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Fast Algorithm for Recognition of 2D Barcode: A Review

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ABSTRACT
Mobile phones with cameras are the most popular combination for 2D bar code reading, which has increased the commercial values to use camera phones. The reported work provides discussions on introducing solutions of the difficulties introduced by low image quality which is the most commonly found in barcode images taken by a phone camera. This study also compares results of different approaches used for recognition of 2D barcodes. The relevant discussion on Fourier-Radon transform has been made to estimate the parameters of the blurring kernel with improved robustness to noise over available techniques. Experiments on both simulated and real images have shown that blurring kernels can be accurately identified for a wider range of motion types. For localization of 2D barcodes edge tracing is also proposed for further validate the initially localized corners. For recognition of 2D barcodes by Richardson Lucy Method is also discussed.

Keywords-*2D codes, QR code, Radon Transform, Lucy-Richardson*

INTRODUCTION

A barcode is an optically machine-readable illustration of data relating to the object to which it is affixed. Linear or one dimensional barcodes are represented by changing the widths and spacing of parallel lines in barcode. Later by using hexagons, rectangles, dots and other geometric patterns two dimensional codes (2D codes) were developed. The QR code (Quick Response Code) is a two-dimensional information storage tool developed by the Japanese company Denso-Wave in 1994, and was approved as an ISO international standard and Chinese National Standard in 2000. Nowadays, the QR code has been widely used as part of daily life due to its good features such as square shaped and contains smaller squares, large capacity for data encoding, high scanning speed, dirt and damage resistant, high speed reading, small print out size, 360 degree reading and structural flexibility of various applications. In QR codes, the information is encoded to the position of the small squares whereas in 1D code in which the length of the lines does not hold information. It is designed to encode the full 256 byte ASCII character set as well as the Kanji (Shift-JIS character set). QR Codes are available in 40 different square sizes each with a user selectable error correction level L, M, Q and H in four steps. With the highest level of error correction used, up to approximately 30% of the code words which are damaged can be restored. Some mobile manufactures are providing software to aid in interpreting QR codes for free.

Structure of QR Barcode

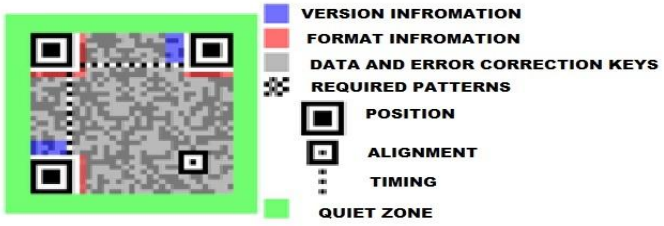

Figure.1: Structure of QR barcode.

FINDER PATTERN

A pattern for detecting the position of the QR Code. It is a pattern which comprises of large black and white identical squares arranged in the corners of the QR Code, except for the bottom right corner. By arranging this pattern at the three corners of a symbol, the position, the size, and the angle of the symbol can be detected. The finder pattern can be detected in all directions (360°). The finder patterns enable the decoder software to recognize the QR Code and determine the correct orientation.

ALIGNMENT PATTERN

It is a pattern for correcting the distortion of the QR Code. It is positioned symmetrically on either side of the diagonal running from the top left corner of the symbol to the bottom right corner. These patterns are spaced as evenly as possible between the Timing Pattern and the opposite side of the symbol. It is a Pattern for correcting the distortion of the QR Code. It is highly effective for correcting nonlinear distortions. The central coordinate of the alignment pattern will be identified to correct the distortion of the symbol. For this purpose, a black isolated cell is placed in the alignment pattern to make it easier to detect the central coordinate of the alignment pattern.

TIMING PATTERN

It is a pattern that is arranged in both vertical and horizontal directions. Basically, it is used for identifying the central coordinate of each cell in the QR Code with black and white patterns arranged alternately and for correcting the central coordinate of the data cell when the symbol is distorted or when there is an error for the cell pitch.

QUIET ZONE

It is a margin space necessary for reading the QR Code. In addition to this, quiet zone makes it easier to have the symbol detected from among the image read by the CCD sensor. Four or more cells are necessary for the quiet zone.

DATA AREA

The data area is used to store QR code data. It is the grey part as represented in the figure 1. On the basis of encoding rule, QR code data will be encoded into the binary numbers of '0' and '1'. The binary numbers of '0' and '1' will be converted into black and white cells and then will be arranged. The data area will have Reed-Solomon codes incorporated for the stored data and the error correction functionality [3].

Applications of QR codes

Magazine/Newspaper And Notebooks
Business Cards
Food Products
Note Book And Book
Concert Venue
Clothing Labels
History Sites
Online Banking
Online wallet: Paytm
Bus Schedules

Scope of QR Barcodes

Now a day's QR barcode has been used frequently. QR barcodes can be seen on the posters for advertisement, business cards, and party invitations. One need to do is to click an image of the QR barcode with the help of phone having camera and the image can be decoded with the help of decoding application of phone. But the case may be that the images taken are under different condition i.e. under uneven illumination, low contrast, and the image may not be a proper square etc so before decoding the image we need to enhance the image first or it may need some geometric corrections. Algorithms had been generated to correct the distorted geometry of the QR barcode. Canny edge detection method is used to find the external contour. At least two advantages of Canny edge detection is estimated, one is filtering quasi-squares, the other is reducing computation in finding contours the inverse perspective transformation method was used to normalize the code shape. In previous work on 2D codes, authors have worked on many applications such as (in references) are Feng Liu, Anan Liu, Meng Wang, Zhaoxuan Yang have worked on Radon Transform and Hough Transform on data matrix and shows that localization speed is 67 barcodes/sec for Hough Transform, 78 barcodes/sec

for Radon Transform whereas proposed method is more efficient having 159 barcodes/sec speed for localization[1]. Kinjal H. Pandya1, Hiren J. Galiyawala concludes that there are many possibilities for using QR codes in different areas such as security, better recognition, reducing redundancy in order to save space, possibility of encoding different kind of data like audio, etc. QR codes have structural flexibility so, there is scope to perform experiments to improve data capacity of QR Codes, use of coding techniques other than RS coding and use of encryption to encode data first, and then encode it to QR code for better security solutions[2]. Manpreet Kaur performs recognition of 2D QR bar codes by using Lucy Richardson method and describes deblurring, localization and geometric correction. Abhishek Mehta takes account on QR codes basics, real application in day to day and associated research areas. With the technology of mobile phones constantly emerging, especially in the area of mobile internet access, QR codes seem to be an adequate tool to quickly and efficiently converse URLs to users. QR codes are also used in offline media such as magazines, newspapers, business cards, public transport vehicles, signs, t-shirts. Any other medium that can embrace the print of a QR code can be used as carriers for advertisements of online products. Pattern extraction: image pre-processing, Tilt Correction, Geometric Correction, Image Normalization, Segmentation and localization, feature Extraction, and classification were proposed by author [4]. Young Sil Lee proposed a new Online Banking Authentication system. It uses Mobile OTP with the combination of QR-code which is a variant of the 2D barcode in order to handle emergency situations to do online banking which cannot be done without security card[5]. Guenther Starnberger, Lorenz Froihofer and Karl M. Goeschka proposed QR-TANs are a transaction authentication technique based on 2D barcodes for providing security of electronic transactions which in turn depends on security of the user's terminal and advantage of QR-TANs over existing authentication techniques is that they do not require any additional software installation on the terminal, while a software implementation QR-TAN authentication technique is required on the trusted device[6]. By using the camera phones 2D barcodes can be read at much faster rate, hence they can be encode and decode efficiently. Contextual QR codes were introduced by few researchers as a result of which public code and private information was combined to provide data related to a particular context. For example the user scans a generic "Hello World" XML message and obtains a personalized as well as contextual message. Another example, users were allowed to scan a QR Code that contains public information about a meeting (venue, time, date etc).The combination of these data with the ones given during the interaction (i.e. name, location, language used) was send to a web service able to manage the provided information. Finally the result of interpretation of the contextualized QR Code was received by the user. Most of the electronic transactions have a common problem that is for electronic signatures the user depends on a client who cannot be trusted. Even in case of using a secure smart card, the user is mostly not able to assert the displayed information on screen which is actually equal to the information signed by smart card. The examples also include online banking and electronic signatures for contracts. QR-TAN (Quick Response-Transaction Authentication Numbers) is the proposed authentication technique by researchers. In order to fit the capabilities of commonly used Web-based applications, QR-TANs use a method based on transaction-signing. QR-TANs were based on 2D QR barcodes and allow a user to validate and approve a transaction using an untrusted terminal over an untrusted network. The security of QR-TANs is provided by the terminal so one can place any requirements. Even if an attacker has complete control over the terminal, then this would still not affect the security of QR-TANs. Now days, electronic banking services are increasing at rapid pace and existing online banking requires the usage of security card from each bank which does not match modern mobile environment. Online banking authentication system using 2D

barcode is more useful than security card because if there is an emergency situation occurs, even then online banking cannot work without security card. QR Code is generated by the bank by using user input transfer information. Then the user needs to recognize the code by using mobile phone. Finally, the transfer is terminated by user typing the generated OTP Code on the screen. An OTP is a generated password which can be validated once. An algorithm and cryptographic keys are used to generate an OTP by user's device. On the server side the validity of the password can be checked by sharing the same algorithm and keys. Researchers proposed an effective recognition method by using QR Code symbolic characteristics and they also analyse the localization and rotation of QR code and found out ways to rectify geometric distortion of QR code. The position patterns of QR Code symbols are consist of three location detection graphics, which are positioned in upper left comer, top right and bottom left directions. As the faintness of the edge and randomness of encode data, we are often difficult to judge the graphics. We can detect the distance relationship among the locating probe graphics and eventually determine the location detection graphics by using special features of QR codes. Owing to the shooting angle and image distortion, we may get the geometric distortion images when we recognize the QR bars. The barcode images which we get may be quadrilaterals instead of perfect squares. Because of the presence of geometric distortion, it makes the QR bar code symbols difficult to identify the position and orientation as well as bring a significant difference; therefore, we can correct the QR image according to the symbols feature of QR code. After determining the three position detecting images, we need to determine the direction of the bar code. We can be directly connected to the centre of a position patterns by using Hough transform to form a triangle. Geometric distortion correction was based on bilinear transform and Interpolation method. As the QR code symbol has not the start symbol and terminator, and all around it is maybe also the interference of irrelevant information, so we cannot use scanning algorithm to get barcode boundary directly. Correction of geometric distortion-free images by using bilinear transform was used. On the rotation of QR code images, because the coordinate after transformation is not an integer, it is necessary to estimate the coordinate values of pixels after transformation. Here is the bilinear interpolation algorithm. It solves problems of the image size and the position of interference under rotation and transformation, and has the high ability of interference with irrelevant information and pollution. In the final, by using bilinear interpolation algorithm, it solves the transformation problems in rotating space on the barcode image geometric distortion correction.

Discussion on Localization of 2D Barcodes by using Edge Detection, Corner Detection and Radon Transform

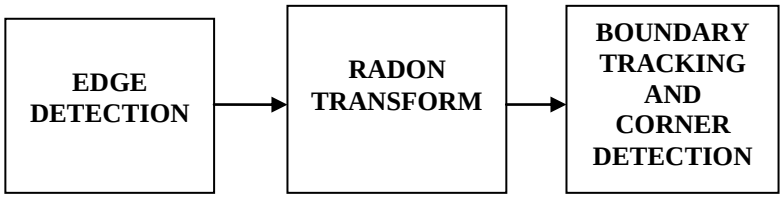

Figure.2: Steps to locate barcode

The recognition of 2D barcodes includes edge detection, corner detection and radon transform. The Laplacian of Gaussian also refers as edge detection is a 2D isotropic measure of 2nd spatial derivative of an image. The Laplacian of an image Highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian L(x,y) of an image with pixel intensity values I(x,y) is given by:

$$L(x,y) = \frac{\partial^2 I}{\partial X^2} + \frac{\partial^2 I}{\partial Y^2} \quad (1)$$

In order to reduce the sensitivity to noise Laplacian are applied to an image that has been firstly smoothed by approximating Gaussian smoothing filter. Following the above process has advantages that are both the Gaussian and the Laplacian kernels are much smaller as compared to the image, so this method usually requires fewer arithmetic operations.

At the run time only one convolution needs to be performed as log kernel can be recalculated in advance.

A modified version of Features from Accelerated segment test (FAST) corner detection algorithm is used to locate each of the four corners of 2D barcode. FAST Corner detection algorithm was simple to implement, faster in operation and it uses the convolution function. The above algorithm was implemented on radius of 3 by ignoring all the pixels that have corner heuristic less than 10 because they are usually residual noise along the edge of the barcode. Radon Transform named after the Austrian mathematician Johann Radon, is the integral transform consisting of the integral of a function over straight lines. It was introduced in 1917 by Johan Radon. The radon function is used to compute the projections of an image matrix, line integrals from multiple sources along parallel paths or beams which are apart by 1pixel unit. It also include des multiple, parallel-beam projections of the image from various angles by rotating the source around the centre of the image. The test data includes 50 images (320*480) which were captured in uneven illumination and have low contrast between barcode and the background. The proposed algorithm gives 90.5% accuracy at 10% pixel level rate and average speed (barcodes/sec) is 90.

Deblurring the Image by Lucy Richardson Method

The problems that arise while capturing the image by using mobile camera includes low contrast, uneven illumination and blur motion and geometry of the code may be distorted if the angle of projection is not correct. As a result of which the QR code is not readable because it is required that QR Code should be a perfect square and image should not be blurred. The Lucy-Richardson algorithm is used to deblur the image by using deconvlucy function. The algorithm maximizes the likelihood that the resulting image, when convolved with the PSF, is an instance of the blurred image, assuming Poisson noise statistics [2]. Deconvlucy function is effectively useful provided PSF is known with little information about noise. For deblurring the image different values of blur length (Len) and blur angle (theta) were selected to check that at which value of LEN and THETA the image is deblurred and code is readable. This method is accurate for lengths between 10 to 40 and breaks down at large blur lengths. The experiment was performed on database set of 50 images and time estimated to read 50 deblurred images was 14.1 sec.

CONCLUSIONS

The review of literature is performed which helps in the identification of some potential research issues pertaining to the areas where QR barcodes have been used and also provides information regarding recognition of QR barcode by using different algorithm with images captured in different conditions. It has been observed by researchers in the existing literature that there are many approaches for accomplishing the above mentioned inspection task.

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