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A Removes Scratches from QR Code Image

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Abstract: ***An advanced technique was developed to remove scratches from damaged QR codes.Some curtain areas were considered as information areas of the QR code. To extract scratches from damaged QR code, HSV (Hue, Saturation and Value) was applied. The QR code decoding algorithm was unable to operate if the scratch on the QR code exceeded the error correction level threshold. A morphological image processing technique was applied, starting with adilation process to change the image structure and allow the scratch to become even more obvious. A clear scratch can be more easily deleted. To increase the efficiency of decoding, a median filter algorithm was applied by transforming the image into binary to remove local noise.***

Keywords: QR Code, HSV, Median Filter

1. Introduction

QR code stands for Quick Response Code and is well known in the 2D barcode industry. This code is efficient with high accuracy and reading speed. Blackberry integrates QR code functionality into their devices as an alternative method for users to invite people to join their contact list. QR codes provide both encryption and decryption. Users can create and convert unique Blackberry pins into their personal QR codes for other users to scan and decipher. Decoded users can then be added to contact lists. QR codes are familiar to Thaisas 2D international standard barcodes with high efficiency and excellent features. QR codes are developed continuously by Denso Wave [4].Today, with enhanced ability to store additional data, QR code can store up to 7,089 numbers. Data can be stored in different formats as letters, numbers, Kanji characters, symbols, binary and control codes.

In the decoding process, the curtain array can interfere and cause image distortion. One type of distortion occurs as scratches or damage applied to images after the encoding process is completed. QR code features also include an error correction level. This allows corrections of up to 30%. However, there are limitations and distortions cannot be corrected in certain curtain areas. The decoding process focuses on two different colours as black and white. Damage only occurs to the black areas of the matrix. This problem inspired this research. The experiment to remove scratches and damage from the QR code involved several techniques including HSV (colour segmentation), stem and binary image processing and median filters(noise reduction).The next section explains the QR code in detail, while the third section explains ways to remove scratches from the QR code. Results and analysis are presented in section four, with conclusions and recommendations for future studies in section five.

2. Methodology

a) Quick Response (QR) Codes

A quick response (QR) code is a type of barcode that stores information and can be read by a digital device. QR codes are used to track information about products and frequently employed in marketing and advertising campaigns. QR codes consist of black squares arranged in a grid (matrix) on a white background. QR code readers extract data from the patterns present in the QR code matrix. QR codes are considered more advanced than older, one-dimensional barcodes.

Figure 1: One-dimensional bar code

Figure 2: Two-dimensional bar code (QR code)

b) Structure of QR Codes

There is no official QR code standard and decoding programs maintain the most popular formats.

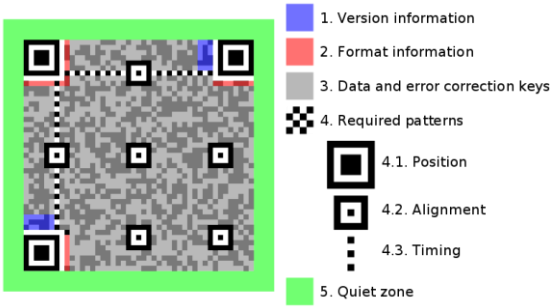


Figure 3: Structure of a QR code

The QR code structure includes:

1) Version information: This pattern of the image contains encoded information about the version of the code. All versions are directly connected with their dimensions and the amount of data that can be encoded varies from the first, the smallest to the fortieth, the largest.
2) Format information: This area of the image helps the scanning device to define the data format encoded in the QR code. This may be contact information, calendar date or the web site link.

3) Data and error correction keys: A QR code always has an image of a square. The main element of the code is its matrix. The elaborate pattern consisting of black squares and lines, called modules, contains different information. The number of modules varies according to the amount of information that is encoded to the image.
4) Required patterns:
   4.1. Position: These patterns are placed at the corners of the image, except for the left.
   4.2. Alignment: There may be several patterns according to the version of the QR code.
   4.3. Timing: These patterns are situated between the three position patterns and look like a line of alternating dark and light (black and white) squares.
5) Quiet zone: This is represented as a blank margin on either side of a bar code. It is used to tell the barcode reader where the symbology of the barcode starts and stops.

c) Error Correction in QR Codes

Error correction in QR codes is classified into four levels. Error correction can restore data even if the QR code contains damages such as scratches. The damage portion is calculated as a percentage of the QR code area. This must be less than the error correction level to restore the data. However, the damage must not infect a certain area, called a Finding Pattern or Format Area, as this contains essential information concerning the decoding process. This process halts if the Finding Pattern or Format Area is damaged [2].

Figure 4: QR code is unable to decode as an essential area has been damaged

3. Theories

Recording devices capture images for decoding process information of the colour base. The priority of image segmentation is to analyse either interesting objects or non-interesting objects.

a) Steps for Decoding the QR Code

Steps to remove the QR code [4]were identified as opposed to encoding as shown in Fig. 5.

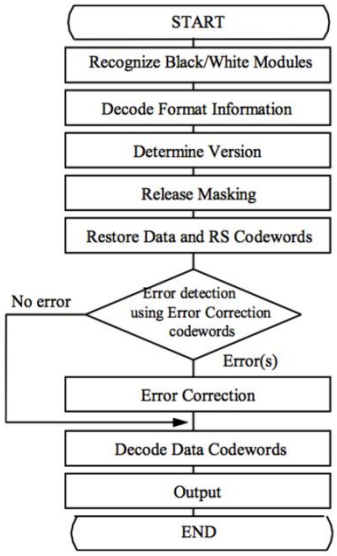


Figure 5: Steps to remove the QR code

b) Colour Model

Image Segmentation using Hue, Saturation and Value (HSV)

HSV allows the use of colour more easily than the standard red, green, blue (RGB) and was created as an alternative, shown in Fig. 5[1]. For example, in a colour such as yellow, it is difficult to distinguish a group of yellow colours. Light yellow, dark yellow and even brown are considered as a yellow base from the design point of view.

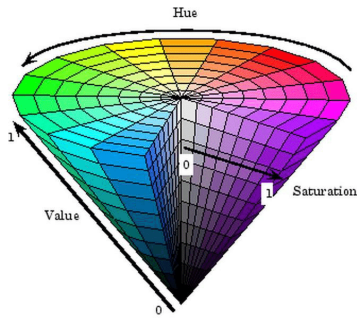


Figure 6: Colour model HSV

- H (Hue) refers to the value of colour such as red, yellow and green measured as the angle from 0 to 360 degrees. Red, yellow and green colours are different at60 degrees.
- S (Saturation) is the intensity of colour as purity of the colour values from 0 to 100. When colour intensity increases, the saturation value also increases.
- V (Value) is the brightness of the colour from 0 to 100. Increasing the brightness of the picture results in increasing its Value. Any value of Hue with Saturation of 0 and Value (brightness) of 100 will represent a white colour, while any configuration with Value (brightness) of 0 will represent as black.
- Assume that Hue is a yellow colour with Saturation of 100. Maximum brightness will represent as yellow, while minimum brightness will represent as black. Advantages of using the HSV Model include the least variation with a light beam. Values of HSV are more familiar with humans. Therefore, HSV was selected as suitable for use with a QR code for this research [5].

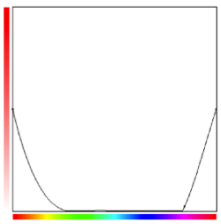


Figure 7: HSV curve

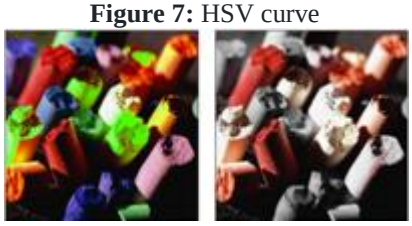


Figure 8: Original image and results obtained from HSV adjustment

c) Binary Image

A binary image has two different levels as black and white, with values 0 and 1 respectively. There are only two levels of intensity in a binary image. Pixels that have low intensity are image pixels and those with high intensity are background pixels. A QR barcode is two dimensional with only two colours as black and white in similar aspect ratios. Before the removal of Noise using a median filter, the image must be converted to a binary image to obtain more effective results.

d) Morphological Image Processing

Here, a dilation technique was used as a morphological operation to remove the scratch on the image surface and focused on binary images. The technique adds white spots and reduces the number of black spots.

e) Median Filter

A median filter calculates the mean value of the neighbourhood. The median filter is a very popular technique for the removal of random noise and can significantly reduce blurring. Median filters are very effective when associated with impulse noise, called 'salt-and-pepper' noise, for white and black spots scattered on the image.

Figure 9: Comparison of QR code with/without a median filter

4. Experimental Results and Analysis

4.1 Experimental Procedure

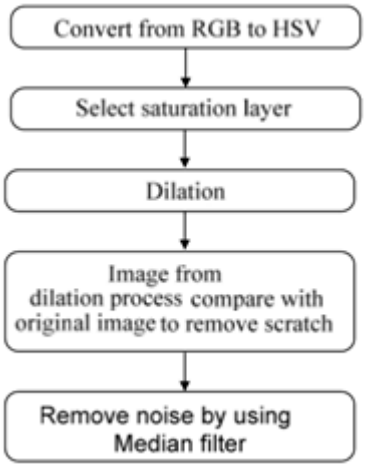


Figure 10: Separation process for removing scratches on QR code

a) Conversion from RGB to HSV

The image was captured and processed by the camera as an RGB colour value. The light source was divided into three domain colours as red, green and blue. The RGB values are bright and it is necessary to convert from an RGB to an HSV Model. Fig. 11shows each model layer of RGB and the result of conversion to HSV is shown in Fig. 12.

Figure 11: Image in RGB Model

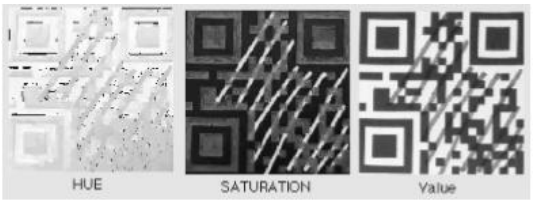


Figure 12: Image in HSV Model

Comparison of the histograms from the test provided sufficient detail to help ease the level of optimisation. The scratched image had a saturation value between 0.5 and1 optimisation limits.

Figure 13: Scratched images after optimisation criteria

b) Comparing the Damage of QR Codes with Results to Remove Scratches

QR codes usually consist of black and white squares. as shown in Fig. 14.

Figure 14: Results of the scratch process

c) Convert Binary Images

To be decoded by a decoder the QR code image must be composed of only black and white squares. The QR code image from the scratch removing process is not ready for decoding if the image is not clear enough. Therefore, conversion to a binary image is required as only two domains which are black and white as 0 and 1 respectively. The result is shown in Fig. 15. The binary image can be read and decoded by the decoder using the QR code reader software in a modern cell phone [3].

Figure 15: Binary image

d) Remove Noise by Median Filter

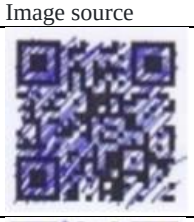
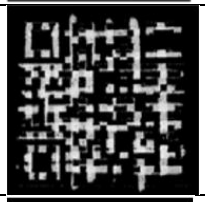
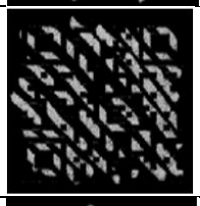
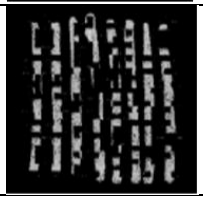
To maximize the quality of the QR code a median filter is needed. This provides a satisfactory result in binary form. Fig. 16 shows the result of using a 3x3 median filter.

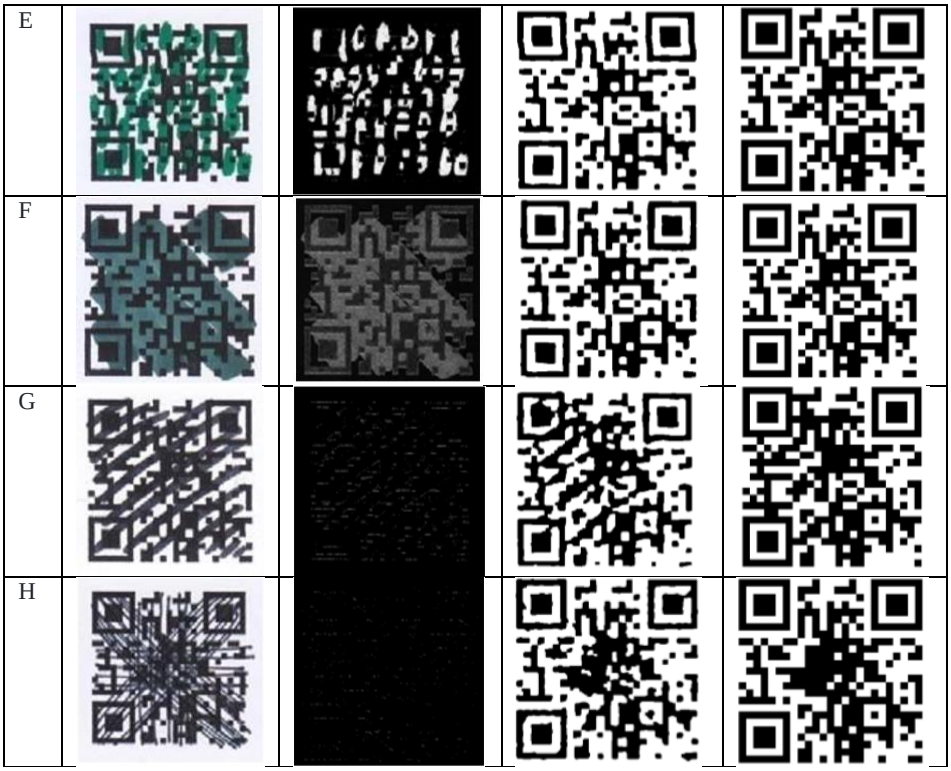
Figure 16: Comparison of QR codes with/without a median filter

5. Experimental Results

Eight samples of the QR code were selected for the trial. Each illustration in Table 1 shows a different pattern of scratches located on the surface of the image.

Table 1: Comparison between image source and output from image processing

No	Image source	Scratches	Noise	Output
A				
B				
C				
D				



The experimental results show that images sources G and H, which are written with a black pen cannot be read as QR codes efficiently, while images A-F, which are written with blue, red and green pen scan be read and decoded efficiently.

6. Conclusions and Future Work

This paper used image processing techniques to achieve the next level. The process consisted of image segmentation by HSV, binary image magnification and noise reduction using median filters. A sample of damaged QR code was prepared with scratches. QR code software on a mobile phone was unable to decipher the current situation of the image. The damage on the QR code was resolved using well-researched techniques. Based on the experimental results, images were improved by image processing techniques and could be decoded with standard mobile QR code software without data loss. These image processing techniques and procedures are effective and can be used as advanced QR code processing. However, if the scratch colour intensity is close to black or the threshold level limit cannot be adjusted, the key significance value may increase.

References

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