Hybrid Watermark System for Color Images based on DCT, DWT and Kohonen Network

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Abstract

Digital watermarking is the process of embedding data into multimedia such as image, audio, and video to protect the digital content from counterfeiting and stealing. In this paper, the hybrid algorithm is proposed by using discrete wavelet transform (DWT) and discrete cosine transform (DCT) with generation a secret key to determine locations of the cover which used in embedding and extracting the watermark depended on Kohonen network. The aim of the study is to achieve higher robustness and imperceptibility by applying more than one transform domain operation on the host image. The proposed method attempts to choose the best from discrete wavelet transform and discrete cosine transform techniques based on their individual suitability to distinct regions in the image. Results have shown that the proposed method provides images with good quality after embedding the watermark. The efficiency is measured using PSNR and NC.

Keywords: Digital Watermark, Discrete Wavelet Transform, Discrete Cosine Transform, Kohonen Network

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نظام علامة مائية هجين للصور الملونة مستند على تحويل جيب تمام المتقطع والتحويل المويجي المتقطع وشبكة كوهونين

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الخلاصة

العلامة المائية الرقمية هي تضمين البيانات في وسيط متعدد مثل الصور, الصوت، الفديو لحماية المحتوى الرقمي من التلاعب والقرصنة والسرقة. في هذه الورقة، تم اقتراح خوارزمية هجينة باستخدام التحويل المويجي المتقطع و تحويل جيب تمام المتقطع مع توليد مفتاح سري لتحديد مواقع الغلاف التي تستخدم في تضمين واستخراج العلامة المائية بالاعتماد على شبكة كوهونين. الهدف من هذه الدراسة هو تحقيق متانة أعلى وعدم إدراك من خلال تطبيق أكثر من عملية تحويل المجال على الصورة المضيفة. تحاول الطريقة المقترحة اختيار الأفضل من تقنيات التحويل المويجي المتقطع و تحويل جيب تمام المتقطع على أساس ملاءمتها الفردية إلى مناطق متميزة في الصورة. اظهرت النتائج بان الطريقة المقترحة توفر صور ذات جودة عالية بعد تضمين العلامة المائية. وتم قياس الكفاءة باستخدامPSNR و NC.

الكلمات المفتاحية: العلامة المائية الرقمية، التحويل المويجي المتقطع، تحويل جيب تمام المتقطع، شبكة كوهونين.

Introduction

Today, there is a need to develop multimedia protection programs to prevent unauthorized from accessing the data, where it became of importance to validate the information as well as copyright. We can define copyright for digital images is a process of proving intellectual property rights by law against reproduced, processing, changing and publishing [1]. The digital watermark is used to determine the original publisher of the product. Traditional watermarking includes visual small watermarks on the papers to ensure originality, such as instruments, documents, and paper money. This method has been updated and developed to suit multimedia (images, video, audio, digital text). All ways of the watermark are sharing in the same of the digital content (embedding watermark and watermark recovery) [2]. Watermarking can be any nature such as (image, audio, text) and should use a secret key to prevent unauthorized from

extract and processing watermark. There are some watermark algorithms which propose combining between transforms, the study [3] proposes a method to embed and extraction the watermark by DCT and DWT and using several attacks to evaluate the algorithm, this algorithm is working without a secret key. The study [4] depends on four level DWT and DCT and comparing with DWT-only. In the study [5] the integer wavelet transforms and DCT are proposed depending on the coding process by Huffman code but this study is dealing with hiding text in the digital image. This paper, have used two transforms DCT and DWT with generating a secret key by Kohonen network. The aim of the method is to achieve higher robustness and imperceptibility by applying more than one transform domain operation on the host image. Furthermore, the proposed method is focused on the quality of the watermarked image after embedding stage and the recovered watermark after extraction stage that is achieved by using joint process between two transforms and Kohonen network. The first step in the proposed system is decomposing the host image into sub-blocks, then perform the transforms and generating a secret key to select the proposed cells. After that, the watermark will be embedded in the cover image.

The used techniques

1- In this paper, the Discrete Cosine Transform (DCT) and inverse DCT (IDCT) will be used according to the following formula:

$$F(jk) = a(j)a(k)\sum_{m=0}^{n-1} \sum_{n=0}^{n-1} f(mn)\cos[\frac{(2m+1)j\pi}{2N}]cos[\frac{(2n+1)k\pi}{2N}] \quad (1)$$

$$F(mn) = \sum_{m=0}^{n-1} \sum_{n=0}^{n-1} a(j)a(k)\, f(jk)\cos[\frac{(2m+1)j\pi}{2N}]cos[\frac{(2n+1)k\pi}{2N}] \quad (2)$$

2- Discrete Wavelet Transform (DWT) and inverse DWT (IDWT) will be used in this study as shown in figure (1) where (LH, HL, HH) are frequency districts.

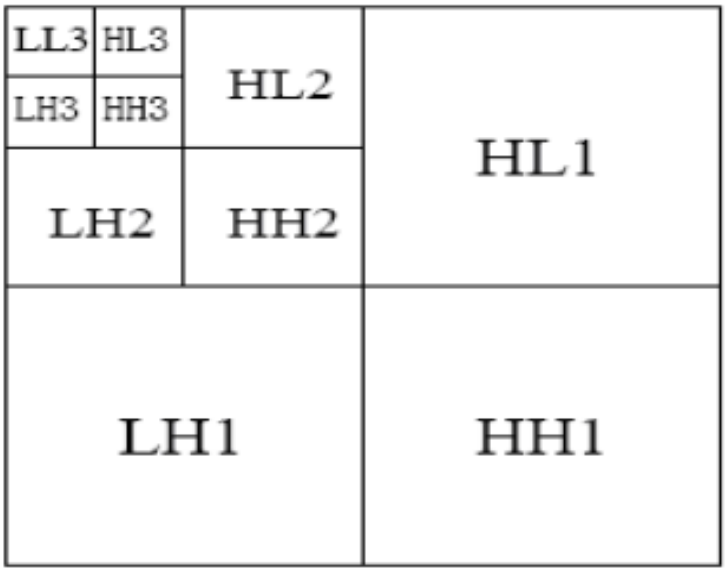


Figure 1: DWT Map

3- Kohonen network consists of two layers, the input layer and the output layer. The winner cells in the network are depending on the measure of the distance between input cells and output layer cells, the cell which has a less value to distance in output layer is the winner [7]. The equation of Kohonen network algorithm is as following:

$$d_i = \sqrt{\sum_{i=0}^{N-1} (x_i - w_{ij})^2}$$

Where d_i is the distance between input cells and output layer

$$w_{ij}^{new} = w_{ij}^{old} + \alpha(x_i - w_{ij})$$

Where w_{ij}^{new} represented the new weight, w_{ij}^{old} isthe old weight, X_i is input form, W_{ij} is the weight between input and output layer. Figure (2) shows the Kohonen network algorithm.

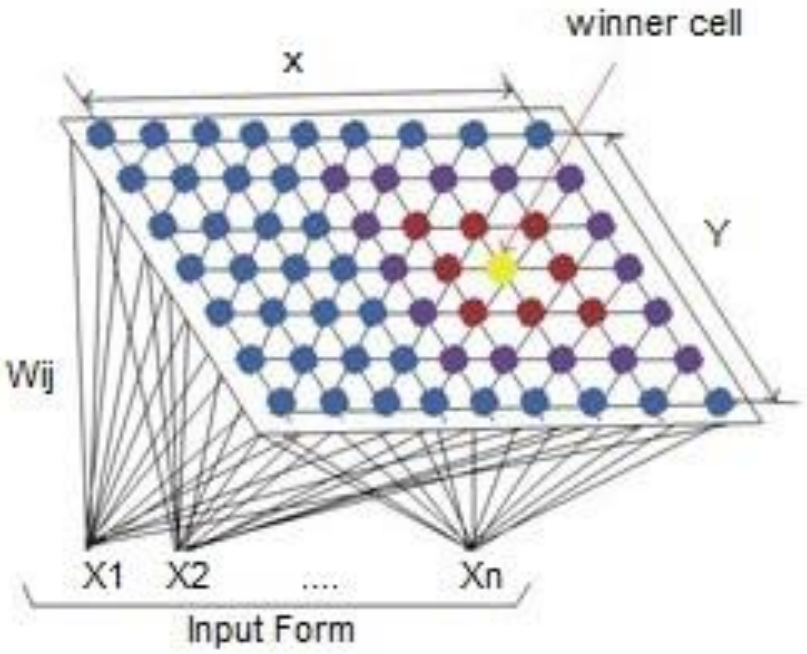


Figure 2: Kohonen Network Algorithm

The Proposed Method

In this method, a hybrid watermark system is introduced, it consists of two stages; the first is process digital watermark embedding and the second is digital watermark extraction by using combined DWT – DCT. The host image is broken down into non-overlapping blocks. The sub-blocks are then decomposed using DWT. The medium frequency bands HL and LH are used for watermark embedding considering the fact that the alterations effected here do not significantly distract the human visual system. DCT of HL and LH bands are computed to utilize the preferred coefficients for embedding the watermark information.

The watermark bit is embedded on selected DCT coefficients from each sub-block. After embedding the watermark, inverse transform operations are computed. The process is repeated on the next sub-block from host image, thus producing watermarked hidden blocks. Once all the blocks are watermarked they are recombined to output the watermarked image.

Embedding algorithm

Input: Original image, Original watermark

Output: Watermarked image

Step1: Read host color image,

Step2: Read watermark image,

Step3: Decompose the host image into non-overlapping blocks (B)

Step4: Perform watermark bit embedding on sub-blocks (Bi), select the LL band and compute DWT. Let HLi2 and LHi2 be the level two medium frequency bands of Bi. Compute inverse DWT, followed by level one inverse DWT to obtain the watermarked block B'i.

Step5: Perform watermark bit embedding on sub-blocks (Bii), Compute level one DWT. Apply DCT operation on the resulting HL and LH band. Compute inverse DCT, followed by inverse DWT to obtain the watermarked block B'i.

Step6: Generating a secret key to determine a group of locations which have hidden inside it by using neural Kohonen network

Step7: Recombine the watermark integrated sub-blocks, B'i’s

Step8: Output the watermarked image

The figure (3) shows a diagram for embedding algorithm

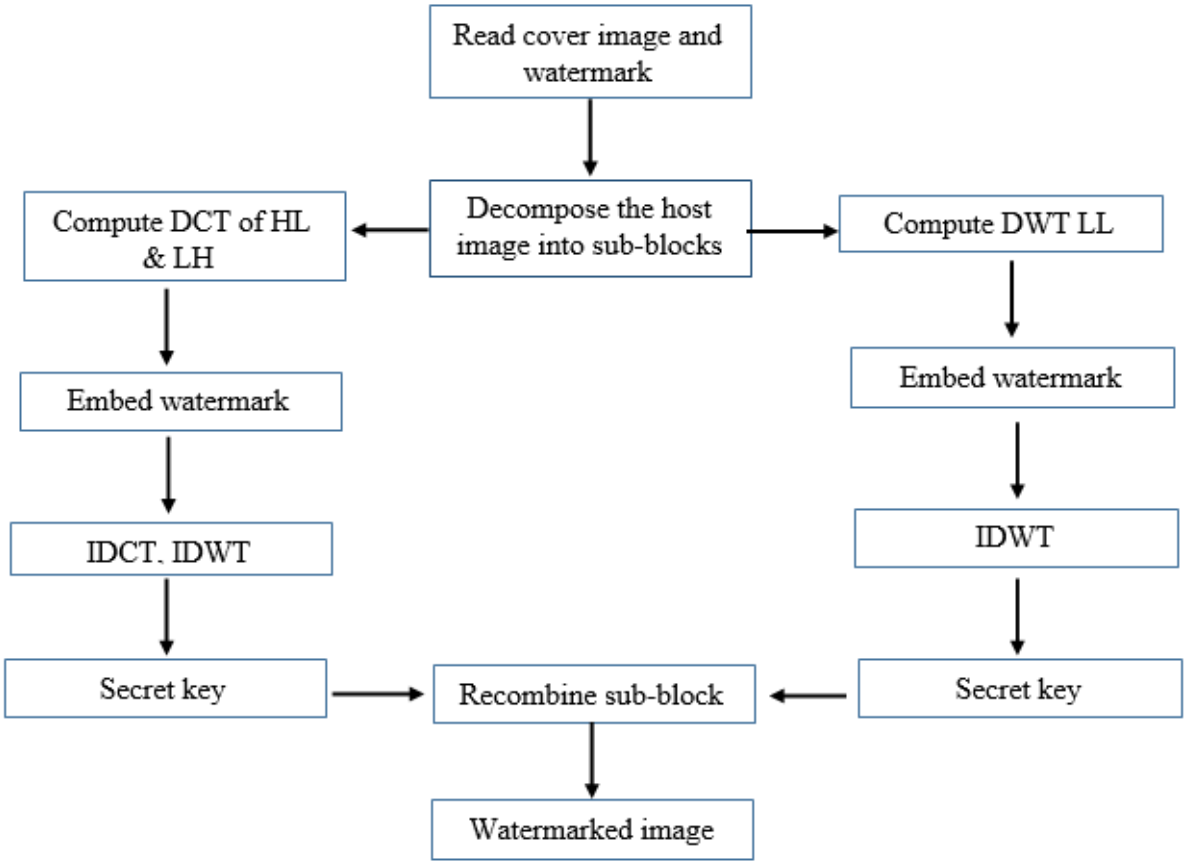


Figure 3: General Diagram for Embedding Algorithm

Extraction algorithm

Input: Watermarked image

Output: Recovered Watermark

Step1: Read watermarked image

Step2: Decompose the image into non-overlapping blocks

Step3: Perform two –level DWT on sub-block (Bi), select LL

Step4: Perform one-level DWT on sub-block (Bii), select HL and LH bands and compute DCT

Step5: The watermark is reconstructed using the extracted watermark bits

Performance measures

Peak Signal to Noise Ratio (PSNR) is used to measure the objective quality after the embedding process by using the formula as follows [4] [5]:

$$NC = \frac{\sum_{i=1}^{M1} \sum_{j=1}^{M2} w(i,j) w^*(i,j)}{\sqrt{\sum_{i=1}^{M1} \sum_{j=1}^{M2} w(i,j)^2 w^*(i,j)^2}} \quad (3)$$

Where w(i,j) is the original watermark, w^*(i,j) is the extracted watermark.

$$\text{MSE} = \frac{1}{n.n} \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (I(i,j) - Iw(i,j))^2 \quad (4)$$

Where I(i,j) is the original image, I_w(i,j) is a watermarked image. We can evaluate the error ratio between original watermark and extracted watermark by using normalized correlation coefficient (NC) [6]

$$\text{PSNR} = 10.\log_{10}\left(\frac{255^2}{MSE}\right) dB \quad (5)$$

Results

In this paper, we used several color images with size 512*512 as cover images and watermark images with size 128*128 as shown in tables (1) and (2)

Table 1: The PSNR values for the watermarked color images

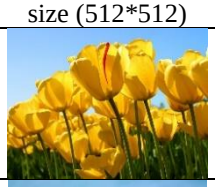
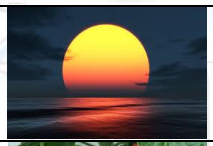
cover image with size (512*512)	watermark image with size (128*128)	watermarked image	PSNR (dB)
			43.52
			40.98
			45.3
			39.76

Table 2: The NC values for the recovered color watermark images

Watermarked image	Extracted image	NC
		0.9
		1
		0.981
		1

Discussion

By grouping blocks on the basis of their contrast the transform technique that can better spread the external watermark energy can be chosen. Accordingly, by applying DCT on to the low varying block we are able to concentrate the energy in the medium frequency HL and LH bands to a set of DCT coefficients which are then effectively utilized for watermark integration. The DWT coefficients in this region are otherwise comparatively smaller in magnitude, thus making them unsafe for direct watermark addition. However, DCT operation in such cases concentrates the signal energy facilitating stronger watermark embedding.

Conclusion

In this paper, a hybrid watermark system for color images has been applied. The proposed method is done by combining between DWT and DCT to obtain a high quality for watermarked image and extracted watermark. In the experimental results, the best value of PSNR is 45.3 and NC value is about 1. Where, there is no distortion in the cover image and invisible watermark image after embedding process. The extracted watermark is substantially identical with the original watermark. Moreover, the key is stored inside the host image to increase the security of the proposed system. Without knowledge of the key, the receiver cannot extract the watermark. To summarize, the objective of an imperceptible and robust watermark signal embedding is achieved as demonstrated by the various metrics for measurements and analysis.

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