ABSTRACT: Quick Response (QR) code is 2d code and widely used in magazine advertisement, product packet, museum, and tour tickets. It has high data capacity compare to 1d code. The invisible QR code is watermarked via popular wavelet transform algorithm in images. The results show that the proposed method is robust and tested against attacks.

KEYWORDS: QR code, watermarking, Wavelets.

I. INTRODUCTION

In this modern era mobile and wireless technology is taking over all fields of life. They are more than a communication device; they act as your PC, music player, your bank, your shopping area and more [1]. In near future the smart glasses like google glass are going to replace the current hand held devices which make to overlay the physical world with a digital layer of tags, ads, maps etc [2].

In current smart phone scenario, one of the important technology used to connect the physical world to internet or digital world using smart phone, is QR codes. They are used mainly for marketing and commerce but their applications are numerous including virtual marketing, virtual maps, QRpedia etc. We are making the QR code as invisible watermark in image using digital watermarking technology. Other alternatives proposed were marking QR code in invisible ink which is only visible with Ultraviolet [3], QR transparent stickers etc.

The main challenge in making invisible QR code is the detector part. Since the detection is expected to be done in smart phone which has slower processors, the detection must be very simple with very little processing required before passing information to QR reader. Here we implement and simulate the QR encoder and decoder in MATLAB to study the effectiveness of algorithm. This paper uses watermarking scheme in wavelet domain where multiple copies of QR code is inserted into low frequency components of host image. Since the data requires no secrecy compared to existing watermarking schemes, public watermarking technique is used [4] [5] [6].
The watermarking is intended to encode secret or copyright information into host digital data to demonstrate and protect the ownership of products. But in this paper we use this technology to hide QR code in the background rather than using it to protect the information. Anyway the same methodologies used in this paper can be used for copyright protection process. In this paper invisible watermarking of QR code is done in wavelet domain.

The main advantages of invisible QR Code are 1. As opposed to adding yet another element to the marketing piece or direct mailer, marketers can use existing images within the material to use as a code; 2. It won’t waste advertisement area with QR.

This paper is organized as follows: QR code is explained in section 2. The implementation is explained in section 3. The simulation and result are analyzed in section 4 and it followed by conclusion.

II. QR CODE

QR Code is the trademark for a type of matrix barcode, first designed for the automotive industry [7]. Two-dimensional bar code technology comparing with the traditional one-dimensional bar code has the following advantages: 1. higher information density; 2. it can express Chinese characters, images and even sound; 3. with error correction function. More recently, the system has become popular outside the industry due to its fast readability and large storage capacity compared to standard UPC barcodes. The code consists of black modules (square dots) arranged in a square pattern on a white background. QR Code is capable of handling all types of data, such as numeric and alphabetic characters, Kanji, Kana, Hiragana, symbols, binary, and control codes. Up to 7,089 characters can be encoded in one symbol [6]. Data can be restored even if the symbol is partially dirty or damaged. A maximum 30% of codewords can be restored. Fig. 1 shows the QR code structure.

III. IMPLEMENTATION

The invisible watermarking of QR code is done in wavelet domain as shown in Fig. 2. Discrete wavelet transform (DWT) is used due to its spatial resolution: it captures both frequency and location information (spatial information). The multilevel DWT decomposition is used (4 level Daubechies-4 wavelet transform). The block diagram of watermarking is shown in Fig. 2.
The watermark is embedded into host image in 4th level of wavelet decomposition. As we go deeper with decomposing low frequency sub image (approximate component) the data will get more concentrate on approximate component in next levels. That is information in high frequency components (horizontal, vertical and diagonal) will be very less compared to low frequency component. So inserting can be done on high frequency component since it won't destroy high amount of information. Usually these components will be black with small amount of white patches which corresponds to high frequency portion (sudden variation in brightness) of host image. So the location of insertion of watermark should be suitably selected so that it won’t include sudden variations. In this paper we use multiple watermarking techniques where three copies of QR code is inserted in all three high frequency sub images after multiple levels of wavelet decomposition. The location of insertion is made same for all the three subimages since at time of reception it would be easier in slower processors to recover QR code easily by simple pixel manipulations like addition or correlation. The location is found using approximate subimage such that in particular block selected for insertion is the one with minimum variation in pixel values.

Another important thing to be noted while insertion is the peak level of pixel value of QR code. Our empirical studies showed that the insertion with pixel value greater than one by fifteenth of mean value of approximate subimage give better results while if value exceeds one by hundredth of maximum pixel value of approximate image make the QR visible after reconstruction. So trade off done between these values to set the maximum pixel value of inserted watermark.
At decomposition phase most simple algorithm is used to decrease computational complexity. We use blind recovery technique which does not require the original image for recovery. We use QR decoder developed by Z Xing (Zebra barcode decoder an open-source, multi-format 1D/2D barcode image processing library implemented in Java, with ports to other languages powered by google code project). First we take multilevel DWT and give each high frequency subimage directly to QR decoder. In the absence of any noise it gives direct output. If QR decoder fails to decode it directly use group of subimages and use majority check to remove pixel errors and again give it to QR decoder. Still the QR coder fails which happens in presence of high noise we use threshold techniques to get a binary image with minimum bit errors compared with original QR. Our studies show that thresholding at levels between 0.3 and 0.4 gives better results. Those data are provided in simulation and analysis section. The block diagram for recovery algorithm is shown in Fig. 3.

IV. SIMULATION AND ANALYSIS

The entire simulation is done using Matlab. The algorithm is tried for more than twenty five images and the study mainly concentrated on 4 test images – Lena, Baboon, Air Plane and House Boat. The first three are 512x512 image while last one is 960x536 pixels. QR code for testing is generated using QR code generator by Z. Xing project. While the maily used QR is 33x33 pixel QR (encoded with www.facebook.com). The Peak signal to noise ratio (PSNR) is measured after embedding invisible QR code. The PSNR is given in Table 1. The qualitative result is shown in Fig. 4.

<table>
<thead>
<tr>
<th>Test Image</th>
<th>Lena</th>
<th>Baboon</th>
<th>Airplane</th>
<th>Houseboat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>512x512</td>
<td>512x512</td>
<td>512x512</td>
<td>960x536</td>
</tr>
<tr>
<td>PSNR</td>
<td>72.66</td>
<td>73.0749</td>
<td>66.5892</td>
<td>73.1276</td>
</tr>
</tbody>
</table>

Table 1: Output performance is measures using peak signal to noise ratio (PSNR) calculation

Fig. 4: The qualitative results- first image without and next same image with watermark

To find out robustness of proposed watermarking techniques, the efficiency is checked with various attacks. In our smart phone camera scenario most common attacks on images are noise due to grain, JPEG compression, cropping or white spaces at outer parts of images and rotation. We tried to model these attacks and found out robustness against them.
To analyze noise performance of decoding algorithm we used Lena test image with water mark as base. The salt and pepper noise is added and plot between PSNR and no of detection as shown in Fig. 5. The algorithm works well when PSNR is greater than 28 dB.

To find out thresholding level noise is fixed at a given value and no of bit errors are finding with thresholding level between 0 and 1. The plot for bit error vs. threshold value for salt and pepper noise at 0.05 level is shown in Fig. 6.

Fig. 7 shows watermarked image with varying level of JPEG compression. Since the watermark is inserted in wavelet domain chance of distortion is more as extend of compression increases. Simulating Lena image with various levels of JPEG compression shows that faithful detection is not possible if compression is more than 60%. One of the highest probable chances of attack on watermark image is cropping. The chance of small parts at outer ridge of image be cropped while taking photo in mobile camera is more. To avoid data loss due to these type of attack a 10% margin is set where watermark is not inserted. Even though for smaller images if large part is got cropped chance of recovery is little due to spatial properties of wavelet transform.
V. CONCLUSION AND FUTURE WORK

In this paper we try to model a new scheme to embed QR code in host images so as to make it hidden from visual perception. We used multilevel wavelet transform and multiple copies watermark is inserted for faithful and easy detection. The insertion location and value are found using algorithm. Also we checked the robustness of technique with various attacks. The results show that this scheme gives better result even in presence of noise (When PSNR greater than 28dB). It can resist JPEG compression upto 60%. Data can be recovered when image is cropped along the boundary region. However performance of this algorithm is not tested in smartphone environment in this study. We are looking into the implementation of this algorithm in android and iphone platforms and further modification based on performance.

REFERENCES


BIOGRAPHY

Jithin V M was born in Payyanur, Kerala, India in 1989. He received the B.Tech degree in Electronics and Communication Engineering from Government College of Engineering Kannur (Kerala), India in 2011. He is pursuing his M. E in Communication Engineering at BITS Pilani, Pilani Rajasthan, India. His current research interests focus on Image Processing, DSP and Wireless communication.

Gupta K K was born in UP, India in 1969. He received the PhD degree from BITS, Pilani, India in 2008. His current research interests focus on Image Processing, DSP and Instrumentation.