

Analysis and Implementation of an Automatic Marking System for Single-choice Question Based on OpenCV

Weiye Tao^{1,a}, Huaying Zhou^{1,b}, Hexian Wang^{1,c}, Maosheng Huang^{1,d}

¹School of Medical Information and Engineering,Guangdong Pharmaceutical University,
Guangzhou, Guangdong, China

^a 289597320@qq.com,^b 287059250@qq.com,^c 735113@qq.com,^d 31342181@qq.com

Abstract. Aiming at a common choice question answer card style, with the help of OpenCV open source library, a variety of image processing technologies were used to to realize the function of an automatic marking system for single-choice question.

Keywords: image processing,computer vision,automatic marking.

1. Introduction

At present, the mainstream of exams is still traditional paper exams, and after each exam, teachers face pressure to grade the test papers.The tedious grading of test papers not only consumes a lot of time and effort, but also leads to grading errors. If automated grading methods are used, it will undoubtedly reduce grading errors and improve grading efficiency.In all kinds of test papers, choice question are very common, and the number of questions is also quite large. If the automatic marking function of choice question is realized by computer, it obviously has very important application value.



Fig 1: An answer cards with larger range

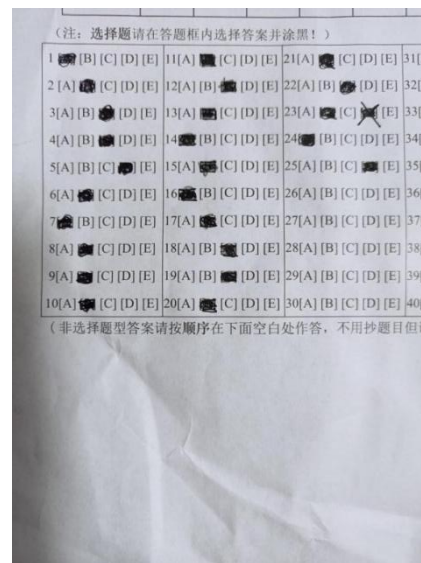


Fig 2: An answer cards with small range

Ma Fei and others grade objective questions automatically based on image processing technology, and the recognition and processing of objective examination paper images is mainly aimed to cursive student ID characters and answer characters in the images [1].At present, the main ways to realize automatic marking system are cursor reading machine and marking system based on image processing. The drawbacks of these two methods are very expensive, need high requirements for writing and printing, and there are many limitations on the format of answer cards, which make it difficult to popularize.In order to make up for the shortcomings of the current grading system, Liu Zhifang has developed an automatic recognition software that can support multiple answer cards and is compatible with various paper and printing methods. The software is developed based on C++and OpenCV[2].Wang Shan et al. developed an automatic grading system based on computer vision technology. In order to solve the problem of answer recognition and automatic grading, they proposed a paper filling information recognition algorithm based on

perceptual hash technology and a paper grading algorithm based on image comparison approximation results, tests have shown that the system has fast[3]

There is no uniform standard for the style of choice question answer cards. In the more authoritative exam, the design style of the answer cards should meet the requirements of machine marking as far as possible. In general examinations, the correction of test papers is mainly done manually, so the answer card is not designed to meet the format of machine reading requirements. Figure 1 and Figure 2 show the photo information of a certain answer card style. Starting from the answer card, we analyze how to achieve automatic marking of choice question.

Figure 2 shows the image captured by a 2992×4000 pixel mobile phone, when it is reduced to 30% of its previous horizontal size while maintaining the same aspect ratio, the pixel space is adjusted to 898×1200 , the space of the area for each small rectangular option is 34×25 pixel. The height distance from the last row choice to the horizontal frame is about 13 pixels, the width from the vertical frame is about 14 pixels, and the pixel distance from the first row choice to the top frame is about 18 pixels. After careful observation, it was found that the question numbers and options of question 1 and question 2 were offset, with an option offset of 4 pixels to the right. A 30 question answering area with a width of 9.5 centimeters and a height of approximately 7.4 meters, with a width to height ratio of approximately $9.5/7.4=1.283$.

2. Technologies

2.1 Python

Python language is widely used in big data and artificial intelligence because of its simplicity and efficiency. Compared with Java and C++, which are also popular languages at present, although their execution efficiency is low, Python language can develop powerful systems with a large number of third-party libraries through short code. Python also has excellent performance in the field of image processing.

2.2 OpenCV

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library[4]. Image processing involves a large amount of computation, complex algorithms, and high implementation difficulty. The development cost of image processing systems from scratch is high, and the efficiency is very low. With OpenCV, developers can focus on the functionality itself without overly focusing on implementation details, therefore, developing image processing systems based on OpenCV technology is a very ideal choice.

3. Solution

3.1 Image preprocessing

To grasp the essence of the problem and facilitate processing, we use an answer sheet shown in Figure 3 as an example to describe the solution and related algorithms. The filling method of some options on the answer sheet is very uneven and representative.



Fig 3: Sample Answer Card Example

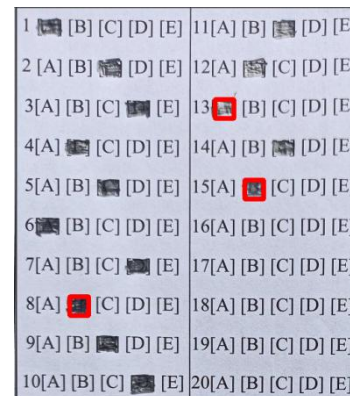


Fig 4: identified incorrect answers

The pixels contained in the small rectangle corresponding to each option in the figure are 33 25. In order to obtain the filled options, it is necessary to eliminate other unnecessary image information. Analyzing each option that has not been filled, it can be seen that each pair of square brackets contains a letter, and there is a small gap between each letter and the square brackets that is not connected. After filling in the options as required, The letters and brackets will be covered by black pencil handwriting, and the area between the brackets will form a whole. The filling of the answer is difficult to fully comply with the standard, either the area formed by brackets is not fully filled, or there are small gaps between the filled lines, which brings trouble to contour extraction.

In order to identify and extract the filled options, there are two different schemes. One is to perform an open operation, first using a corrosion operation to erase the unfilled options, and then using an expansion operation to restore the removed part of the image; The second solution is to run a closed operation, first using an expansion operation to close the gap between the filled lines as much as possible, and then using a corrosion operation to erase the unpainted options.

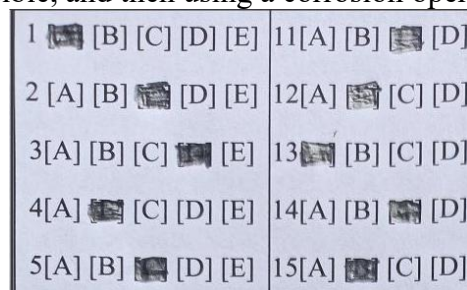


Fig 5(a): original answer sheet

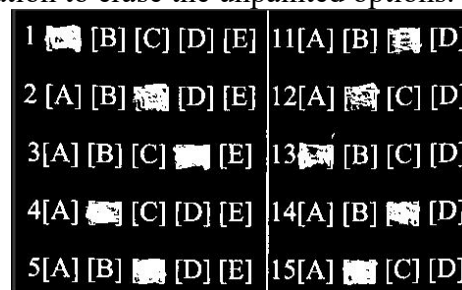


Fig 5(b):anti binarization

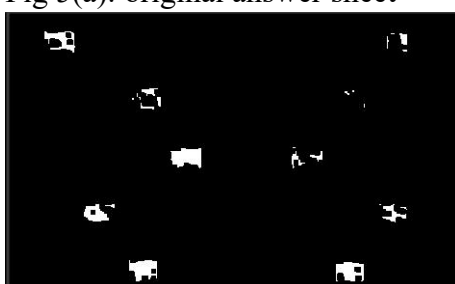


Fig 5(c): corrosion effect diagram



Fig 5(d):expansion effect diagram

When using the first solution, it will be found that the filled options are easily divided into multiple segments. The reason for this phenomenon is that there is a gap between the filled lines during the filling of the answer, and the corrosion operation makes this gap more enlarged and obvious. This will undoubtedly cause the problem of re identification, which will cause difficulties for further processing, as shown in Figure 5.

Table 1 Selection of Morphological Operation Parameters and Experimental Results

Experiment Number	Expansion Nuclear Parameters	Corrosion Nuclear Parameters	Contour Number	Option Integrity
1	4	12	17	good

2	4	11	24	good
3	3	11	15	poor
4	5	12	33	poor

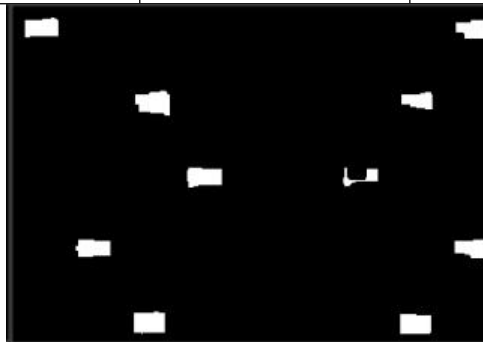


Fig 6::rendering of experiment 2

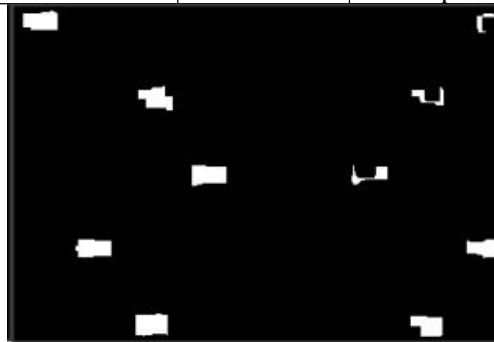


Fig 7::rendering of experiment 3

Therefore, choosing the second solution is relatively ideal. In practical operation, it is difficult to achieve good results when the nuclear parameters for expansion and corrosion are the same. After continuously adjusting the parameters, the experimental results obtained are shown in Table 1. It can be found that when the nuclear parameter for expansion is 4 and the nuclear parameter for corrosion is 12, good results can be obtained. The results corresponding to Experiment No. 2 and Experiment No. 3 are shown in Figures 6 and 7.

3.2 Identification and judgment of answer options

Firstly, call the findContours function to find the contour. The example code is as follows:

```
contours, hierarchy = cv2.findContours(erodeimg,  
cv2.RETR_LIST, cv2.CHAIN_APPROX_NONE)
```

The number of contours found is often greater than the number of options in the answer sheet. In this case, the size of the options in the answer sheet is used to filter out. After identifying the answer options, it is best to check if the answer is correct. The example code is as follows:

```
for i in range(0, length):  
    if optionSelected[i]==rightAnswers[i]:  
        score+=2  
    else:  
        #print("Wrong: ", answers[i][0], answers[i][1])  
        wrongAnswers.append(i+1)  
        cv2.rectangle(img, )
```

4. Results

Take the answer card with only 15 choice question as an example, the score of each question is 2 points, The correct answer is shown in the first column of Figure 8, and the identified filled in answer is shown in the second column. After judgment, a total of 3 questions were answered incorrectly, namely, question 8, question 13, and question 15. In addition to providing text prompts for incorrect answers, the filling options for incorrect questions were also circled in a square on the answer sheet to more clearly locate the incorrect questions, as shown in Figure 4.

```
['A', 'C', 'D', 'B', 'C', 'A', 'D', 'B', 'C', 'D', 'C', 'B', 'A', 'C', 'B']  
['A', 'C', 'D', 'B', 'C', 'A', 'D', 'C', 'C', 'D', 'C', 'B', 'B', 'C', 'C']  
总分: 24  
错题共 3 道, 题号如下列表: [8, 13, 15]
```

Fig 8:example of automatic grading results

5. Conclusion

Although the automatic marking function of choice question can be initially realized, there are still some problems to be solved if you want to be really practical, for example, when the respondent does not fill in an option, or multiple options of a question are filled in, the difficulty of identifying and processing the options will increase. In addition, the answer card image we analyzed is relatively standard. In reality, it is difficult to take such an answer card image with a mobile phone. The image taken with a mobile phone often has a significantly larger coverage, and there is a picture tilt. The image needs geometric transformation before it can be further processed with the current technology. These are problems to be solved in the next stage.

Acknowledgments

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- [4] <https://opencv.org/about/>