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Analysis on E-Ticket Image Recognition Technology Based on Mobile QR Code

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ABSTRACT Currently, most urban rail transits have adopted IC card technology, yet a huge amount of passengers has to wait and buy tickets in the railway stations or stations located in large-scale shopping malls. As a result, there exists potential safety hazard to the operation department. This paper proposes the electronic ticket system based on mobile 2D barcode; the ticket inspection system is able to swiftly recognize 2D barcode ticket, which is a key technology; it mainly analyzes and researches the recognition of QR Code. QR Code image is recognized and analyzed to effectively reduce recognition time and upgrade recognition rate. With the development of the technology, it is able to realize swift ticket procurement and inspection in the rail transit field.

KEYWORDS
2D Barcode
Mobile
QR Code
Genetic algorithm

1. Introduction

With constant improvement in the domestic communication network framework, people have required more functions rather than simply communication on the mobile but to integrate more functions as a whole. As the carrier of 2D barcode, mobiles play an important role in the E-commerce. Although most urban rail transits have adopted IC card technology, yet a huge amount of passengers have to wait and buy tickets in the railway stations or stations located in large-scale shopping malls. As a result, there exists potential safety hazard to the operation department. The author hereby proposes the electronic ticket system based on mobile 2D barcode in order to reduce queuing time of passengers. The integration of mobile and 2D barcode technologies would improve the automation degree of rail transits and transportation departments, and assist the better performance of automatic ticket sales and inspection system.

2. 2D barcode ticket

The "be read model" was adopted based on 2D barcode ticket system. That is to say, 2D barcode is encoded and calculated on PC platform and encoding information is stored in the database; the communication dealer transmits 2D barcode information to the passenger's mobile. The passenger needs to adopt the barcode as voucher. The ticket inspection equipment reads 2D barcode through CCD reader-writer; decodes 2D barcode [1,2].

3. Design of key technologies

In the design of this paper, the key technology has been laid on how to enable the ticket inspection system to swiftly recognize 2D barcode ticket. Though the comparison of 2D barcodes, this paper selects and adopts QR code as the system barcode plan.

An important image recognition method of 2D barcode is the recognition and withdrawal of image elements. Generally speaking, elements are simple model graphs such as triangle, rectangle and circle. Hough conversion method is adopted for the recognition and withdrawal of image elements; it is better at the non-sensitivity to partial defects and robustness of random noise; the defects lie in the very high space and time consumption; in particular, it suffers from lower efficiency in the inspection of multi-parameter complex elements. In recent years, the cost function is optimized as a whole to withdraw elements (such as analog annealing method and Genetic Algorithm); a new development is attained [3].

To combat with it, the paper proposes the Genetic Algorithm to search for the whole image and thus swiftly obtain the location of 2D barcode. This method is invariable in scale and rotation, and is convenient for improving the

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recognition rate of QR code.

3.1. Recognition of QR code

(1) Structural features of QR code

One QR code is one sign; each color point in QR code is a module. The sign specification is 21*21–177*177 modules from version 1 to 40; each specification requires four additional modules at each side. In the sign, the left upper, right upper and left lower 8*8 modules are fixed and not changed with the version.

(2) Restriction analysis of QR code image

The taken QR code image enjoys the following features:

i. Given differences in the photography equipment, the taken image is a rectangle with same width and height.

ii. The photography is affected by subjective factors of human; therefore, the main image is QR code and the image is complete.

iii. QR code position is not fixed in the image.

iv. Given differences in the photography angle and distance, QR code in the image has rotation, magnifying and tensioning functions.

(3) Recognition problems of QR code

In the recognition of QR code, the user first confirms the position of sign in the image (recognition of fixed part in the image); then reads the data. It is easy to read so long as inspected part is recognized. Therefore, the whole inspected part is adopted as a recognition model. Recognition is the main problem [4].

3.2. Model establishment in the model recognition

The version of QR code is defined into V; "N" modules are adopted for inspection and recognition:

$$N = 64*3+1+((21+4*(\nu-1))-16)*2$$
$$(\nu \in [1.40], \text{integral number}) \quad (1)$$

The integration of position inspection module of QR code sign is adopted as a recognition model; one model is adopted as one point. The point sequence P of recognition model is as follows:

$$P = \{p(x_1, y_1), p(x_2, y_2), \wedge, p(x_N, y_N)\} \quad (2)$$

Where: (x_i, y_i) refers to the coordinate of gravity (x_0, y_0) relative to the original point of model: QR code sign. P(*) refers to the ash degree; the model is magnified for M times; θ is rotated and oθriginal point of model is moved to (x_i, y_i). Then point sequence P is changed into Q:

$$Q = \{p(x_1^*, y_1^*), p(x_2^*, y_2^*), \wedge, p(x_N^*, y_N^*)\ \} \quad (3)$$

Where:

$$\begin{pmatrix} x_j^* \\ y_j^* \end{pmatrix} = M \cdot \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \cdot \begin{pmatrix} x_j \\ y_j \end{pmatrix} + \begin{pmatrix} x_c \\ y_c \end{pmatrix},$$
$$(j = 1, 2, \cdots, N) \quad (4)$$

The ash degree of point sequence Q is obtained from the image and comparison is made with the ash degree in point sequence P. The point quantity based on $p(x_j^*, y_j^*) = p(x_j, y_j)$ (j=1,2...,N) is marked with n_b. In the designed image, the matching ratio between point sequence and recognition model is R:

$$R = \frac{n_b}{N}, \quad R \in [0,1] \quad (5)$$

Larger R leads to higher recognition degree; therefore, recognition of QR code is transformed into maximum matching rate R in 4D space (x_c, y_c, M, θ θ). This problem is suitable to Genetic Algorithm [5–7].

3.3. Application of Genetic Algorithms for recognition

The Genetic Algorithm mainly follows this idea: First, establish a group of candidate solutions; according to certain adaptability conditions, measure and calculate the adaptability of these candidate solutions; according to the adaptability, reserve certain candidate solutions and abandon others; operate the reserved candidate solutions and produce new candidate solutions. In the Genetic Algorithm, the said features are integrated by a special method: parallel search based on the chromosome, selective operation, exchange operation and mutation operation with guessing property. The special integration distinguishes Genetic Algorithm from other search calculation methods.

3.3.1. Encoding strategy

As for the maximum matching rate R of said 4D space (x_c,y_c,M, θ θ), the genetic type G_k in the$_k$ individual I_k(k=1,2,3…) of Genetic Algorithm is defined as follows:

$$G_k = (x_{ck}, y_{ck}, M_k, \theta_k) \quad (6)$$

Where: x_{ck}, y_{ck}, M_k and θ_k refer to the expression forms of x_c, y_c, M and θ with same meaning. G_k is deemed as one point in 4D space and corresponding to the expression form H_k as follows:

$$H_k = \{h_{kl}(x_{k1}^*, y_{k1}^*), h_{k2}(x_{k2}^*, y_{k2}^*), \ldots h_{kN}(x_{kN}^*, y_{kN}^*)\} \quad (7)$$

Where:

$$\begin{pmatrix} x_{kj}^* \\ y_{kj}^* \end{pmatrix} = M . \begin{pmatrix} \cos\theta_k & -\sin\theta_k \\ \sin\theta_k & \cos\theta_k \end{pmatrix} . \begin{pmatrix} x_{kj} \\ y_{kj} \end{pmatrix} + \begin{pmatrix} x_{kj} \\ y_{kj} \end{pmatrix}, (j = 1, 2, ...N) . \quad (8)$$

According to the physical restriction features of image, the value scope and mutual mapping relationship of expression form H_k are confirmed as follows:

The image width is w and height is h; we can know from restriction 1 that: w ≥ h. QR code sign is u in side length; we can know from restriction 2 that: u ≤ h. Since the image topic is QR code, u ≥ $\frac{3}{4}$ h is adopted. Therefore, $x_c \in \left[\frac{3}{8}h, \frac{5}{8}h\right]$. Since the expression form x_{ck} and $y_{ck}$are binary system codes, the value direction of x_{ck} and $y_{ck}$is expanded: $x_{ck} \in [0,127]$, $y_{ck} \in [0,63]$ in order to overcome rather large Hamming distance in binary system code and precision mapping error in the discretion of continuous function. In x direction, the offset step length is e_k=

$\frac{w-\frac{3}{4}h}{128}$; in y direction, the offset step length is $e_k = \frac{h}{256}$. Therefore, the relationship between expression form and $\frac{h}{256}$ image in the gene is as follows.

$$x_c = \frac{3}{8}h + e_k(1+x_{ck}), y_c = \frac{3}{8}h + e_y(1+y_{ck}) \qquad (9)$$

In the image, QR code sign is defined to have a land area of s: $s \in [\frac{9}{16}h^2, h^2]$. The minimum area change is $\frac{1}{16}h^2$; then scope of expression form M_k under M magnifying times is confirmed as follows:

$$M_k\ [0,7] \text{ and } M = \frac{9}{16} + \frac{1}{16}h^2 M_k \qquad (10)$$

Given subjective factors in the photography, if the rotational angle is assumed to have a unit of 45 degrees, then $\theta = 450_k$, $\theta \in [0,7]$.

We can confirm the full length of chromosome G_k code to be 19 digits:

$$G_k = \boxed{x_{ck}}\boxed{y_{ck}}\boxed{M_k}\boxed{\theta_k}$$

3.3.2. Definition of adaptability

The individual adaptability adopts matching rate as the evaluation basis. Since the previously defined general points of QR code sign contain numerous pixels in the image, a slight tension is realized in the photography and rotational angle can not be absolutely fixed; therefore, it is difficult to evaluate according to 100% pixel matching rate contained by the points. 75% pixel matching rate is set up in the point, which is compatible.

3.3.3. Definition of crossing

First, it sets up a crossing factor; in each candidate solution, selects partial candidate solution formulated in the crossing factor for crossed operation. The crossed operation aims at four parameters: position (x, y), magnifying time (M) and rotational angle (θ)'s average value [8].

3.3.4. Definition of mutation

First, it offers a mutation factor; executes mutation to four parameters in the candidate solution; follows the mutation principle of "less mutation for high adaptability, less mutation for position parameters with poor adaptability, more mutation for rotational parameters and more mutation for magnifying times"; upon mutation, possible solution replaces the previous solution; in case of convergence of possible solution, the mutation factor is gradually reduced.

3.3.5. Convergence principle

i. Evolve algebra into a set upper boundary I.
ii. Terminate the evolution if new best point does not occur for ten consecutive times.

3.3.6. Calculation methods and procedures

i. Make a random search and obtain the initial cluster.
ii. Calculate the adaption value; judge the termination of calculation methods; if yes, transfer to "v".
iii. Execute inheriting operation.
iv. Judge the best solution: if yes, transfer to "v"; if no, transfer to "iii".
v. Output result.

3.4. Test result and analysis

In order to verify the effectiveness of calculation methods, the recognition parameters are set up as follows:

Form 1. Parameters of Genetic Algorithms.

Parameters of calculation methods	Value
Cluster dimension	100
Iteration frequency	150
Crossing probability	0.8
Mutation probability	0.02
Test frequency	20

QR code image in Figure 2 is recognized; Figure 1 demonstrates the iteration process of best adaptation value tested by Genetic Algorithm. The horizontal coordinate is the iteration frequency and vertical coordinate is the best value until now (best value in the whole range). According to the figure, image is basically converged to the best solution after 60 generations; it is difficult to obtain the best solution with random search system.

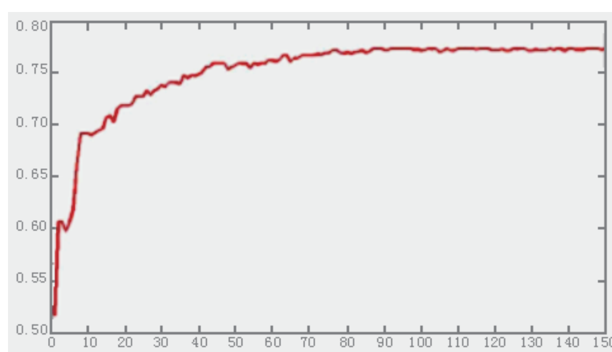

Figure 1. Iteration process of GA algorithm.

Figure 2a. Original figure.

Figure 2b. Result figure.

4. Conclusion

Currently, most urban rail transits have adopted IC card technology, yet a huge amount of passengers have to wait and buy tickets in the railway stations or stations located in large-scale shopping malls. As a result, there exists potential safety hazard to the operation department. We hereby propose the electronic ticket system based on mobile 2D barcode in order to reduce queuing time of passengers. The integration of the existing mobile and 2D barcode technologies could improve the automation degree of rail transits and transportation departments, and assist the better performance of automatic ticket sales and inspection system. How to swiftly and effectively recognize 2D barcode in the mobile is the core system technology, which was the focus of this paper. The research reveals that as the electronic ticket, QR Code can realize swift reading and recognition. The ticket sales and inspection system of rail transits based on 2D barcode is able to meet the ticket procurement demand for a huge amount of passengers. This finding is important for both reference and application.

References

1. Ning, F. (2009). Research on Ticket System of Dedicated Passenger Line. *Application of Railway Computer*, *18*.
2. Pan, J. C. (2009). 2D Barcode Technology and Application. *Modernization of Shopping Mall, 03*.
3. Liu, N. Z. (2003). Research on High-dimensional Barcode Recognition Technology and Encoding Theory. *Nanjing: Nanjing University of Technology*.
4. Chen, Y. Y., & Shi, P. F. (2006). Recognition and Application of 2D Barcode. *Measuring and Control Technology*, *25*(12), 17—19.
5. Wang, Q. (2007). Encoding, Decoding and System Realization of 2D Barcode. *Shanghai: Shanghai Jiaotong University*.
6. Peng, X.B., & Jiang, J. G. (2006). Division Technology of Image Threshold Value Based on Brightness Balance. *Computer Technology and Development, 16*(11), 10—12.
7. Jiao, Y. Q., & Zhang, C. H. (1996). 2D Barcode Technology. *Beijing: China Price Press.*.
8. Liu, N. Z. & Yang, J. Y. (2004). 2D Barcode Recognition Based on Wave Form Analysis. *Computer Research and Development*, *41*(3), 463—469.