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A Robust Image Watermarking Scheme for Images Captured by Mobile Cameras Using Haar Discrete Wavelet Transform

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Abstract: The color images captured by a camera of mobile phone has become a much traded and it has a great privacy of the people in this study will be designed robust method using the mechanism of the watermark "digital image watermarking" for colorful images for the purpose of securing stored and transmitted over communication networks after treatment and improved by known ways and then add watermark image and Which are known from the powerful methods used in landfill operations data, thus obtaining appropriate security for this image. At this study will examines a technique for digital watermarking which use properties of the Discrete Wavelet Transform (DWT) using Haar wavelet for each of original captured image and watermark image in separate way. In short, the results support the idea that the simpler wavelet transforms, e.g., the Haar wavelet, consistently outperform the more complex ones when using a non-colored watermark.

Key words: Color images captured, watermark image, DWT, IDWT, Haar wavelet, mechanism

INTRODUCTION

The watermarking is a technique of imperceptibly embedding information into a multimedia objects such (images, video, audio and text) as a technological security to digital right management. Digital image watermarking is a technique of embedding an image into the cover image which is extracted later or being detected for various benefits. The image embedded is called as watermark image and the cover image is the original captured image. The digital image watermarking techniques can be divided into two domains (Mohananthini and Yamuna, 2015) such as spatial-domain and frequency-domain techniques.

The frequency domain techniques have been achieved more effective in term of imperceptibility and robustness. The frequency domain techniques are grouped into Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT) and Discrete Wavelet Transform (DWT). Xia *et al*. (1997) proposed 2 level wavelet decomposition using the haar wavelet transform. Their method the pseudo random noise codes are only added to the large coefficients of the middle and high frequency bands of the discrete wavelet transformed image. Jabade and Gengaje (2011) set the suitability of wavelet transform based watermarking which is widely used today, approaches and analyses of wavelet based image watermarking techniques and also their reviewed the applications and attributes of image watermarking. A DCT blind watermarking scheme based on spread spectrum communications is proposed by Taherinia and Jamzad (2009). Their method proved to be highly resistant in cases of many common attacks while maintaining high PSNR for the watermarked images. Novel digital image watermarking scheme using bi-orthogonal wavelets are proposed by Yamuna and Sivakumar (2011). Mohananthini and Yamuna (2012) presented a digital image watermarking based on Discrete Wavelet Transform (DWT). In their proposed method, the watermark as well as the cover image seldom loses the quality in both embedding and extraction process. Their scheme shows good performance on different types of cover images in terms of imperceptibility and resist to JPEG compression. Loukhaoukha (2012) proposed the security of digital watermarking scheme based on SVD and tiny-GA. They demonstrated that their watermarking algorithm is fundamentally flawed and has a very high probability of false positive detection of watermarks. A set of schemes and their analysis for multiple watermark placements that maximizes resilience to the above mentioned cropping attack proposed by Frikken and Atallah (2003). Mahmood *et al*. (2013) proposed watermarking technique is based on dividing the medical image in to blocks and inserting the watermark to the ROI by shifting the blocks. Their watermarking approach does not effect on the

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ROI of the medical image against some watermarking attacks such cropping and noise. Kaur (2013) presented its applications as an indicator of quality of a watermarked medical image when exposed to intentional (noise, cropping, alteration) or unintentional (compression, transmission or nomination) operations. Their proposed method's performance is evaluated by computing MSE and PSNR of original and extracted mark. Memon and Gilani (2011) proposed a fragile watermarking technique to ensure the integrity of the medical image that avoids the distortion of the image in ROI by embedding the watermark information in RONI. Their watermark is composed of patient information, hospital logo and message authentication code computed using a hash function.

Literature review: There are a lot of watermarking methods which use the watermarking algorithms in order to performance improved have been submitted in the literature review for secure the confidentiality and more robustness. It will be a brief overview of some of the research presented here.

Nasir *et al*. (2008) proposed novel and more robustness color image watermarking technique in spatial domain based on merge four identical watermarks into the component of blue of the cover image. In the extraction process, the cover image is attainable and five watermarks can be recovered from different regions of the watermarked image and only one watermark is detectable from the five watermarks according to the maximum value of Normalized Cross Correlation (NCC). The experimental results explain that their proposed scheme is robust for several attacking attempts including Mediterranean filter, JPEG2000, JPEG-lose compression, image cropping, image scaling, rotation, rotation-scaling, rotation-cropping, randomly removal of some rows and columns lines and self-symmetry. Their proposed technique is also safe and only the one with the correct key can extract the watermark.

Tao and Eskicioglu (2004) popularized an idea in a new study that enter a binary pattern in the form of a binary image in the LL and HH bands at the second level of Discrete Wavelet Transform (DWT) decomposition and a comparison of entering a watermark at first and second level decompositions. Embedding the watermark in lower frequencies is more robustness to a set of attacks (JPEG compression, clarity, adding Gaussian noise, rescaling, rotation, cropping, pixilation and sharpening) and embedding the watermark in higher frequencies is more robust to another set of attacks (histogram equalization intensity adjustment and gamma correction). The re-watermarking and collusion attacks, the watermarks extracted from all four bands are similar. Their experiments indicate that first level decomposition show advantageous for two reasons: the region for watermark embedding is maximized and the extracted watermarks are more textured with better visual quality.

A novel image watermarking technique in the wavelet domain is submitted by Sharkas *et al*. (2006). To achieve more robustness and security their suggested techniques depend on using two watermarks that are embedded into the cover image to be watermarked. A primary watermark in the form of a PN sequence is first entered into an image (secondary watermark) before being embedded into the original image. Their method is implemented using Daubechies mother wavelets where an arbitrary embedding factor α is introduced to improvement the robustness and invisibility.

A multiple watermarking scheme on Discrete Wavele Transform (DWT) is proposed by Mohananthini and Yamuna (2013). In the embedding process, the two watermarks are embedded to original image. In the extraction process, then active warterrmarks are retrieved from the watermarked image. Their proposed method has good in term of imperceptibility on the watermarked image and superior in terms of Peak Signal to Noise Ratio (PSNR).

Mintzer and Braudaway (1999) discussed about three types of watermarking applications in the submitting of multiple watermarking and classification of different ways how to employ and to construe multiple watermarking. Multiple watermarks can be worn to address one or multiple applications may be head for a few times. For example, a first watermark can be used to cultivate proprietorship information, a second one to integument verification what's more a third person to captioning. On the other hand there can be multiple copyright watermarks, multiple verification watermarks or multiple watermarks for multiple suspensions with focus on the way how single watermarking techniques are actually melted into multiple watermarking schemes.

Ali *et al*. (2014) proposed a Differential Evolution (DE) algorithm to achive the tradeoff between robustness and imperceptibility by exploring multiple embedding factors in image watermarking. The original image is fragmented into blocks and the blocks are transformed into Discrete Cosine Transform (DCT) domain. Experimental results show that their proposed scheme save a satisfactory image quality and watermark can still be identified from a seriously distorted image.

Giakoumaki *et al*. (2006) discussed the perspectives of digital watermarking in a range of medical data management and distribution issues simultaneously addressed medical data protection, archiving and retrieval as well as source and data authentication. The experimental results show that the transparency and efficiency of their scheme which conforms of the strict necessities that apply to areas of symptomatic importance. Woo *et al*. (2005) proposed a multiple digital image watermarking method which is suitable for privacy control and tamper detection in medical images. Their visual quality of watermarked image is very good.

MATERIALS AND METHODS

The proposed scheme is the process of embedding awatermark by decomposing the original image and the watermark image using Discrete Wavelet Transform (DWT). Before the piece will be segmentation of each image into partial images grouped by color scales to facilitate handled. The discrete wavelet transform, watermark embedding and extraction process are discussed.

Discrete Wavelet Transform (DWT): The wavelet analysis is the essence of multi resolution analysis decomposition of an image into sub images of size resolution in different levels. Multi resolution dissection is intended to give best time precision and poor resolution frequency at high frequencies and good resolution frequency and poor time precision at low frequencies. Best for signal having high frequency components for short periods and low frequency components for long periods (Mohananthini and Yamuna, 2015).

For two-dimensional image DWT, four bands of data will produce from every level of decomposition, one corresponding to the Low pass band (LL) and three other corresponding to vertical (LH), Horizontal (HL) and diagonal (HH) sub-bands. The decomposed image shows an approximation image in the lowest resolution low pass band and three detail images in higher bands. The two levels of discrete wavelet decomposition of original image are illustrated in Fig. 1. The approximation sub-band can be also decomposed to obtain another level of decomposition. The proposed method choosing LL2 sub-bands because it containing high information and best visual quality compared to other sub-bands.

Watermarking embedding algorithm: Every crisis measures to the process of embedding the watermark to the original image is described in Fig. 2. Embedding algorithm steps are as follows:

Step 1: In first of all our proposed algorithm, the original color image and the watermark image both are divided into three colors RGB sub images.

Step 2: After first step, the Discrete Wavelet Transform (DWT) is made for each layer of original and watermark images, then the indexing of sub bands in two level wavelet decomposition is described as follow. The same as the previous two steps repeated in Fig. 2 on the watermark image.

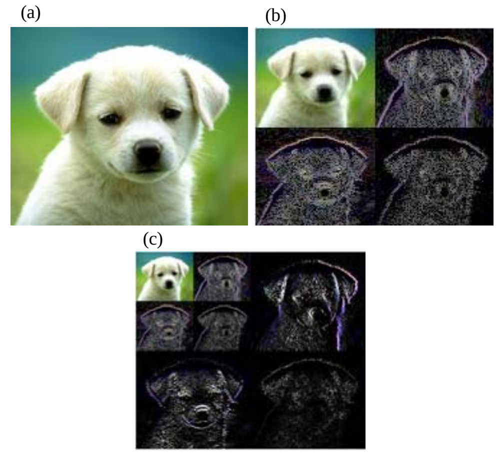

Fig. 1: a) Original image; b) First level of wavelet decomposition and c) Second level of wavelet decomposition

Step 3: After apply the discrete wavelet Haar transform, the watermark image contents is embedded to the original image then a two dimensional image is obtained. A good visual quality is achieved using a different factor for embedding the watermark information. This algorithm shows that the original color digital image is decomposed into three color sub images of O(Red), O(Green) and O(Blue), respectively resulting in three color components of two layer of wavelet decomposition.

Step 4: The resulted color components obtain are Wd (Red), Wd (Green) and Wd (Blue), respectively for the same color digital watermark. The decomposition coefficients corresponding to this original color image obtained by including the digital watermark of three basic color (RGB) used are in Eq. 1-3 (Zude *et al.*, 2006):

$$Wd(r)A(i,j) = O(r)A(i,j) + a1 \times W(r)A(i,j) \quad (1)$$

$$Wd(g)A(i,j) = O(g)A(i,j) + \alpha 2 \times W(g)A(i,j) \quad (2)$$

$$Wd(b)A(i,j) = O(b)A(i,j) + \alpha 3 \times W(b)A(i,j) \quad (3)$$

where the parameter $\alpha 1$, $\alpha 2$, $\alpha 3$ are called R, G, B embedding intensity factors (scaling factors), O(r, g, b) A(i, j) is the Original image of the red, green and blue component, W (r, g, b) A (i, j) is the watermark image of the red, green and blue component and Wd (r, g, b) A (i, j) is the color image obtained by embedding the digital watermark, these affect the validity of the algorithm directly.

Step 5: Reconstruction the processed image use the inverse Discrete Wavelet Transform (IDWT) for dealing with the watermarked image in R, G, B separate channel.

Step 6: Color images are combined into R, G and B through channel combination approach. So, the final watermarked image is obtained. According to the human eye sensitivity varies through different colors by R: G: B = 2:1:4.

Watermark extraction algorithm: The extraction algorithm is the inverse of the embedding algorithm as shown in Fig. 3. Watermark is the seed value for authorized users at the receiver. The watermark extraction algorithm steps are as follows:

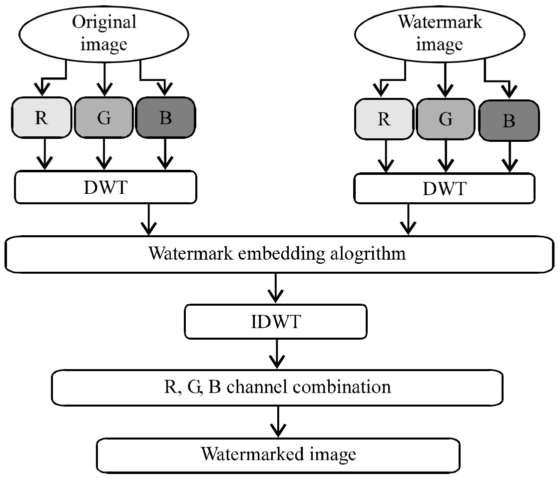

Fig. 2: Block diagram of watermark embedding algorithm

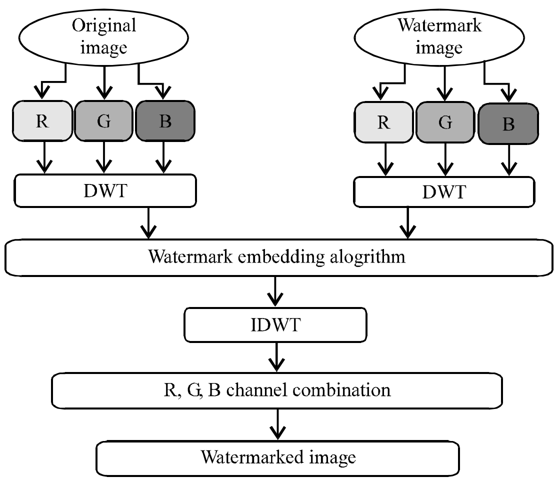

Fig. 3: Block diagram of watermark extracting algorithm

Step 1: Firstly in watermark extraction algorithm, the channel of separation operation is applied on the obtained watermarked color image and the original image to generate its sub color images as shown in Fig. 3.

Step 2: For the proximity coefficients and detail coefficients the 2-level discrete wavelet harr transform is applied for the sub images of both obtained watermarked color image and original color image.

Step 3: After apply the discrete wavelet Haar transform for the two-dimensional images, the watermark information is extracting from the watermarked image. According to the algorithm, the original color digital image is decomposed into three color components of O(Red), O(Green), O(Blue), respectively.

Step 4: Finally, original watermarked image decomposes into Wd(Red), Wd(Green), Wd(Blue) are three color components, respectively. In this process the formula for the extraction algorithm is Zude *et al.* (2006):

$$W(r)A(i,j) = \left(Wd(r)A(i,j) - O(r)A(i,j)\right)/\alpha 1 \quad (4)$$

$$W(g)A(i,j) = \left(Wd(g)A(i,j) - O(g)A(i,j)\right)/\alpha 2 \quad (5)$$

$$W(b)A(i,j) = \left(Wd(b)A(i,j) - O(b)A(i,j)\right)/\alpha 3 \quad (6)$$

Step 5: Three watermark images (RGB) are extracted after the implementation of above algorithm and application of inverse two levels Haar Discrete Wavelet Transform (IDWT).

Step 6: The original watermark image is obtained by combination of the three R, G and B watermark image.

RESULTS AND DISCUSSION

The experiment is done with a PC having configuration of 2.53 GHz personal laptop having 4 GB RAM and MATLAB 14.0 Software platform is used to perform the experiment. In the proposed algorithm experiment, we take 512×512 dog and girl as an example. The watermark is a visually recognizable color image which is 256×256 lading Toyota logo, Fig. 4a and 5a shows the original image, Fig. 4b and 5b shows watermark image. Figure 4c and 5c shows the watermarked image that is composed by inclusion the color watermark into the original image. Comparison Fig. 4a, 5a, 4c and 5c, we find that these two pictures look almost the same. Figure 4d and 5d show the recovered watermark image from proposed methods.

In our experiment of proposed algorithm for testing of the robustness, we will experiment this watermarked image by using common operations of image processing such as adding pepper and salt noise, Gaussian noise, Brightness and contrast increment, rotation on 45° and 90°, etc. The resulted images in Fig. 5 show the experimental results with these operations. Experiment results show that the algorithm has more robust when it face this attacks like salt and pepper noise, Gaussian noise, brightness and contrast increment, rotation as show in Fig. 5.

In this study, we will compute the normalized correlation NC between the original Watermark image (W) and extracted Watermark image ($\hat{W}$). NC can be used to evaluate the watermarking algorithm as follow:

$$NC = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} W(i,j)\hat{W}(i,j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} W(i,j)^2} \quad (7)$$

Compute the Peak-Signal-to-Noise Ratio (PSNR) from Eq. 8 between the original image I and the watermarked image Wd:

$$PSNR = 10\log\frac{(M\times N)^2}{MSE} \quad (8)$$

where the Mean Square Error (MSE) between the watermarked image Wd and cover image I:

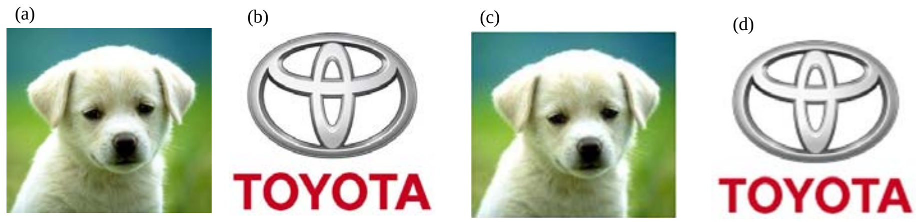

Fig. 4: a) Original dog's image; b) Watermark image; c) Watermarked image and d) Extractedwatermark image

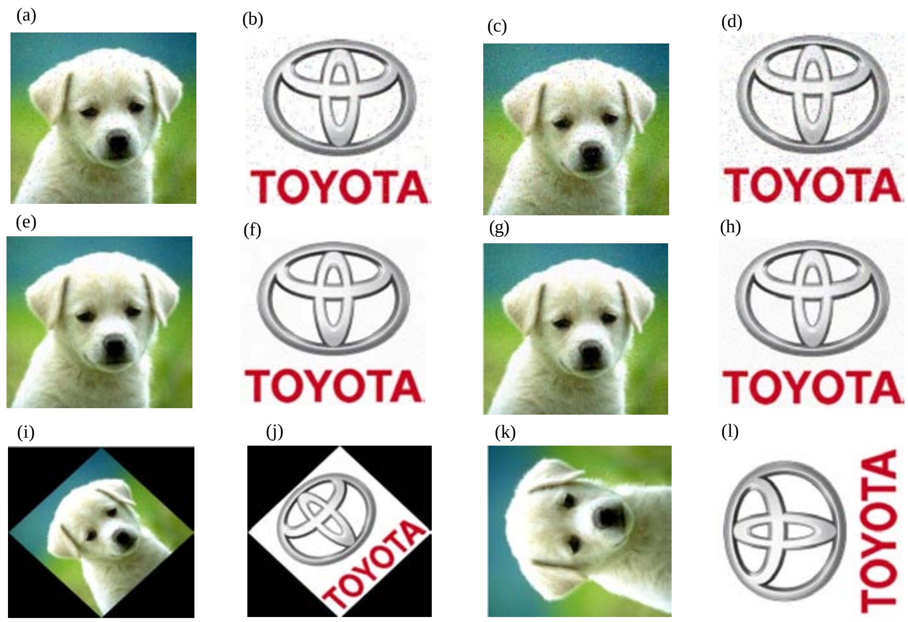

Fig. 5: a) Pepper and salt noise (0.01) on watermarked image; b) Pepper and salt noise (0.01) on recovered watermark; c) Pepper and salt noise (0.02) on watermarked image; d) Pepper and salt noise (0.02) on recovered watermark; e) Gaussian noise (0.001) on watermarked image; f) Gaussian noise (0.001) on recovered watermark; g) Gaussiannoise (0.002) on watermarked image; h) Gaussian noise (0.002) on recoveredwatermark; i) Rotation 45° watermarked image; j) Rotation 45° recovered watermark; k) Rotation 90° watermarked image and l) Rotation 90° recovered watermark

Table 1: Experiment results and analysis on dog image

Image	Watermarked image PSNR (dB)	Extracted watermark (NC)
Dog	50.4213	0.8732
Girl	51.4317	0.8830

Table 2:Experiment results and analysis on dog image

Operation type/Parameters	Watermarked PSNR/db	NC
Original		
Proposed	35.699	0.9798
Pepper and salt noise		
0.01	29.522	0.8921
0.02	26.991	0.8859
Gaussian noise		
0.001	34.451	0.6938
0.002	32.428	0.8978
Rotation		
45°	39.532	0.9785
90°	37.491	0.8965

$$\text{MSE} = 10\log\frac{1}{MN}\sum\nolimits_{i=1}^{M}\sum\nolimits_{j=1}^{N}\big(Wd(i,j)\big)-I(i,j)\big)^2 \quad (9)$$

Table 3: Experimental result and analysis

Operation type/Parameters	Watermarked PSNR/db	NC
Original		
Proposed	36.897	0.9875
Pepper and salt noise		
0.01	30.529	0.8546
0.02	28.987	0.8545
Gaussian noise		
0.001	33.258	0.9632
0.002	36.987	0.9325
Rotation		
45°	38.235	0.6589
90°	36.658	0.8364

The extracted watermark can be then identified even after attacks have been used results of Table 1-3. This proves the robustness of the algorithm against of noisy, geometric and physical attacks.

CONCLUSION

This study gives a Robust watermarking algorithm for color images based on haar discrete wavelet transform. The watermarked picture's quality has a fine and enhanced nature of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) between the watermarked image and cover image. The method proposed is more durability to loud, geometric and physical attacks. The experimental results are better as far as PSNR of the watermarked image and NC values of the extracted watermarks. At last the proposed algorithm is simple and has better in the secure transmission.

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