Poker card recognition with computer vision methods

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2021 IEEE International Conference on Electronic Technology, Communication and Information (ICETCI) | 978-1-6654-3251-1/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICETCI53161.2021.9563607

***Abstract*—In this paper, the face of playing cards is used as the identification target carrier. The card picture to be recognized is a 24-bit true-color image taken by a mobile phone, and then the image is preprocessed to a 256-grayscale picture, and then further converted to only 0 and 1 binary image. Finally, the contour shape matching is carried out according to the templates of hearts, spades, diamonds, clubs, and Ace-King obtained in advance. The contour shape matching is based on the Hu invariant moment. The nature of the Hu invariant moment shows that the rotation of playing cards does not affect it. Playing card recognition can assist visually impaired people to play poker games so that some people can also feel the fun of poker games and enjoy it. The playing card recognition can also realize the digital storage of cards, which can make the game fairer.**

Keywords—The moment of binary image, Contour shape matching, Graying, Binarization, Gaussian filtering

I. INTRODUCTION

A. Research background

With the continuous improvement of people's economic income and the rapid improvement of the quality of life, people's leisure and entertainment are also constantly emerging in new and interesting ways. In particular, today's information science and technology are changing with each passing day, and people love to pursue a variety of the latest IT products, such as various mobile games, software applications, and computer online games, etc. A playing card recognition technology based on machine vision is widely used in mobile phone and computer game development, intelligent sports competitions, and leisure and entertainment appliances. For example, if the image recognition technology is applied to the automatic poker dealer, many disadvantages of manual card making in poker competition can be successfully solved. On the other hand, the playing card recognition system can also be used in the production process of playing cards, to monitor the quality of the produced playing cards, and improve the reliability of product quality and the automation of the production process. Due to the high frequency of playing cards used in various magic shows, and the diversity of ways. Therefore, playing card recognition can also be used in magic shows to increase the mystery of magic.

Playing card recognition can help people with visual impairments play card games. For color-blind people, the corresponding card face is displayed for the recognition of playing cards, which improves their game efficiency. For the blind, playing card recognition can also be combined with a voice module to inform the blind of the corresponding numbers and suits of the card. People with visual impairment can also play poker effectively and happily and are more willing to participate in the game to make their lives colorful.

Playing card recognition can also realize the digital storage of card games. When people are playing poker, they can identify the poker cards in the whole process and store them digitally. This step can effectively observe whether someone cheats during the game, prevent cheating, and eliminate those cheating people. It can make the game fairer. Every game will be clearer and clearer, and fair poker games make people more willing to participate.

Poker appears in all aspects of people's leisure and entertainment life. It has a long history and is international. It can be said to be a worldwide entertainment language. Poker games can be seen in almost every country, and different countries have their unique gameplay. Therefore, digital recognition of playing cards can bring greater convenience to people's leisure and entertainment, and greatly expand people's entertainment methods, and enrich people's leisure and entertainment life.

B. Current status of research on detection and recognition of playing cards

At present, for the detection and recognition of playing cards, foreign countries have also carried out a part of the research on this aspect, such as a study of foreign journals:

In 2010, a Robust poker image recognition scheme in playing card machine using Hoteling transform, DCT, and run-length techniques[1] was researched by Chen Wen Yuan and Chung Chin Ho. Poker is an interesting field. It's a game with incomplete information and opportunity-related results. Players are dealing with probability, risk assessment, and possible deception, just like real-life decisions. The implementation steps are as follows:

Use Hoteling transform to place the target image at the correct position in the poker picking stage

Image weighted compression energy (WCE) as the first feature of using DWT and DCT

Calculate the four-direction connectivity run value (FOCRLV) to distinguish different playing card images. This paper has two contributions -- one is to use FOCRLV as a special feature to improve the image recognition ability, and the other is to use the compactness of the image as another

feature to effectively identify the image.

Furthermore, in 2011, Playing Card Recognition Using Aforge.Net was researched by Nazmi Altun, describes how to use the Aforge.Net framework to recognize playing cards from a still image or a live webcam input. The system introduced in this article is designed for British and American Poker, and may not be suitable for other kinds of poker. However, this paper describes the basic methods of poker detection and recognition. Therefore, the specific recognition algorithm needs to be changed according to the characteristics of the playing cards. AForge.NET framework technology includes Binarization, Edge detection, Affine transformation, BLOB processing, and Template matching algorithm, etc. This article identifies only separate cards (no overlap). Another known problem is that variations in the light environment often cause recognition errors.

In addition, in 2013, Playing Card Recognition Using Rotational Invariant Template Matching[2] was researched by Chunhui (Brenda) Zheng and Dr. Richard Green. This paper proposes a rotation-invariant template matching method to achieve recognition of playing cards. Recognition of poker includes character segmentation, affine transformation, edge detection, and template matching. Rotation and scaling apply character segmentation algorithm and affine transformation to playing card recognition system. The system has a good recognition effect on low noise and this method is suitable for baccarat card games.

Target detection and recognition is the most important link in computer vision task. To detect and identify playing cards, use playing cards as the target for classification and location positioning. It has important application value in the process of fighting only the landlords. There will be a large number of categories of playing cards in the scenario of landlords, which will affect the detection and recognition. Detection and identification of playing cards are essential to building an intelligent landowner platform. Playing card detection and recognition refer to the process of finding playing cards in the landlord scene. It consists of two processes: detection and identification. However, the research on target detection in the scene of fighting landlords is relatively few, and the effect is not very good. Some studies are carried out using traditional image recognition methods, such as playing card color recognition based on Naive Bayes.

Taking the recognition of playing cards as an example, this paper practices the recognition of playing cards based on contour shape matching[3]. Hu invariant moments[4] are generally used to identify large objects in an image. The shape of the object is described well, and the texture characteristics of the image should not be too complicated. The number of the playing card and the shape of decor is better to distinguish, and from the nature of Hu moment, we can know that the rotation of playing cards has no great influence on Hu moment, so we can recognize it according to Hu invariant moment. The characteristics of playing cards are obvious. There are four suits: hearts, spades, clubs, and diamonds. Each suite has 13 cards and a total of 52 cards (not including big and small kings). This article realizes the suits and numbers of playing cards to separate recognition.

II. METHODS

A. Algorithm introduction

The most basic problem of target image detection is to find the features of the image to be recognized and distinguish it from other objects. This paper is to identify a set of 52 playing cards (excluding Da Wang and Xiao Wang). And a deck of cards is made up of 13 numbers and 4 kinds of suit combinations, these two characteristics in the upper left corner and the lower right corner of playing cards can be very well-reflected. So, we just need to select the upper left and lower right corners as the region of interest section for detecting the playing card. The corresponding recognition result can be obtained by matching the contour shape of this part with the template. Although the whole playing card is composed of monotonous red and black, the recognition based on contour shape matching has nothing to do with color. Therefore, the image can be directly processed into a single binary image to extract the part of interest to make the outline more obvious. Then can be better for contour shape matching.

1) Graying

The process of converting a color image into a grayscale image becomes the grayscale processing of the image. The color of each pixel in a color image is determined by the three components of R, G, and B, and each component has a median value of 255, so that a pixel can have more than 16 million (255*255*255) color changes range. However, a grayscale image is a special color image with the same components of R, G, and B, and the variation range of a pixel is 255 kinds. Therefore, in digital image processing, we usually transform various formats of images into gray-scale images to reduce the amount of calculation of subsequent images. The description of grayscale images, like color images, still reflects the distribution and characteristics of the overall and local chromaticity and brightness levels of the entire image. The grayscale processing of the image can be realized in the following two ways:

The first method is to find the average value of each pixel's R, G, and B components, and then assign this average value to the three components of the pixel.

The second method is based on the YUV color space. The physical meaning of the Y component is the brightness of the point which reflects the brightness level. According to the relationship between the RGB and YUV color spaces, the brightness Y and R, G, and B can be established. Correspondence of each color component: Y=0.3R+ 0.59G +0.11B, express the gray value of the image with this brightness value.

2) Gaussian filtering

Due to the differences in shooting devices such as mobile phones, as well as the influence of the environment such as lighting and background, the images taken will contain noise. Noise is usually generated randomly, so its distribution and size are very irregular. To emphasize the playing card and its characteristics, it is necessary to denoise the image of the playing card.

Gaussian filter[5] is a linear smoothing filter, which is suitable for eliminating Gaussian noise. It is widely used in the denoising process of image processing. Generally, Gaussian filtering is the process of the weighted average of the whole image. The value of each pixel is obtained by the

weighted average of itself and other pixel values in the neighborhood. The specific operation of Gaussian filtering: scan each pixel in the image with a template (or convolution mask), and replace the value of the central pixel with the weighted average gray value of the pixels in the neighborhood determined by the template. The global threshold is that an image contains the target object, background, and noise.

3) Binarization

In this paper, simple threshold binarization[6] is used in playing card recognition. The so-called binarization of the image is to set the gray value of the pixel on the image to 0 or 255 and is the entire image shows an obvious visual effect of only black and defeat. To extract the target object from the multi-value digital image. The common method is to set a threshold T, and use T to divide the image data into two parts, the pixel group larger than T and the pixel group smaller than T. That is image binarization.

4) The moment of binary image

Moments are ways that describe image features. Nowadays, moment technology[7] has been widely used in image retrieval and recognition, image matching, image reconstruction, digital compression, digital watermarking, and motion image sequence analysis. Common moment descriptors can be divided into the following categories: geometric moments, orthogonal moments, complex moments, and rotational moments.

The moment set calculated from an image can not only describe the global features of the image shape, but also provide a lot of information about the different geometric features of the image, such as size, position, direction, and shape. The description ability of image moment is widely used in target recognition and azimuth estimation in various fields of image processing, computer vision, and robot technology. First-order moment: related to the shape; Second-order moment: the extension degree of the display curve around the straight lines average; Third-order moment: about the symmetric measurement of the mean value.

Seven invariant moments can be derived from the second and third-order moments. Invariant moments are the statistical characteristics of images. They satisfy the invariance of translation, scaling, and rotation and are widely used in image recognition. The distribution of the grayscale image can be represented by the continuous function $f(x,y)$, and the two-dimensional $(p+q)$ order origin moment of the image as:

$$m_{pq} = \sum_{x,y} x_p y_q f(x,y) \quad p,q = 0,1,2... \quad (1)$$

The zero-order moment represents the sum of the gray levels of the image, expressed as:

$$m_{00} = \sum_{x,y} f(x,y) \quad (2)$$

For binary images, the zero-order moment is the sum of white pixels and the area of white area. Therefore, the zero-order moment is the basis of judgment to get the used playing card region.

5) Contour shape matching (Hu moments)

When the scale of the image changes, the moment remains unchanged. When the image is rotated or translated, the moment will change. However, the image moment center is not affected by the pixel change, which constructs the center moment with proportion and translation invariant.

The $(p+q)$ order central moment is expressed as:

$$u_{pq} = \sum_{x,y} (x - x_0)^p (y - y_0)^q f(x,y) \quad (3)$$

Among them (x_0, y_0) is the centroid, expressed as:

$$x_0 = m_{10} / m_{00}, \; y_0 = m_{01} / m_{00} \quad . \quad (4)$$

The moment with rotation invariance is obtained by normalizing the central moment, expressed as:

$$n_{pq} = u_{pq} / u^r \quad , r = (p+q+2)/2 \quad . \quad (5)$$

The Hu moment uses the second and third normalized central moments to construct seven invariant moments. It is shown that the characteristic moment obtained under continuous image conditions can maintain the invariance of scaling, rotation, and translation.

Seven invariant moments are as follows:

$$\begin{aligned}
h_0 &= n_{20} + n_{02}; \\
h_1 &= (n_{20} - n_{02})^2 + 4n_{11}^2; \\
h_2 &= (n_{30} - 3n_{12})^2 + (3n_{21} - n_{03})^2; \\
h_3 &= (n_{30} + n_{12})^2 + (n_{21} + n_{03})^2; \\
h_4 &= (n_{30} - 3n_{12})(n_{30} + n_{12})[(n_{30} + n_{12})^2 - \\
&\quad 3(n_{21} + n_{03})^2] + (3n_{21} - n_{02})[3(n_{30} + \\
&\quad n_{12})^2 - (n_{21} + n_{03})^2]; \\
h_5 &= (n_{20} - n_{02})[(n_{30} + n_{12})^2 - (n_{21} + n_{03})^2 + \\
&\quad 4n_{11}(n_{30} + n_{12})(n_{21} + n_{03}); \\
h_6 &= (3n_{12} - n_{03})(n_{30} + n_{12})[(n_{30} + n_{12})^2 - \\
&\quad 3(n_{21} + n_{03})^2] + (n_{30} - 3n_{12})(n_{21} + \\
&\quad n_{03})[3(n_{30} + n_{12})^2 - (n_{21} + n_{03})^2].
\end{aligned} \quad (6)$$

The distance is calculated according to the invariant moments of two images. If the distance is small, the shape looks closer, and if the distance is large, the shape looks farther. When the distance is minimum, it is a matching image.

The influence of playing card rotation can be solved through the rotation invariant nature of the Hu invariant moment. Finally, the contour shape matching based on Hu moment invariants is used to realize the final recognition of playing cards.

B. Implement algorithms and procedures

After analyzing the algorithm, it tries to study the algorithm and steps to realize the playing card recognition. The flow chart of the identification of playing cards, as show in Fig.1.

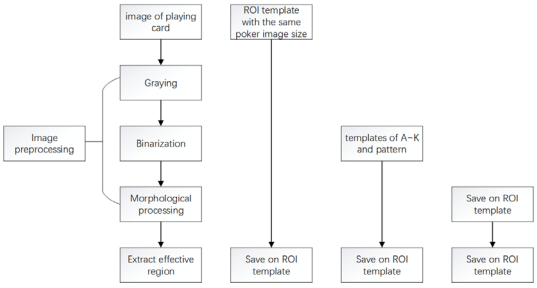

Fig. 1 The chart of playing card recognition

1) Get template

The digital and suit parts after image preprocessing extracted from 13 playing cards in the format of. JPEG shot by mobile phone camera, and rename them to corresponding numbers (suits), as show in Fig.2. The suits: H-hearts, S-spades, D-diamonds, C-clubs. As can be seen from the figure, there is no template of 10 in the figure, but only 10 is the combination of 1 and 0. Therefore, when the matching recognition is 0 or 1, it will show that the recognition is 10. This step is to prepare for subsequent contour shape matching.

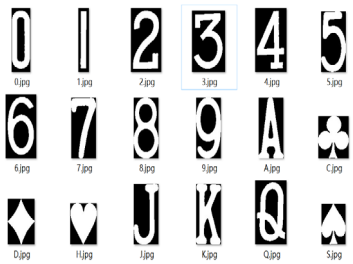

Fig. 2 Templates for numbers and suits

2) Obtain the picture to be recognized

A playing card picture with a format of. jpeg, which We obtained 24-bit true-color shot by mobile phone, as show in Fig.3. To facilitate subsequent identification processing, it is necessary to place playing cards on dark background for shooting. Each image should be taken at the same height, otherwise, it will affect the subsequent extraction of the contour. It is necessary to ensure the integrity of the picture playing cards and expose the feature area completely. It is convenient for subsequent feature region extraction.

Fig. 3 Original picture of playing cards

3) Picture preprocessing

A preprocessing operation of the first original image. First of all, the grayscale processing is carried out to convert a 24-bit true-color image into a 256-color grayscale image, as show in Fig.4. Then set a threshold based on the grayscale graph to process the image into an image containing only 0 and 1 data. The threshold value of this step should be set well. We set it as 180. The threshold value set in this step will affect the subsequent recognition. And the threshold of image preprocessing for numbers and suits templates is also set to this value.

Fig. 4 Picture preprocessing

4) Get ROI

The number and suit ROI part of the playing card obtained by searching through the zero-order moment, as show in Fig.5. From the binary picture of the picture to be recognized, we can see that the white area outside the playing card affects the recognition, so we need to remove these parts. By observing, the zero-order moment of the effective part that we want is between 180~1000, and this range will be affected by the height of taking the picture. Therefore, keep your pictures at the same height so that the user area can be roughly maintained in this area. The height of the four pictures we took is the same, and the suits and numbers can be completely extracted. Then draw the valid area on the same size ROI previously defined as the original image. The subsequent shape matching operation is carried out directly on the ROI. This step can remove other factors that interfere with the recognition other than the valid area of the playing card, and keep the used part undisturbed.

Fig. 5 ROI

5) Contour shape matching

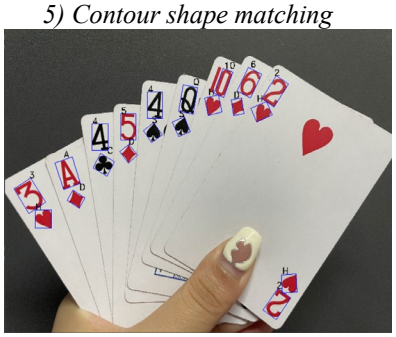

Fig. 6 The result of card identification

The template is traversed and loaded from the corresponding template file, and the contour shape is matched with the number and decor area obtained in the fourth step. The data when a profile shape match is saved in an array, and finds the smallest values of the array, and traverses the template again when the value of shape match is equal to the minimum value, the recognized profile matches the template. Then convert the picture name of the template into a string and assign it to a variable so that it can

be displayed on the corresponding rectangle of the picture later (During the operation, the identification of the three numbers 2, 3, and 5 May change. The number should be 2 instead of 3, such as 8 and Q, 6 and 9, such error will also occur). But we didn't make mistakes when we identified the contradictory points in this figure. Finally, we got the result as show in Fig.6. The operation of the other three pictures is the same as that of the first picture, and the final result is shown in Figure 7.

Fig. 7 Identification results of four playing cards

III. Experiment Results

The result of the recognition of the four playing card pictures taken by myself, as show in Fig.7. Each picture is taken against a dark background and maintained at a certain height so that the characteristics of the playing cards in each picture can be fully showed. The shooting environment of the first picture is different from the other pictures and the quantity and content of the recognized playing cards are different. The other three cards have the same environment but the order of the playing cards is different. The cards are also changed, but each playing card can be identified correspondingly. By observing, we can find that the result of recognition will be affected by the environment and shooting angle of the playing card.

IV. Conclusions

In this paper, the region of interest of playing cards is studied, and the region of interest is extracted based on the zero-order moment of the binary image. On this basis, further image recognition algorithms such as Graying, Gaussian filtering, Binarization, contour shape matching, etc. are carried out to complete the recognition of the suit and number of playing cards. Hu invariant moments are generally used to identify large objects in an image. The shape of the object is described well, and the texture characteristics of the image should not be too complicated. The shape of the suit and number of playing cards is clear, so the contour shape matching (Hu moment invariants) is selected as the main method to identify playing cards. At the time of recognition, an outline is matched with all templates in shape, and the value of the best match is the smallest. The corresponding template is the number (color) corresponding to the outline, which is displayed on the corresponding outline of the original image. Although there are recognition errors, the time of recognition is relatively fast.

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