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Geometric Invariant Digital Image Watermarking Techniques for QR code

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Abstract – **Online media content distributions require methods to protect the intellectual property of distributed content. Intellectual property protection measures preserves the ownership rights of original work so that no one can plagiarize the work in any way without seeking permission for the use and, if necessary, paying a royalty for the usage. Digital watermarking is one such technology in electronic rights protection. We propose to replace the age old text watermark fitting scheme with a technology that uses a QRCode (2D Barcode) as a digital watermark. For implementing the technology we use Geometric Invariant Digital Image Water marking. QR code usage offers various levels of benefits ranging from content protection to marketing. Experimental results have demonstrated the feasibility of the technique**.

Keywords – QRCode, DWT, Geometric Invariant Techniques, Digital Image Watermarking.

I. INTRODUCTION

Barcodes, which are considered as an automatic recognition method with high-speed reading, high-accuracy, low-cost and high-reliability, is widely applied in commodity labels, data security, anti-counterfeiting, electronic commerce and many other fields. It can be classified into two types, one-dimensional (1D) barcode and two-dimensional (2D) barcode. The 1D barcodes use different width of lines and spaces to represent data, for example, code 39, code 128, EAN-13, EAN-128, ISBN, and etc. Comparing with a one-dimensional barcodes, a two-dimensional (2D) barcodes carry information along both horizontal and vertical directions, enabling greater information capacity, higher reliability and supporting different levels of error correction. So far, the common 2D barcodes are PDF417 code, Data Matrix code and QR code. Among all these codes, Quick Response (QR) code is a typical matrix two-dimensional barcode as illustrated in Fig.1.It has many advanced features, such as readability from any direction and high efficiency in storing Chinese characters.

Table 1 shows different types of 1D barcodes and 2D barcodes.

1D barcodes	Code 39	Code 128	EAN-13	ISBN
2D barcodes	QR Code	PDF417	DataMatrix	Maxi Code

TABLE 1: 1D Barcodes and 2D Barcodes.

Fig.1. Example of QR code Symbol

In generally, 1D barcodes put emphasis on “product identification” and 2D barcodes put emphasis on “product descriptions”. The security of 1D barcodes is lower than 2D barcodes.

In this paper, we describe a novel method to embed the QR code into still digital images as a digital watermark.

The rest of the paper gives a review on QR Code, Digital Watermarking and a technique how a QR Code is embedded in a still image as water mark.

II. QR CODE

QR Code is a type of 2-D (two-dimensional) symbology developed by Denso Wave (a division of Denso Corporation at that time) and released in 1994. It has large Kanji- and Kana-holding capability, and has error correction capability. Data can be restored even if the symbol is partially dirty or damaged. The following fig.2 shows the basic structure of QR code.

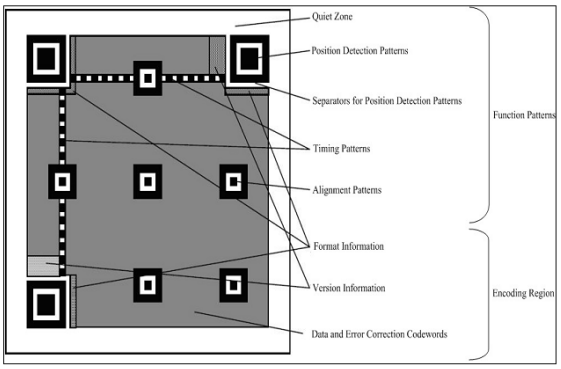

Fig.2 Basic Structure of QR Code

A. Features: QR Code provides the following features compared with conventional bar codes**.**

(i) High Capacity Encoding of Data

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.

QR Code Data capacity	
Numeric only	Max. 7,089 characters
Alphanumeric	Max. 4,296 characters
Binary (8 bits)	Max. 2,953 bytes
Kanji,full-width Kana	Max. 1,817 characters

Table 2 : Data Capacities of QR Code

(ii) Small Printout Size

Since QR Code carries information both horizontally and vertically, QR Code is capable of encoding the same amount of data in approximately one-tenth the space of a traditional bar code.

Fig.3

(iii) Kanji and Kana Capability

QR Code is capable of encoding JIS Level1 and Level 2 kanji character set. In case of Japanese, one full-width Kana or Kanji character is efficiently encoded in 13 bits, allowing *QR Code* to hold more than 20% data than other 2D symbologies.

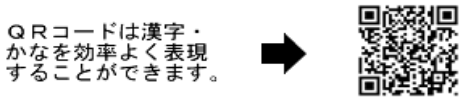

Fig.4

(iv) Dirt and Damage Resistant

QR Code has error correction capability. *Data can be restored* even if the symbol is partially dirty or damaged. A maximum 30% of codewords[*1] can be restored[*2]

Fig.5

(v) High Speed Reading

QR Code is capable of reading from any direction in 360 degree (Omni-directional). QR Code accomplishes this task through position detection patterns located at the three corners of the symbol. These position detection patterns guarantee stable high-speed reading, circumventing the negative effects of background interference.

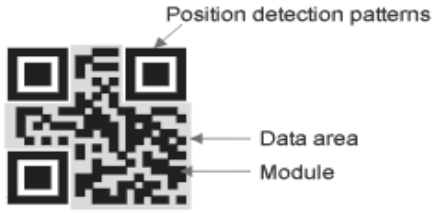

Fig.6

(vi) Structured Append Feature

QR Code can be divided into multiple data areas. Conversely, information stored in multiple QR Code symbols can be reconstructed as single data symbols. One data symbol can be divided into up to 16 symbols, allowing printing in a narrow area.

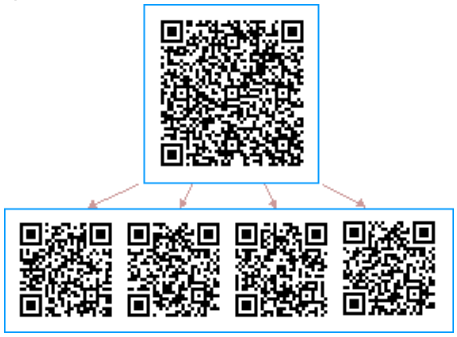

Fig.7

The same data can be read either from the upper symbol or the lower four symbols.

III. DIGITAL IMAGE WATERMARKING

With the rapid development of digital multimedia and the web technology, the application of multimedia (video, audio and image etc) has been widely spread. As the application increases, the issue on the security of the copyright has been receiving more and more attention recently. The concept of digital watermarking basically came at the time of trying to solve the problems related to the management of intellectual property of media. The basic cryptographic system allows only valid key user to access the encrypted data. But once it is decrypted it is no longer secured. So a new system which provides security even after decryption of the data is digital watermarking system. Digital watermarking is one of the effective technologies to protect the multimedia products by embedding a watermark into the target or source product. Digital watermarking is a visible or invisible identification code that is permanently embedded in to the cover data. This digital watermarking could be used to prove the reliability of products, track the pirates and authenticate the owner's right on the product. In Fig.8 a typical watermarking system is shown, which includes watermark embedder for embedding the watermark in the cover data using a secret key and watermark detector for extracting the watermark using the same key. Here key is used to make the whole system more secure .The input of the watermark detector is watermarked image, security key and original cover data.

Fig.8 A typical watermarking system

The watermark to be hidden is W, I is the cover image and K is the security key in watermarking system. The embedding function E (.) takes the watermark W, the cover image I, and security K, as the input parameters, and outputs the watermarked data I'. In Eq.1 the input parameters are given to the embedding function and it produces watermarked data as output. The input parameters are data to be marked called as cover data, watermark to be hidden and a key for hiding watermark in a secured way.

$$I' = E(I, W, k)$$

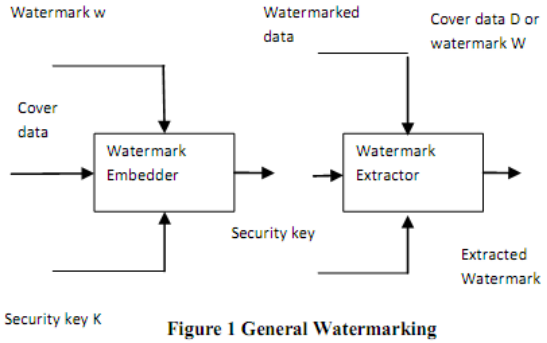

Figure 1 General Watermarking System

Theoretically the watermarking algorithm is consider as robust if it is embedded in such a way that the watermark can remain present even the watermarked data I' is passed though severe kind of distortions. The watermark detection procedure is presented in Eq. 2

$$W = D(I', k) \qquad (2)$$

The basic requirements of any watermarking system are as follows .

1. The watermark W' (extracted watermark after distortion) can be detected from I' with/without requiring explicit knowledge of I

2. I' should be very close to I in most of the possible cases

3. If I' is unchanged then detected watermark W' exactly matches W

4. In the robust watermarking, if cover image I' get modified, W' should still match W up to maximum extent to give authentication of the existence of the watermark.

5. In the fragile watermarking, if cover image I' get modified W' will also be totally changed from W even if minute change takes place in I

A. Classification of Digital Watermarking

Digital watermarking can be classified into different categories on the basis of host signal as follows

(i) Digital Image Watermarking: In present scenario most of the research in digital watermarking is focused on image watermarking. There might be many reasons behind it such that as these days many images are available on the internet at free of cost without any copyright protection mechanisms.

(ii) Digital Video Watermarking: A video sequence consists of still images therefore all the watermarking methods applied on image could also be applied on video sequences

(iii) Digital Audio Watermarking: In case of audio signals, "watermarking" can be defined as follows "Robust and inaudible transmission of additional data along with audio signals". Audio watermarking is based on the Psycho-acoustic approach of perceptual audio coding techniques.

Another classification of watermarking system is based on the domain in which the watermark is embedded. If watermark is embedded by modifying the intensity value of the pixels then it is called spatial domain watermarking, if the frequency coefficients are changed then it is called transform domain watermarking system. Many transformation techniques are used for transforming image from spatial to frequency domain which includes Discrete Fourier Transform (DFT),Discrete cosine Transform (DCT), Discrete wavelet transform (DWT) and Discrete Hadamard Transformation (DHT).

Any watermarking system must possess the following properties.

- **Robustness**
  Robustness means the embedded image should be secure against different types of attacks. A good watermarking algorithm should be robust against signal processing operations, geometric attacks such as rotation, scaling and translation and lossy compression.

- **Imperceptibility**
  Invisibility is the most important concern of the watermarked image. The embedded watermark in the cover image should not be visible. The fidelity of the cover image should be maintained.

- **Capacity**
  The maximum amount of information that can be hidden without degrading the image quality is known as the capacity of the watermark. This amount depends upon the different kinds of application e.g. copyright protection, content authentication, fingerprints, broadcast monitoring etc.

B. Geometric Distortions

Geometrical distortion includes rotation, translation, scaling and shearing, projective transformation.
Geometrical distortions are classified basically into two types

1. Global geometrical distortion
2. Local geometrical distortion

Global distortion affects all the pixels of the image in the similar manner while local distortion affects different portion of an image in different way.

Figure 2(a)

Figure 2(b)

The basic transformations which come under the geometrical distortion are as follows.

- **Rotation :** Two dimensional rotations is applied to an image by repositioning it along a circular path in two dimensional XY plane. Let f1(x.y) is achieved by rotating the image f0(x,y) by a degree of in spatial domain .

$$f1(x,y) = f0\big((xcos\theta + ysin\theta), (-xsin\theta + ycos\theta)\big) \quad (3)$$

- **Scaling:** Scaling means changing the size of an image by either multiplying or by dividing the coordinate values (x,y) by scaling factors a and b to execute the transformed coordinates .

$$\begin{cases} x' = x.a \\ y' = y.b \end{cases} \quad (4)$$

where a & b are the scaling factor along x-axis and y-axis respectively.

- **Translation:** A shift is applied to an image by repositioning it along a straight line path from one coordinate location to other. A coordinate (x,y) is translated to a new position (x',y') by Eq. (5).

$$\begin{cases} x' = x + x_0 \\ y' = y + y_0 \end{cases} \quad (5)$$

C. Invariant Techniques to Geometric Distortions

Geometric distortion affecting image and video data includes rotation, spatial scaling, and translation, skew or shear perspective transformation and change in the aspect ratio. Geometric distortion can be global; affecting all samples in same manner, or may vary locally. Although many different approaches have been investigated, robustness to geometric distortion remains one of the most difficult outstanding areas of watermarking research. Many works have been carried out to make the algorithm robust to geometric attacks. Some of the important techniques used are given below.

- **Exhaustive search**
  Exhaustive search is the simplest approach for watermark detection after the temporal and geometric distortion. It entails inverting a large number of possible distortion, and testing for a watermark after each one. As the number of possible distortion increases, the computational cost and false positive probability using this approach become unacceptable.
- **Synchronization or Registration**
  Synchronization or registration pattern can be embedded into cover image to simplify the search. This step prevents an increase in the false alarm rate and usually more computationally efficient as compare to exhaustive search.
- **Autocorrelation**
  The autocorrelation approach of a work typically has a large peak at zero and then decays rapidly at non–zero shift. This is even truer when examining the autocorrelation of a "white" or uniformly distributed signal. When a periodic, white synchronization pattern is embedded in a work, the resulting autocorrelation will contain a periodic train of peaks identifying the periodicity of the added pattern in the work. Thus in turn can be used to identify and invert any scaling applied to the work since embedding of the synchronization pattern.
- **Invariant watermark**
  Invariant watermark can be constructed in log-polar Fourier transform. These remain unchanged under certain geometric distortions, thereby eliminating the need to identify the specific distortions that have occurred.
- **Implicit synchronization**
  There is a class of blind detection watermarking technique in which the suspect work goes through a synchronization process prior to detection. However in place of synchronization pattern actual features of the work are used. This type of synchronization is called as implicit synchronization. Implicit synchronization requires that the salient features be reliably extracted during detection. Some distortion may affect the locations of the salient features relative to the work. When these distortions are applied after watermark embedding but before detection, the implicit synchronization can fail and watermark can go undetected.

IV. HOW IT WORKS

After the QR Code is watermarked in a still image by using the above proposed technique, now lets see how the watermark in the still image is encoded .W e know that each QR Code symbol consists of an encoding region and function patterns, as shown in Fig. 2. Finder, separator, timing patterns and alignment patterns comprised function patterns. Function patterns shall not be used for the encoding data.

The encode procedure of QR Code including follows steps. Firstly input data is encoded in according to most efficient mode and formed bit stream. The bit streams are divided into code words. Then code words are divided into blocks, and add error correction code words to each block. All these code words are put into a matrix and are masked with mask pattern. Finally function patterns are added into the QR symbol. A QR Code symbol is formed

IV. CONCLUSION

In this paper , we proposed a system of embedding a digital watermark QR Code in a still image which is spread online . This experimental result gives an assurance that the copyright belongs to a particular one and the information of that particular one is also secured in distributed systems .In future we can implement the same by using the other three techniques like **Asymmetric Watermarking Method Based on Subspace Projection , Using Spatial Projection Approach , Watermarking Based on Independent Component Analysis in Spatial Domain .**