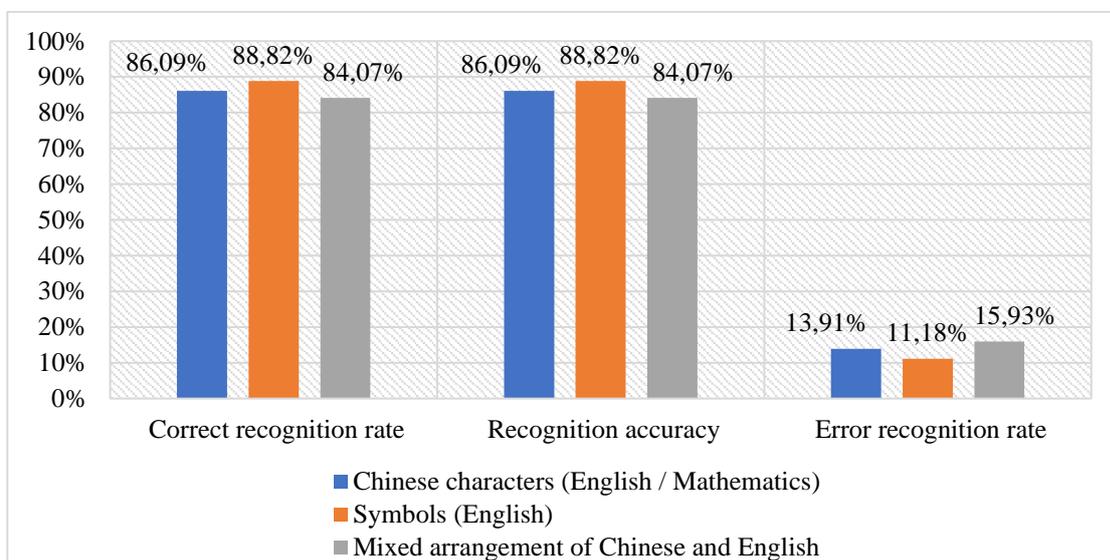


Figure 6: Graphical presentation of statistical results of recognition accuracy.

The experimental results show that the accuracy of character recognition is about 90% for pure English text images and close to 90% for pure Chinese text images. However, for the mixed arrangement of Chinese and English, the accuracy of character recognition is lower than that of pure Chinese and English. Nowadays, the accuracy of most commercial character recognition software is about more than 90%. Except for the mixed arrangement of Chinese and English, other products can basically achieve the accuracy of general commercial character recognition software. The product has certain practicability and can be applied to recognize text images taken in natural scenes in daily life.

4.5 System comprehensive evaluation

The optical character recognition system based on Android determines the system architecture and functional modules through user demand research and business analysis. The interface design part adopts the design style of material design. After the system test and user experience feedback on the UI effect of OCR system, the evaluation is mainly based on the scores of

system function, response performance, accuracy and interface. The system application evaluation survey is shown in Table 3. According to the application evaluation table, the system has complete functional modules, high availability, neat and beautiful system interface and good operability. However, the recognition response performance and recognition accuracy score of the system are not very good. Therefore, in the later stage, we should deeply study the detailed technology of character recognition, break through the key technical points and improve the comprehensive ability of the software.

Table 3: System application evaluation

Evaluation content	Average score
Functional module	92
Response performance	84
Accuracy	87
Interface layout, aesthetic degree	93

5 Conclusion

This paper proposes the design and development of mobile terminal application based on Android, which mainly explains the implementation process from the implementation process of functional modules along with UI implementation effect and some implementation codes. For the UI implementation part, the design of this system is based on Google material design. This design style is a new set of interface design language invented by Google design engineers based on traditional excellent design principles and combined with rich creativity and science and technology, including visual, sports, interaction and other characteristics. The experimental tests are done on the character recognition system, and the experimental results are analyzed. The test shows that under ideal conditions, both Chinese and English recognition have good recognition accuracy. The average response time of the system is about 3s, which can basically meet the response time performance of mainstream commercial OCR software within 3S. However, compared with some cloud-based OCR software whose recognition time is generally less than 2s, there is still a certain gap between this software and cloud-based OCR software. With the gradual upgrading of Android mobile terminal hardware in the future and the further improvement of CPU and GPU processing. The system can quickly carry out image preprocessing and character recognition by relying on gradually powerful mobile terminal computing resources, and efficiently complete the character recognition task at the mobile terminal. However, the recognition response performance and recognition accuracy score of the system are not very good. Therefore, the future research directions should focus on detailed technology of character recognition, break through the key technical points and improve the comprehensive ability of the software.

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