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Watermarking Scheme for using YCbCr based on 2-Level DWT

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Abstract

Multimedia data for both personal and commercial purposes is now accessible to everyone due to the rapid development of the Internet. Consequently, the issue of copyright protection has surfaced and has triggered the development of several techniques for multimedia copyright protection. Such techniques include digital watermarking in which the important information contained in the host media is concealed by embedment in carriers such as images, videos, or audios. In this paper, the adaptive color image watermarking technique is proposed for the satisfaction of both imperceptibility and robustness demands. There are two main stages involved in this technique – coding/embedding and decoding/extraction. Prior to the coding stage, imperceptibility and robustness are preserved by first converting the host image from RGB to YCbCr color space before selecting the Cb component to apply the DWT embedding technique. Once more, the selected quadrant of the hosted image is decomposed using DWT before extracting the watermarked image. The robustness and efficiency of this technique were proved by exposing the watermarked image to six types of attacks, namely Median filter, Gaussian noise, Sharpening filter, Salt & Pepper Noise, JPEG Compression, and Rotation. The results of the study were benchmarked against other methods that deploy DST on the same images. From the benchmarking process, the proposed algorithm was found to withstand the six types of attacks earlier mentioned and achieved a better performance compared to the DST approach. The quality of the watermarked image was also preserved in the proposed method.

Keywords; *Watermarking, Discrete wavelet transform, YCbCr image, discrete slant-let transform*

I. INTRODUCTION

Over the last few years, multimedia communication has become a major tool for information transfer due to the evolution of communication technologies. However, this has resulted in copyright protection issues due to the easy access to multimedia data and its content by everyone [1]. Consequently, several novel protection mechanisms such as watermarking and steganography techniques have been developed to solve this problem. Steganographic techniques involve the hiding of information in a carrier such that its presence cannot be visually perceived. Watermarking, on the other hand, is a technique where the information is concealed in a carrier such as an image, video, or audio in a manner that cannot be visually or audibly detected. It confers protection and robustness to different forms of attacks, including those that involve image operations (such as rotation, Salt & Pepper Noise, cropping, filtering, Gaussian noise, and JPEG Compression) [2]. In the case of multimedia watermarking, it is a form of digital watermarking in which another information is embedded into the watermark. The two main stages of watermarking techniques are embedding and extraction [3]. The embedding stage involves passing the host multimedia through several encryption frameworks based on the type of application or domain. For the extraction stage, the hidden data is retrieved upon fulfilling the copy protection requirements. Figure 1 depicts the whole process in a watermarking system

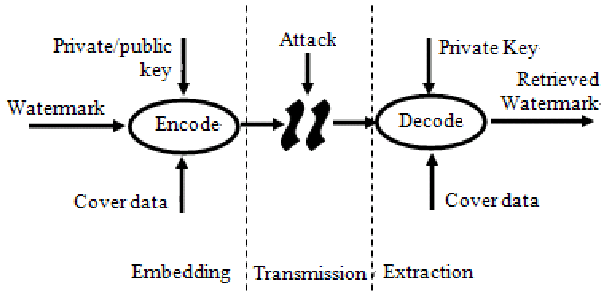

Fig. 1 the whole processes in a watermarking system

II. RESEARCH METHODOLOGY

The method employed in this paper involves the conversion of the RGB color image to the YCbCr color space before converting it into four sub-bands using DWT technique to ensure its imperceptibility and robustness after watermarking. The two important stages in this process are the embedding and extraction stages, both involving several steps that will be explained later. During the embedding process, the cover image is first converted to the YCbCr color space before getting the four sub-bands using DWT techniques. Next is to choose the best band on which the watermark image will be embedded [5]. The next stage involves the use of an extraction method to extract the hidden image. An important step to note in this process is to ensure how to embed the watermarked image within the cover image to guarantee its robustness, capacity, and imperceptibility. Being that the major concern is copyright protection, watermarking is an important method of achieving this feat. Another important thing to consider is to ensure the quality of the watermarking in terms of imperceptibility (can be achieved by controlling the size of the secret image [8]. This involves the conversion of the watermarked image from (0-255) level to (0-15) level, then, changing to I-D array. The aim of the extraction process is to restore the integrity of the original image without compromising its quality and ensuring no observable differences between the watermarked and the cover images. Lastly, the result of this scheme is checked for high robustness by benchmarking against the Salentlet transform.

III. EMBEDDING STAGE

The processes involved in the proposed watermarking method in this study are shown in Figure 2. These processes were adopted to ensure that the main goals of watermarking (imperceptibility, capacity, and robustness) are considered during the embedding process.

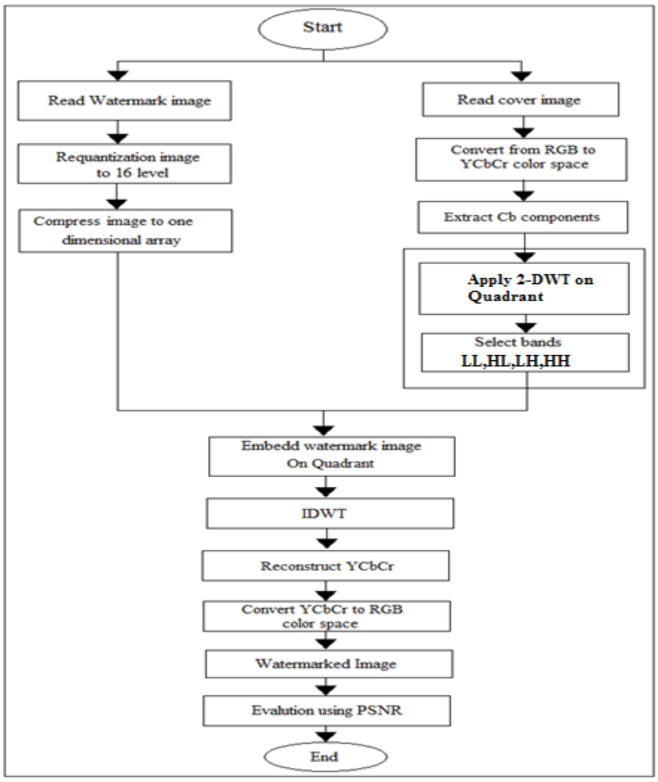

Fig. 2 the processes of the proposed approach

A. Image Requantization

The size of the embedded data is very important in information hiding as it is one of the factors that influence the hiding capacity and PSNR ratio. The efficiency of any hiding technique can be increased by reducing the size of the hidden data [18]. Images can be transformed from 256 level into different levels using image requantization which involves compressing an image in the subsequent stage. The

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requantization process can be represented by the equation below [10]:

$$I_{new} = \frac{I_{old} - Min}{Max - Min} * Range_{new} + Start \quad (1)$$

where: I new = obtained value after image stretching.

I old = original image size prior to stretching.

Range new = targeted value to convert the image value to.

Max and Min = maximum and minimum pixel values prior to stretching

majorly, image stretching is employed when there is a need to convert values from one range to the other. The values in this work were converted from (0-255) range to (0-15) range as discussed in the next subsection. Only 4 representation bits are required for values of this range, as depicted in Figure 2 which depicted the conversion of a Lena image into 2 ranges.

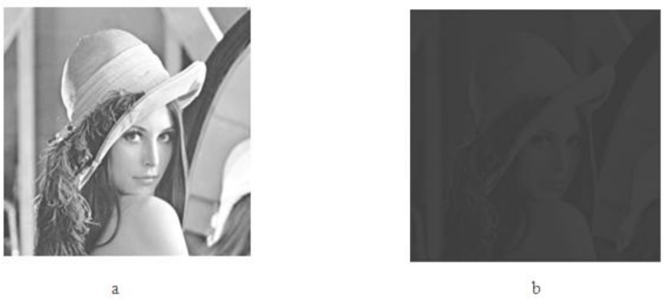

Fig. 3. Lena image requantization in the a) 0-255 and b) 0-15 ranges

B. Image compression

From the previous phase, the values of the image pixel have been converted into a new range. Therefore, these converted values require only 4 bits from each byte to be represented, meaning that in each image byte, 50% of the byte will be empty. Hence, getting 50% of the size of a same requires combining each byte into a 1-D array.

C. RGB CONVERSION INTO YCBCR

Owing to the higher imperceptibility of the YCbCr color space compared to the RGB color space [7], the YCbCr color space is mainly used by researchers. In this color space, Y represents the components' luminance while the blue and red chrominance components are represented by CbCr. For the RGB color space, R, G, and B represents the red, green, and blue channels, respectively. The process of RGB color space transformation into the YCbCr spectrum is shown in Equation 3.2 [11].

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128 & 24.966 \\ -37.0.797 & -74.203 & 112 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (2)$$

The YCbCr mainly differ from the RGB color space by representing bright colors with 2 or more color signals while RGB represents colors as R, G, or B.

D. DWT for the Cover Image

The DWT is a method for hierarchical decomposition of an image [12]. It is based on wavelets (small waves) which differ in frequency and have a limited lifespan. Signals are split during DWT processes into high and low-frequency regions; the high-frequency regions are mainly used for watermarking processes due to the lower sensitivity of the human eye to changes in edges [13].

Having read the watermarked image and having converted the level to (0-15), the DWT algorithm is used to partition the cover image into 4 sub-bands (LL, HL, LH, and HH) and the best bands are subsequently selected for watermarked image embedment.

E. Watermarked Image embedment in the Cover Image

The embedding process involves hiding a secret or private image in a carrier without significantly altering the quality of the carrier. The embedding

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process is represented in Equation 3, where WI represent the watermarked image, H represents the carrier image, and b represents a suitable scaling factor (0.005), and W is the watermarked image (binary) [14,15].

$$WI = H + b * W \quad (3)$$

F. Wavelet Reconstruction (IDWT)

An inverse DWT (IDWT) is applied to revert the image to its spatial domain in a process that will produce one watermarked quadrant.

G. Reconstruction YCbCr

The quadrants are finally recombined to get the watermarked image in the YCbCr color space as illustrated in Figure 5.

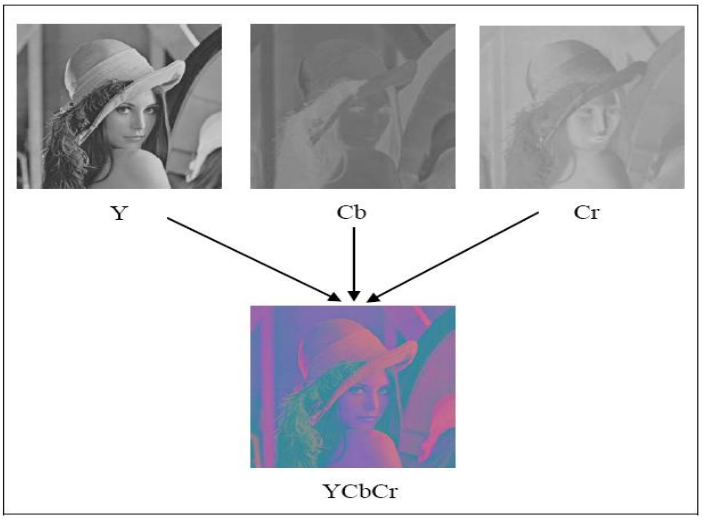

Fig 5.YCbCr reconstruction

IV. EXTRACTION STAGE

In this stage, the watermarked image of the cover image is separated without significantly altering the quality of the watermarked and cover images. Figure 6 depicts the watermarked image extraction process from the cover image.

Later, the cover image will be converted from the RGB color to YCbCr as earlier described to extract the Cb. Then, DWT will be applied to extract the pieces of the watermarked image (as discussed later). After splitting the image into 4 bands, the HH sub-band is then selected to retrieve the watermarked image [16] using the formula below, where WI represent the watermarked image, H represents the value of the host image, b represents a suitable scaling factor (0.005), and W is the watermarked image (binary)

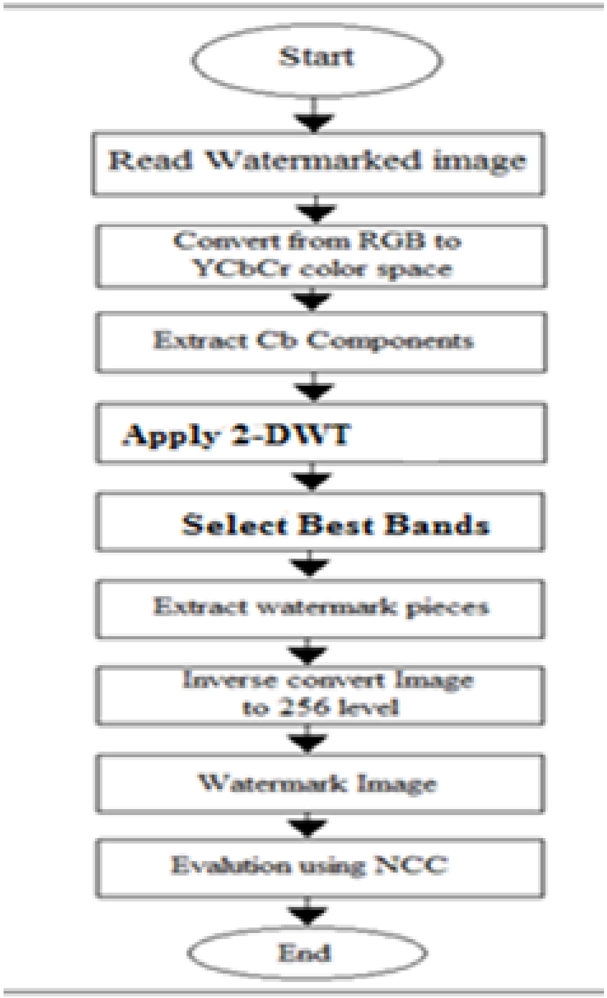

Fig 6. The watermarked image extraction process

$$W = (WI – H) / b \quad (4)$$

After retrieving the pieces of the watermarked image, the requantization process will be reverted to convert the watermarked images' level back to the original range (0-255

V. ROBUSTNESS MEASURE

Equation 5 can be used to determine the similarity between the original image and the extracted watermarked image.

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$$NCC = \frac{\sum_x \sum_y (W_{xy} \times W'_{x,y})}{\sum_x \sum_y (W_{xy})^2} \quad (5)$$

where W x y and W ' x y represents the value of the pixel at position (i, j) of the original image and the extracted watermarked image, respectively, such that $1 \leq (x, y) \leq 32$.

VI. MEASURE OF IMPERCEPTIBILITY

The peak-to-signal-noise ratio (PSNR) measures the variations in the original and watermarked image qualities; higher PSNR values indicate higher image quality. The PSNR can be calculated as follows [15].

$$PSNR = 10 \times \log_{10}\left(\frac{MAX^2}{MSE}\right) \quad (6)$$

Where m is the watermarked image size and n is the host image size, I (i, j) is the host image pixel value, K (i, j) is the pixel value of the watermarked image, MSE represents the mean square error for (I, K).

VII. ATTACKS

The results after applying various attacks on Lena and Baboon images are presented in this section. Some of the applied attacks include Sharpening, JPEG compression, Median filter, Gaussian noise, Salt & Peppers, and Rotation.

A. Gaussian Noise Attack (GNA)

This is one of the commonly used statistical attacks deployed in watermarking processes. Its probability density function is proportional to that of the normal distribution. Gaussian noise is the most commonly used attack in applications, where it serves as an additive white noise to produce additive white Gaussian noise.

B. Salt & Peppers Attack (S&PA)

This attack involves the deposition of black and white pixels on an image at different density ratios (0.01, 0.02, and 0.03 %). It is clearly observed on the affected image as a small randomly spread noise.

VIII. PERFORMANCE TESTING AND EVALUATION

The results of the proposed method are evaluated in this section based on 2 criteria (PSNR and NCC). First, the watermarked image will be tested based on the results of the embedding process of the watermark image in Y, Cb, and Cr components depending on the PSNR. The watermarked image after applying the proposed method is shown in Figure 7 while Figures 8 and 9 presented the extracted watermarked image after exposure to two attacks (Gaussian Noise and Salt & Pepper). Tables 1 and 2 presented the results of the watermarked image (with respect to the NCC and PSNR) after the blue colors have been selected and the proposed embedding technique applied on each of the LL2, LL3, and LL4.

	The original image	Watermarked image prior to attack exposure	Watermarked image post exposure to attack
Lena			

Fig 7. The watermarked image before and after attacks

TABLE I

THE WATERMARKED IMAGES' PNSR AFTER SELECTING THE BLUE (B) COLORS

Channel	The selected band		Image after watermaking	PSNR (db)
B	LL2	Y		50.050
B	LL2	Cb		45.020
B	LL2	Cr		44.180
B	LL3	Y		51.550
B	LL3	Cb		50.560
B	LL3	Cr		51.780
B	LL4	Y		59.780
B	LL4	Cb		55.210
B	LL4	Cb		49.230

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Fig. 9. Extracted watermarked image after exposure to GNA

TABLEII

THE NCC VALUES FOR THE TWO ATTACKS

GNA result				S&PA result		
Ratio	0.010%	0.020%	0.030%	0.010%	0.020%	0.030%
Measure	NCC	NCC	NCC	NCC	NCC	NCC
Lena	0.9620	0.99750	0.99690	0.99620	0.97210	0.95710

IX. RESULTS DISCUSSION AND CONCLUSION

Digital watermarking is was developed to solve at least 3 existing multimedia communication problems, including protection of copyrights, establishing the integrity and authenticity of information, and tracing the unlawful distribution of patented contents. These are the major issues that emanate from wide data distribution over digital networks. Researches have proved that numerous types of attacks exist against watermarking techniques, and experiments have shown previous watermarking approaches to be prone to several types of malicious attacks. As such, the embedded watermarks in digital media must be extracted in order to identify the ownership. Furthermore, some attacks may be complicated for most watermarking methods to handle. Therefore, there is a need for a universal watermarking scheme which can withstand different types of attacks and, concurrently, meet the conventional and embedding capacity requirements. This paper reported a new embedding method which is based on the conversion of RGB images into the YCbCr color space. Here, each color of an image is transformed into the Y, Cb, and Cr components, resulting in RedYCbCr, GreenYCbCr, and blueYCbCr. To extract the frequency components, a two-level DWT is applied after converting the image on each YCbCr color. For the embedding process, the BlueYCbCr component is the best component. The DWT process gives rise to four frequency sub-bands (LL, LH, HL, and HH). All the bands were selected in this paper to embed the watermarked image in order to test the strength of the proposed algorithm. The performance of the system was determined based on the PSNR and NCC values, where the blue channel of LL4 frequency achieved the best PSNR value of 59.78dB, while the NCC of the similarity between the original image and the watermarked image was 0.9969 %. The system achieved an NCC ratio of 0.03% after exposure to Gaussian attack and 0.03% after exposure to Salt & Pepper attack. The final performance of the proposed algorithm was benchmarked against that of Slant-let algorithm earlier reported in the literature [4]. Though there was some difference of about 0.82dB, this is still important when dealing with cryptographic techniques to ensure the accuracy, robustness, and reliability of the transmitted information. Thus, the proposed algorithm in this study is a better image embedding algorithm compared to the Slant-let transform.

Fig. 10. Extracted watermarked image after exposure to Salt & Pepper attack

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