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Research on QR Code Image Pre-processing Algorithm under Complex Background

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Abstract

The performance of QR code recognition technology depends on the pre-processed QR code images, and the complex background always hinders the locating and recognition of the QR code. Aiming at this problem, a QR code image pre-processing algorithm is designed, which combines projection-based initial locating, binarization, feature-based precise locating. The algorithm is used to locate the horizontal and vertical projection by using the information of the edges of the image, and then it uses the K-means clustering algorithm for binarization, finally uses an improved precise locating method based on the symbolic features of the QR code to position accurately. Experiments show that the method can provide strong efficiency to QR code position under complex background.

Keywords: QR Code Recognition; Image Pre-processing; Binarization; K-means

1 INTRODUCTION

QR code has the advantages of large capacity of information, low cost, high fault tolerance, so that the QR code has been widely used in the age of big data[1]. However, the background of the QR code image is relatively complicated caused by other pictures or words on the package, which bring some difficulties to the QR code recognition, so that the work of QR code image pre-processing is particularly important. At present, there are many researches on QR code image pre-processing both at home and abroad, common QR code image pre-processing can be divided into three categories according to different position methods, which are as follows: the first one is a preprocessing method based on Hough transform[2]. The second, a method to determine the location of the QR code by using the information of the edges of the QR code[3]. The last, a correlation matching algorithm is used for image preprocessing[4]. Considering the background of the QR code image is more and more complex, single localization algorithm cannot meet the demand for precise positioning of the QR code, thus a QR code image pre-processing algorithm is studied in this paper, which combines projection-based initial locating, binarization, feature-based precise locating. This algorithm can locate QR code position quickly, and with less computation.

2 A SUMMARY OF QR CODE IMAGE PRE-PROCESSING ALGORITHM UNDER COMPLEX BACKGROUND

In this paper, a QR code recognition technology under complex background is studied, we have carried out research and improvement aimed at the shortcomings of existing algorithms. An initial location algorithm based on edge detection and projection is proposed. The specific process is as follows: image grey processing, filtering, edge detection based on morphology, projection-based initial locating, binarization operation based on k-means clustering algorithm, using the symbolic features of the QR code to position accurately. As shown in Fig. 1:

Specific steps are as follows:

1. Making the gray scale and the filtering to the QR code image to obtain the gray image in order

to reduce computational cost and storage.

2. Using projection and edge detection based on Morphological operations for initial location of

QR code image.

3. Using k-means clustering algorithm for binary operation of the image to further reduce the amount of computation and other interference effects on the background.

4. Using an improved algorithm based on symbolic features of the QR code to position accurately.

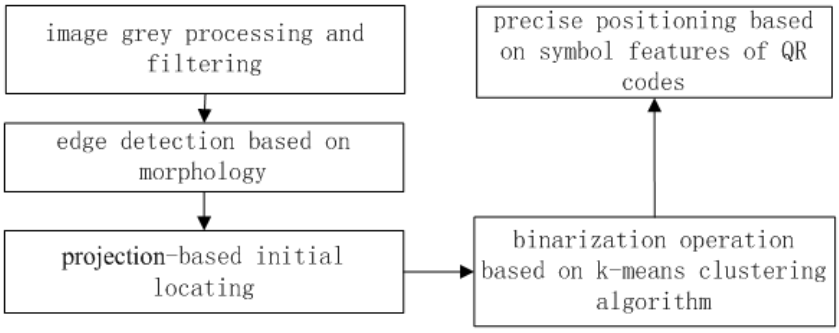


FIG. 1 FLOW CHART OF THE ALGORITHM IN THIS PAPER

3 BASIC ALGORITHM AND OPERATION OF QR CODE AREA LOCATION

3.1 Image Grey Processing and Filtering

The second and following paragraph under the first and second level titles (the Introduction part is excluded) need to indented for one character. Please do not forget. As shown in Fig. 2 (A) most of the QR code image acquisition is the use of optical cameras or general cameras, so the pre-processed images are colorful. Color image contains a huge amount of information, so on one hand, it needs a large amount of computation, on the other hand, it introduces more noise. There are many reasons for the introduction of noise, it may be the noise of the internal components of the acquisition devices, or the infection of the channel in the process of image transmission. Therefore, firstly the current identification needs to transform the color image to gray image in order to reduce the amount of computation and storage, and what's more it will add a filter to eliminate noise. In this paper, the weighted average method is used to image grey processing and the median filtering method is used to filtering. After the image grey processing[5] and filtering the image is shown in Fig. 2 (B).



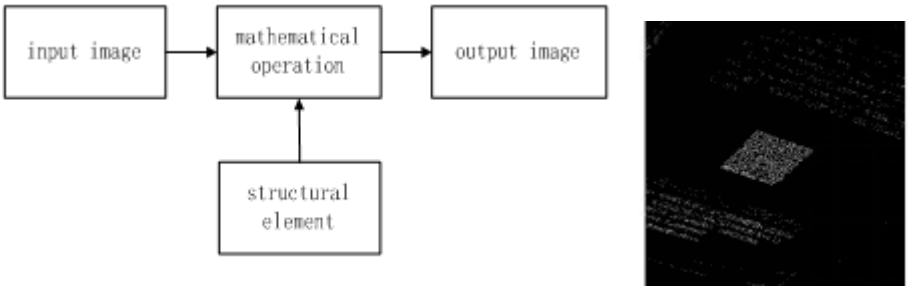
(A) (B)

FIG. 2 (A) FOR THE ORIGINAL (B) FOR AFTER THE IMAGE GREY PROCESSING AND FILTERING

3.2 Projection-based Initial Locating Based on Morphological Edge Detection

In fact, there are not only QR code but also interference factors caused by other texts and graphics in the image, thus it needs to find out the area of the QR code from the complex background. After the analysis of the edge detection of the QR code image, it is found that the QR code is rich in boundary information comparing with the surrounding interference pattern, and it is independent in a certain range, there is a certain distance between the interference information and the area of QR code. Generally, there will be some blank area near the QR code, as a result, the results of projection will have a certain peak-valley, and due to that the QR code is a square, therefore the width of horizontal projection and vertical projection will be roughly equal, and the peak value will be relatively high and have a certain width(horizontal projection and vertical projection are approximately 1:1 in width). We can initially locate the approximate location of QR code by using this feature. Process of algorithm is as follows:

1. Using edge detection algorithm based on morphology[6] for image pre-processing. Edge detection of mathematical morphology has many advantages, first of all, it is less affected by noise, secondly, can accurately detect the edges of the image, in addition, it can preserve the details of image edge and at the same time can adjust the size of structural elements to reduce the influence of noise. Its basic idea is to use a certain shape of the structural elements to do a similar convolution operation on the image.



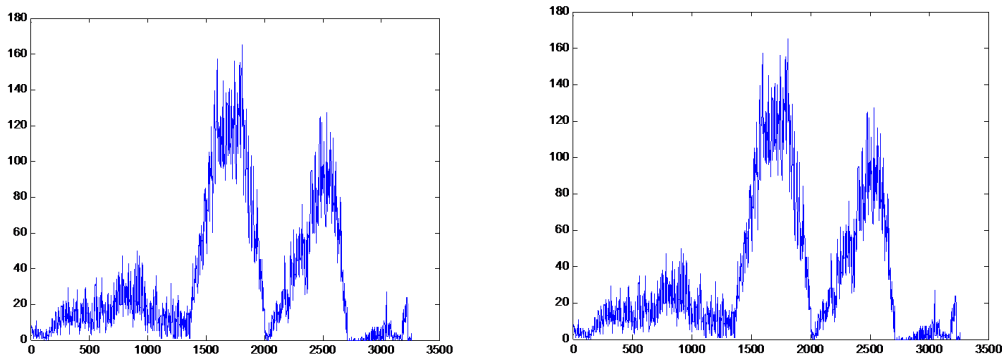
(A) (B)

FIG. 3 (A) THE BASIC IDEA OF MATHEMATICAL MORPHOLOGY (B) MORPHOLOGICAL EDGE DETECTION

2. Two projection curves are obtained from the horizontal projection and vertical projection of the edge detection image. The projection method is to get the summation of the pixel value of the same line (or the same column) of the image after edge detection[7], mathematical expressions are as follows:

$$\begin{cases} hist_H[y] = \sum_{x=0}^{w-1} f(x,y), 0 \le y \le h \\ hist_V[x] = \sum_{y=0}^{h-1} f(x,y), 0 \le x \le w \end{cases} \quad (1)$$

Where respectively represents the value of projection of the x column and the line y. As shown in Fig. 4:



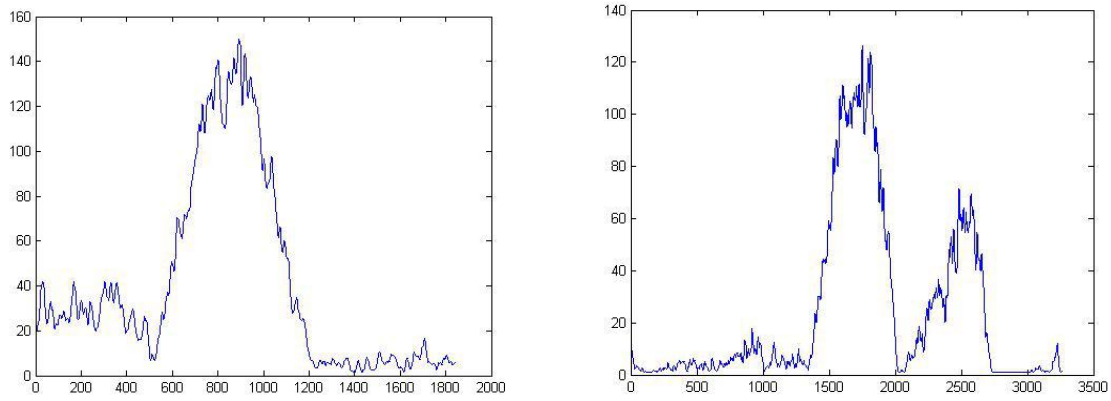
(A) (B)

FIG. 4 (A) HORIZONTAL PROJECTION CURVE (B) VERTICAL PROJECTION CURVE

3. Horizontal and vertical projection curves can be approximately regarded as a series of discrete series, but it has a lot of burr which is not conducive to processing, so it is necessary to smooth the image to eliminate the interference from the burr and the noise. In this paper, the weighted arithmetic average method is used for image smoothing[8], formula is shown in (2). The operation steps are as follows: firstly, setting $hist_v[x]$ to the initial projection value of the column x, and $hist'_v[x-1]$ to projection value of the column (x-1) after a weighted processing. Then using the following expression to calculate the value of the smoothed projection, where a=0.2, as shown in Fig. 5:

$$hist'_v[x] = \alpha hist_v[x] + (1-\alpha) hist'_v[x-1] \quad (2)$$

The two curves are smoothed according to the expression (2), the results vary with the number of treatments. In this paper, we take three times which can not only maintain the shape of the curve but also remove the burr and noise.



(A) (B)

FIG. 5 IMAGE SMOOTHING

4. Threshold processing is applied to the curve, a horizontal region A and a vertical region B which are larger than the threshold value in the curve can be obtained. In addition, we can get the range of X axis coordinates of A area is $X_1 \sim X_2$ and the range of Y axis coordinates of B area is $Y_1 \sim Y_2$. A lot of experiments verify the threshold value that can be:

$$Threshold = mean(hist_H) \times \beta + \min(hist_H) \tag{3}$$

In the expression 3, $mean(hist_H)$ is an average value of all projection values, $\min(hist_H)$ is the smallest value of all projection values. Where β =0.4~0.7.

5. Calculate the ratio of the horizontal region and vertical region obtained by step 4. In the process of shooting QR code, a certain degree of distortion may be caused by different angles of shooting, which brings that the width of the horizontal and vertical projection can not strictly meet the 1:1 relationship. Therefore, when it comes to determining the width, if it satisfies 0.5<A:B<2, you can think this area contains QR code.

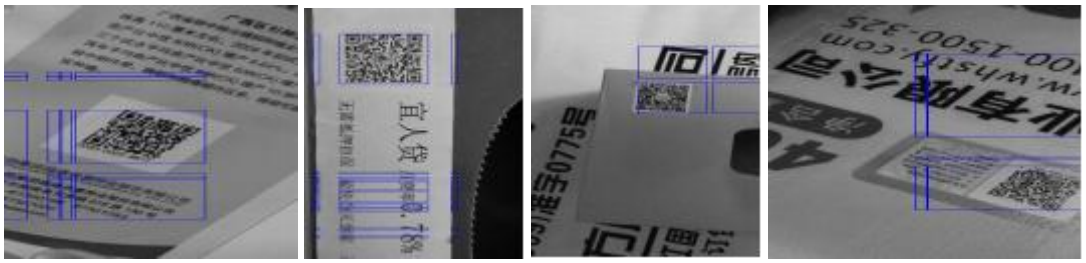


FIG. 6 IMAGE OG INITIAL LOCATION

3.3 Binarization and Precise Positioning Based on Symbol Features of QR Codes

We need to make binarization of the image before precise positioning[9], binarization can not only reduce the amount of calculation in the precise positioning, but also more conducive to the use of precision positioning algorithm based on symbol features of QR codes. An important step in the binarization is to select a threshold value T, if the gray value of the image is larger than T the gray value of the point is changed to 1, otherwise the gray value of the point is changed to 0, that is:

$$f(x,y) = \begin{cases} 1, & f(x,y) > T \\ 0, & f(x,y) \le T \end{cases} \tag{4}$$

K-means clustering algorithm has many advantages, it can efficiently deal with data and has strong robustness. The biggest advantage of using the K-means algorithm for the binarization is that it does not need to define a threshold value, so the edge information of the image can be preserved.

After the operation of the last section we can locate the location of the QR code initially, but for images with complex background may be located in more than one regions, that will bring interference, so we need to further determine the location of the QR code. The most striking feature of the QR code is that when the image is scanned line-by-line to find the pixels satisfying 1:1:3:1:1 in black and white, we can use this feature to precisely locate the location of QR codes. Specific operations are as follows:

1. Each area determined by initial location is scanned line-by-line. If the module to be scanned is black, then the coordinates of the starting point will be denoted as (x_1, y_1), record the length of the black module as L_1 once the white point is scanned. By the same way, the length of the remaining black modules will be denoted as L_2, L_3, L_4, L_5... At the same time, record the coordinates of the boundary point of the last module as (x_5, y_5).

2. Because some factors during the shooting may lead to the skew of image, which brings that the detection ratio may not strictly satisfy 1:1:3:1:1, so in this paper, we just judge whether the ratio satisfies $0.5 \le L_2 : L_1 \le 1.5$, $2.5 \le L_3 : L_1 \le 3.5$, $0.5 \le L_4 : L_1 \le 1.5$, $0.5 \le L_5 : L_1 \le 1.5$. If it meets these requirements, we will implement the fourth step and calculate the center $(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2})$ of the detection area, otherwise we will carry out the third step.

3. $L_1 = L_2, L_2 = L_3, L_3 = L_4, L_4 = L_5$ the coordinates of the starting point are replaced by the point of L_2. Continue to scan until the gray value changes, the length is recorded and assigned to L_5, at the same time, update the coordinates of the boundary point of the last module. Then continue to implement the second step.

4. Considering the different situation of distortion, there may be error. We respectively select a black block and a white on both orientations of the vertical direction of the detection center founded in the second step, calculate the proportion of the 5 black and white blocks to see whether it meets the proportion of step 2, if it meets the requirements, then calculate the center point $(x_2^{'}, y_2^{'})$ of the vertical direction. In the same way, we do the same operation on the two diagonal directions. If results are in accordance with the proportion of step 2, it can be viewed as a detecting graphic, and the center of the detecting graphic is $(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2})$. Then continue to implement the third step.

5. After completing one line scanning according to the above four steps, continue scanning after an interval of some rows.

The area determined by the initial location is detected one by one according to the above steps, if the detecting graphic is detected, and three detecting graphics are in this area, the area will be retained and the coordinates of the area will be recorded. Otherwise, it can be thought that the region does not contain a QR code, we will no longer operate on it. The results are shown in Fig. 7.

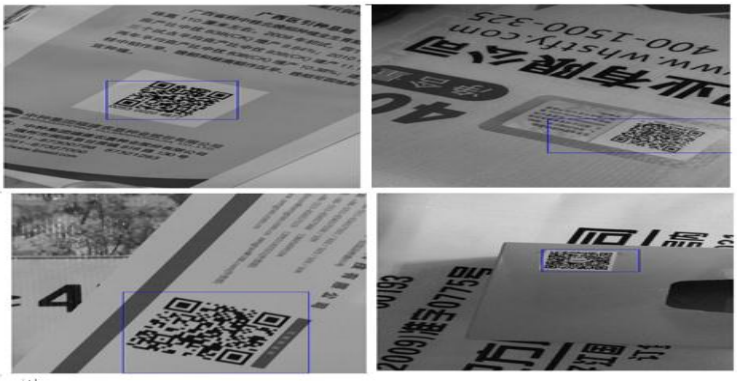


FIG. 7 QR CODE PRECISION POSITIONING

3.4 Analysis of Experimental Results

In this paper, experiments are done on the influence of background complexities on the positioning time and the location rate, and the method is compared with the algorithm in the literature [10]. Test data is divided into three

categories, for one, there are very little other background around the QR code, QR code occupies most of the picture, for another, the QR code is surrounded by some text or pictures, QR code occupies about half of the picture, background is relatively complex, the last, the QR code is surrounded by a large number of text or pictures, QR code occupies about 1/3 to 1/4 of the picture. The results of the experiment are shown in Table 1.

TABLE 1 TABLE OF THE INFLUENCE OF BACKGROUND COMPLEXITIES ON ALGORITHM

test sample	**sample quantity**	**algorithm in literature [10]**		**algorithm in this paper**	
		Recognition rate	recognition time	recognition rate	recognition time
sample 1	50	98%	143ms	98%	210ms
sample 1	50	87%	432ms	94%	383ms
sample 1	50	78%	1200ms	91%	743ms

We can see that in the case of the background of QR code is relatively clean, the localization rate of algorithm in this paper is roughly equal to that in the literature [10], when the background is relatively complex, and the algorithm in this paper is superior to that in the literature [10] in the positioning time and the location rate. Because this paper has an initial location algorithm, so it can reduce the amount of computation in the late pretreatment, thus the positioning time and the location rate are better than the literature [10]. By testing on different background of QR code, found that the background is more complex the number of the area determined by the initial location is more, so more time will be cost, and due to the increase in the number of the area determined by the initial location there will be a smaller influence on recognition rate.

4 CONCLUSIONS

In this paper, based on the study of traditional QR code image pre-processing technology, the positioning and binarization of QR code are improved. A QR code image pre-processing algorithm is realized which can accurately locate the position of QR code under complex background, and good results were obtained.

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