Copyright Protection of Digital Artwork Image based on Robust Watermarking Technique

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Abstract.

In this paper, a robust watermarking technique based on frequency domain has been proposed as a way to guarantee the copyright protection of digital art images. The main idea is based on generate the QR code as a watermark information from the host art image and then embed the generated QR code into same digital art image. The specific frequency DCT coefficients have been selected in carefully in order to embed the watermark information with less distortion as possible. The QR code can be extracted from watermarked art image without need to original art image. The art image is transformed from RGB color space into YCbCr space in order to achieve the optimal trade-off between imperceptibility and robustness. Experimental results show the proposed technique is robust against several of common attacks, including median filter, erosion operation, and JPEG compression.

Keywords: **Digital watermarking, Digital art images, Copyright protection.**

المستخلص:

في هذا البحث، تم أقتراح تقنية قوية للعلامة المائية اعتمادا على المجال الترددي لضمان حماية حقوق الطبع لصور الفن الرقمي. الفكرة الاساسية تعتمد على توليد رمز الاستجابة السريع بأعتباره معلومات العلامة المائية من صورة الفن الرقمية المستضيفة ومن ثم اخفاء رمز الاستجابة السريع المتولد في نفس الصورة الفن الرقمية. معاملات تحويل الجيب تمام الترددي تم أختيارها بعناية لغرض اخفاء معلومات العلامة المائية باقل تشوية ممكن. رمز الاستجابة السريع يمكن ان يتم استرجاعه من صورة الفن الرقمي التي تحتوي العلامة المائية بدون الحاجة الى الصورة الاصلية قبل الاخفاء. صورة الفن يتم تحويلها من المجال اللوني RBG الى المجال اللوني YCbCr من اجل تحقيق امثل تسوية بين المتانة وعدم الادراك. النتائج العملية بينت ان التقنية المقترحة قوية ضد العديد من الهجومات التي شملت المرشح المتوسط و عملية التعرية و الضغط بJPEG.

1. Introduction

These days, digital media has become a growing widely and can be very easily transferred through the Internet and available to anyone. This way provided an opportunity to be copied and reproduced without permission of their owners. Therefore, the protection of intellectual property rights has become a core issue to prevent unauthorized people from claiming ownership of digital media rights and reproduced illegally [1].

Newly, digital art take an important place in the production of digital art images that are drawn by the computer. In digital art, photographers are exploit capabilities and services provided by the computer to highlight the artistic creations and ideas. Digital art can be completely produced by computer (such as regular textures and algorithmic art) or import from extra tools, such as a scanner photograph device or an image construction using standard graphics

software. Artworks are considered digital painting when formed in like style to non-digital drawing but by using computer software and producing the digitally image very similar to one painted on canvas [2].

Since the artists spend very long time to design and generate of digital art image, but, these artworks are simply can downloaded or stolen from the publishing websites in the internet environment. For this reason, there is an urgent need to find a way to protect the copyright of works of art digital image. Digital watermarking technique can consider as one possible solution to such problem by hiding a secret piece of information (typically embed copyright logs) into an image [3]. A watermark is a signs or name that is inserted inside of an image data. Watermark information can consider as guarantee for artist to protect their works and it is very hard for everyone to delete/modify this. Digital watermarking can be applied with a broad field of applications, including: Copyright protection, data authentication, fingerprinting, Broadcast monitoring ...etc. Digital watermarking classified into three classes based on its resistance to attacks as follow: fragile, semi-fragile, and robust. A digital watermark described as "fragile" if it did not resist against unintended attacks. Fragile watermark is usually applied for data authentication. A digital watermark described as "semi-fragile" if it resist against unintended attacks, but fails with intended attacks. Semi-fragile watermark is generally used to identify malicious modifications. In contrast to that, a digital watermark described as "robust" if it resists against unintended and intended attacks. Robust watermark always utilize with copyright protection applications in order to proof of ownership [4, 5].

At this time, a few publications have been focused on design robust watermarking techniques for copyright protection of artwork image. In [6], R. Alastair et al. introduced the concepts and challenges that can be faced when embedding watermark information in color artworks. In additional to that, developed new strategies for embedding watermarking in artworks with enough balance between visibility and watermark robustness. W.K. ElSaid [7] proposed a digital watermarking method based on new combination for the main features of the wavelet transform and Singular Value Decomposition (SVD) for protection of color artworks. T. Kamnardsiri [8] proposed a hybrid watermarking approach to protect copyright of digital art images. The watermark information insert into art image through combination of Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT).

This paper is structured in the following way. The Section 2 introduces the principles and background of proposed work. The robust watermarking technique for digital art images is proposed in Section 3. The experimental results and interpretations are presented in Section 3. Section 4 provided the conclusions of this paper.

2. Preliminaries

In this section, the principles and concepts of methodologies which used in proposed technique have been described.

2.1 Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) is transformation used in order to transform the input data from the spatial domain to the frequency domain.

DCTs are play significant role with several applications in engineering and science, such as lossy compression, pattern recognition, information hiding, and solving partial differential equations using spectral techniques.

When the DCT applied on image data, the input image organized into blocks, and a DCT is applied on each block. After that, the Inverse DCT (IDCT) applied to procedure the output image. The mathematical descriptions of the DCT for M×N block size define as follow [9]:

$$F(u,v) = c(u)c(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\cos\frac{\pi(2x+1)}{2M}\cos\frac{\pi(2y+1)}{2N} \quad \dots(1)$$

The two dimensional IDCT transform formula is:

$$f(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} c(u)c(v)\,F(u,v)\cos\frac{\pi(2x+1)u}{2M}\cos\frac{\pi(2y+1)v}{2N} \quad \dots(2)$$

Where

$$c(u) = \begin{cases} \sqrt{1/M} & u = 0 \\ \sqrt{2/M} & u = 1,2,\dots,M-1 \end{cases} \quad \dots(3)$$

$$c(v) = \begin{cases} \sqrt{1/N} & v = 0 \\ \sqrt{2/N} & v = 1,2,\dots,N-1 \end{cases} \quad \dots(4)$$

The x and y represented the spatial sampling values and the u and v are the frequency domain sampling values.

2.2 Canny Edge Detector

The Canny operator is considered one of the most commonly edge detection filter that uses a multi-stage process to identify a wide range of edges in images. It used to extract useful structural information from various visual objects and theatrically decrease the size of data to be processed. Canny operator usually applied in many applications of digital image processing. The algorithm of Canny edge detector can be divided into five steps: [10]

1. Noise removal by applied Gaussian filter to produce smooth image.
2. Discovery the intensity gradients of the smooth image.
3. Apply non-maximum cancellation to acquire rid of false reply to edge detection.
4. The double threshold is applied to decide possible edges.
5. Aggregation of the detected edges by delete each edge is weak and not related to strong edges.

3. The Proposed Robust Watermarking Technique

In this section, the design of robust watermarking technique for artwork images has been explained. One of the strengths which are characterized the proposed technique is no need to use the original image in the receiver side. In addition to that, the watermark information is derived from the same image to be hosted. In other words, the watermark information is changed every time depending on the properties of the image to be hosted. The block diagram of the proposed robust watermarking technique is shown in Figure 1.

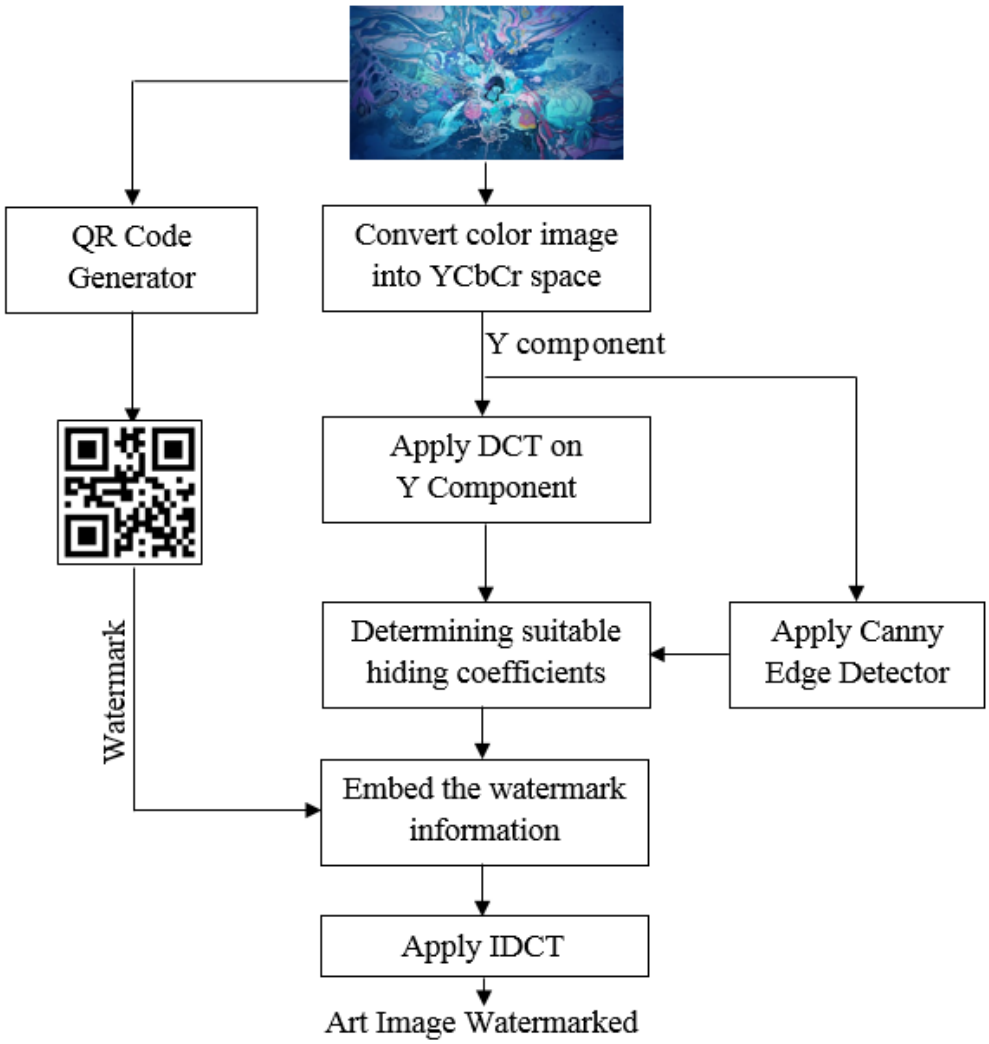


Figure 1: Block diagram of robust watermarking technique for digital art image

3.1 Original Digital Art Image

The input for the proposed robust watermarking technique is a digital art image that was painted by an artist's with using digital technologies. In this work, a digital art image used as host image to store watermark information and also to generate the QR code which considered as a watermark. The digital art images of RGB colors with size of 512×512 pixels are used in this work. Figure 2 shows sample of host digital art image.

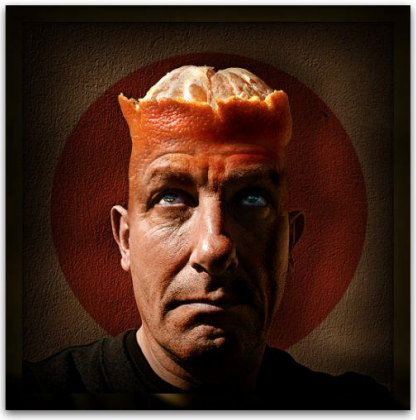


Figure 2: Example of digital art image.

3.2 Generating of Watermark (QR Code)

In this step, the watermark information will be derived from the host digital art image by QR code generator. QR codes become widely use in identifying the objects due to their accuracy, performance efficiency, higher information density, and error correction. In our work, the idea based on read information header of host digital art image with some statistical features and then encodes them using QR code generator to produce unique watermark corresponding to its digital art image. In this case, the QR code considered as watermark. Thus, security level of watermark is increased and prevents unauthorized people from the guess the watermark because it changes according to the art image. Figure 3 shows QR code for art image which display in Figure 2.

Figure 3: QR code for digital art image

3.3 Convert Host Art Image to YCbCr Color Space

The goal of the proposed technique is to obtain a high level of robustness and invisibility. Therefore, the host art image is converted from RGB space into YCbCr color space. This space included three color bands. The Y band called luminance; it represented the most information of image which not removed during JPEG compression. For this reason, the Y band used to store the watermark information (QR code). While, the Cb and Cr consist of less significant information which not used to embed watermark information.

3.4 Apply DCT

As known, embed the watermark through the frequency domain to achieve a high level of robustness against potential attacks. Therefore, the host art image is converted from the spatial domain to the frequency domain using DCT. The DCT is applied on Y band of host art image after divided into equal and non-overlapping blocks; each block has 64 pixels with the size of 8×8. The suitable DCT coefficients will used to embed the watermark information in order to ensure the resistance of proposed technique against JPEG compression.

3.5 Apply Canny Edge Detector

The human eye is less sensitive to changes that occur in coarse areas where the edges and textures appear intensely. Depending on this basis, we need to identify the areas which contain edges in host art image in order to use them to store the watermark information with invisible distortion. Therefore, canny filter is applied to each block in Y band of host art image separately. In each block, the region of edges are detect and the selected for watermark embedding. In other words, the results of canny filter used in the next step as a reference to select the suitable DCT coefficients to embed watermark information.

3.6 Determining Suitable Hiding Coefficients

In this step, the suitable DCT coefficients which store the watermark information have been selected by helping the results of canny filter. The role of the canny filter is just to indicate the DCT coefficients that belong to the edges area. In our technique, the DCT coefficients in middle frequency are selected to embed watermark information if these coefficients belonging to edges area to realize high robustness against compression methods and imperceptible distortions. Figure 4 shows the selected coefficients in the DCT block with size of 8×8.

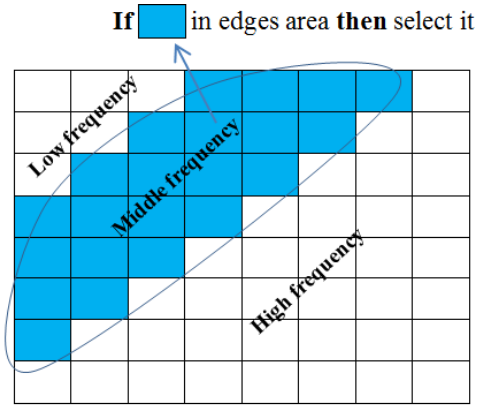


Figure 4: the selected hiding coefficients

3.7 Embedding of Watermark (QR Code)

The watermark information which represented by QR code will be embedding into the selected DCT coefficients in the above step. This operation actually inserts the QR bits into DCT coefficients based on the additive rule as follow:

$$F_w(u,v) = F(u,v) + \alpha \times W \qquad \dots (5)$$

The $F_w(u,v)$ represents the watermarked DCT coefficients, $F(u,v)$ original DCT coefficients, the W is QR code as watermark in binary pattern, and α the represents strength factor for watermark embedding.

3.8 Apply IDCT

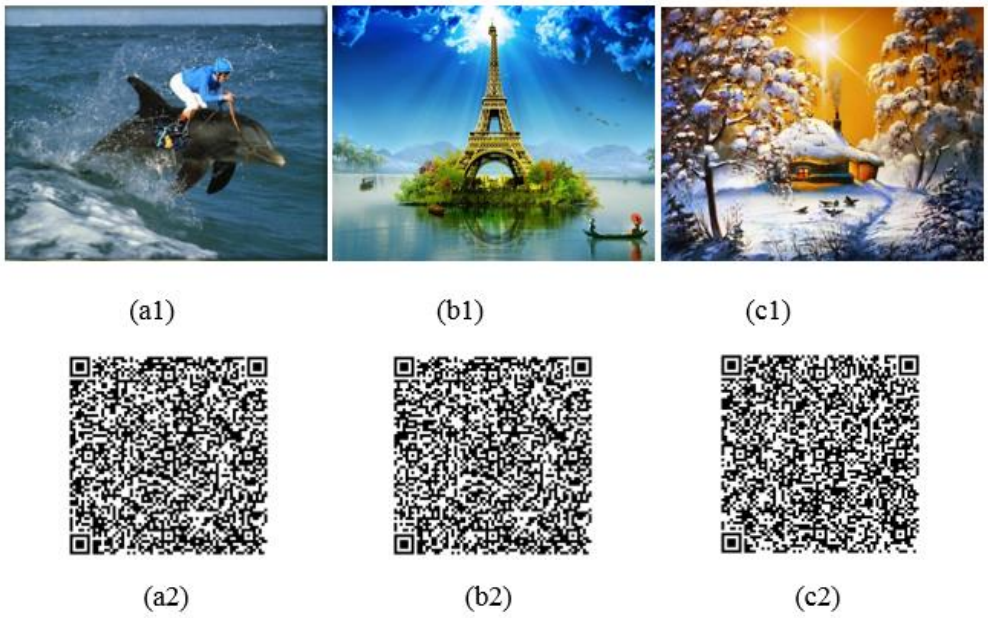
After embedding the QR code (watermark) into the selected coefficients, then IDCT is applied on each block in Y band. At the end, the watermarked art image was reconstructed to the actually size.

3.9 Watermark Extraction

In order to extract the watermark information, we used the same steps that applied in embedding watermark process. The watermark information are extracting from selected DCT coefficients that should determine based on applied canny filter on the Y band in art image watermarked. The extracted watermark (QR code) will be compared with original watermark to proof the ownership of art image.

4. Experimental Results

This section presents overall discussion for the obtained results after implement the proposed watermarking technique. In this experiment, the different host art images have been used in order to evaluate the performance of proposed watermarking technique. Here the results are given for three samples of digital art images. Figure 5 shows the host images with their QR codes which derived from them. The QR code is generated based on the information in header of host image.



(a1) (b1) (c1)

(a2) (b2) (c2)

Figure 5: a1-c1) Host art images, a2-c2) QR code generated from the host art images.

As shown in Figure 5, for each host image the QR code generated in order to use as a watermark in the proposed technique. Figure 6 shows watermarked art images after embed the QR code inside them.

(a) (b) (c)

Figure 6: watermarked art images

As noted in Figure 6, the watermarked art images have high level of visual quality and can be hardly distinguished from the original. To calculate the quality of the watermarked images in numerical form, the statistical measurements have been used. These measurements use the image pixel intensity values for both host and watermarked images. In this test, three statistical metrics used to evaluate the quality of art image watermarked. . In this test, three statistical metrics are used to evaluate the quality of art image watermarked. These metrics included:

Peak–Signal–to–Noise–Ratio (PSNR), Universal Image Quality Index (UIQI), Mean Angle Similarity (MAS). Table (1) presents the quality evaluation results of the proposed watermarking technique [11].

Table (1): Results of Quality Evaluation

Watermarked Art Images	Quality Metrics		
	PSNR(dB)	UIQI	MAS
Dolphin (a)	43.35	0.897	0.722
Eiffel Tower (b)	45.76	0.902	0.789
Winter (c)	46.83	0.913	0.825

As explained in Table (1), the watermarked art image "Winter" achieved high quality level compare with other images. This corresponds with the principle which says the modifications at the edges area produce the lowest level of distortions.

On the other hand, the robustness of proposed watermarking technique has been evaluated using Normalized Correlation (NC) measure. The NC is usually used to calculate the similarity degree between the original watermark bits and extracted watermark bits after passing through various kinds of intentional or unintentional attacks. When the NC value is near from 1 this mean the proposed watermarking technique is more robust. The NC measure can be calculated as follow [12]:

$$NC = \frac{\sum_{i=1}^{L} W(i) \times W(i)'}{\sum_{i=1}^{L} W(i)^2} \quad \dots (6)$$

The L represents the number of watermark bits. The $W(i)$ and $W(i)'$ represents the original watermark and extracted watermark, respectively.

Respectively, median filter attacks, erosion attacks, and compression attacks are applied on the watermarked art images. Figure 7 presents the resulted images after applied three types of attacks on the watermarked art images.

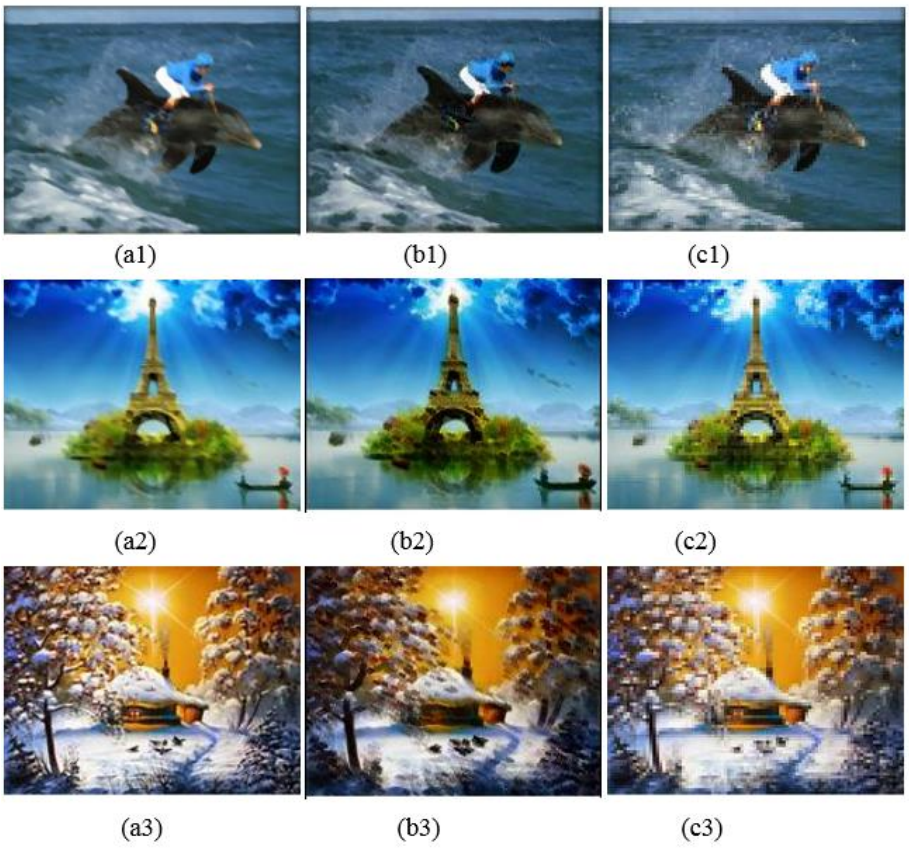


Figure 7: attacked art images, a1-a3) Median filtering, b1-b3) Erosion attack, c1-c3) JPEG compression.

The results of robustness evaluation for proposed watermarking technique are stated in the Table (2).

Table (2): Results of robustness evaluation using NC measure.

Attacks	Watermarked art images		
	Dolphin	Eiffel Tower	Winter
Median filtering	0.982	0.978	0.991
Erosion process	0.972	0.967	0.981
JPEG compression 50%	0.951	0.944	0.956

As noted in Table (2), the values of NC are larger than 0.95 with each type of attacks which shows that the proposed watermarking technique

provides high robustness level. Thus, the proposed technique characterized by a combination of robustness and imperceptibility which are always hard to obtain in the same time.

5. Conclusions

In this paper a robust watermarking technique for digital art images has been introduced. The QR code as watermark embeds in the selected group of DCT coefficients based on human vision system. When tested the proposed technique using Dolphin, Eiffel Tower, and winter images, experimental results illustrated that the impairment due to embedding the watermark bits is insignificant to be visualized. Therefore, the proposed watermarking technique can realize an optimal tradeoff between the robustness and quality. Additionally, the robustness of this technique is more robust to some attack like median filtering, erosion and JPEG compression.

References

[1]. Prachi Khanzode, Siddharth Ladhake and Shreya Tank "Digital Watermarking for Protection of Intellectual Property" IJCEM International Journal of Computational Engineering & Management, Vol. 12, April 2011.

[2]. Mark Mudge, Carla Schroer, et al., "Principles and Practices of Robust, Photography-based Digital Imaging Techniques for Museums" The 11th International Symposium on Virtual reality, Archaeology and Cultural Heritage VAST, 2010.

[3]. Hai Tao, Li Chongmin, Jasni Mohamad Zain, Ahmed N. Abdalla, "Robust Image Watermarking Theories and Techniques: A Review" Journal of Applied Research and Technology, Vol. 12, Issue 1, pp. 122-138, February 2014.

[4]. Mauro Barni, Franco Bartolini, Vito Cappellini, Alessandro Piva, "A DCT-Domain System for Robust Image Watermarking" International Journal of Innovative Research in Computer and Communication Engineering, Vol.2, Special Issue 4, September 2014.

[5]. Gaurav Gupta, Kanika Sharma, "A Hardware Efficient Robust Digital Image Watermarking Algorithm Using Integer DCT" International Journal of Engineering Trends and Technology (IJETT) – Vol. 25 NO. 2, July 2015.

[6]. Alastair Reed, Tomáš Filler, Kristyn Falkenstern, Yang Bai, "Watermarking Spot Colors in Packaging" Proceedings of the IS&T/SPIE Electronic Imaging conference, vol. 9409, San Francisco, USA, February 2015.

[7]. W.K. ElSaid, "Watermarking Digital Artworks" International Journal of Computer Applications (0975 – 8887) Volume 125 – No.12, September 2015.

[8]. Teerawat Kamnardsiri, "Digital Art Image Copyright Protection Using Combined DWT-DCT Based Watermarking Technique" Proceedings of the International Conference on Digital Arts, Media and Technology (ICDAMT), Thailand, February 2016.

[9]. Suppat Rungraungsilp, Mahasak Ketcham, Virutt Kosolvijak, and Sartid Vongpradhip "Data Hiding Method for QR Code Based on Watermark by compare DCT with DFT Domain" International Conference on Computer and Communication Technologies (ICCCT'2012) May 26-27, 2012.

[10]. Y. Luo and R. Duraiswami, "Canny edge detection on Nvidia Cuda" Computer Vision and Pattern Recognition Workshop, vol. 0, pp. 1–8, 2008.

[11]. Methaq T. GAATA, "Developing Metrics Evaluator for Digital Image Watermarking Techniques" PhD. Thesis in Computer Sciences, University of Babylon, 2012.

[12]. Methaq T. Gaata, William Puech, Sattar Sadkhn, "Digital Watermarking Method based on Fuzzy Image Segmentation Technique" IEEE International Symposium on Signal Processing and Information Technology, ISSPIT 2011, Bilbao, Spain, December 14-17, 2011.