High Quality Extracted Contour from Digital Image Watermarking using DCT & DWT Transforms

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***Abstract*—**Digital watermarking has been proposed as a solution to the problem of copyright protection of multimedia data in a networked environment. It makes possible to tightly associate to a digital document a code allowing the identification of the data creator, owner, authorized consumer, and so on. In this paper a new watermarking algorithm for digital images is presented: the method, which operates in the frequency domain, embeds a watermark bits in a selected set of DCT & Wavelet coefficients using high-pass filter. After embedding, the watermark is adapted to the image by exploiting the masking characteristics of the human visual system, thus ensuring the watermark invisibility. The scheme analyzed is deals with researching techniques of watermark embedding into spectral images, and methods of watermark extraction and detection. This scheme is requires side information (high pass filter coefficients) in watermark recovery. It is based on inserting the watermark bits into the high pass filter DCT & Wavelet coefficients. By using of zonal sampling method (low-and-high-pass filters), we select the largest coefficients in the high pass filter which is equal in size to the digital water mark bits. Then these coefficients are used to embed the watermark bits. By exploiting the statistical properties of the embedded sequence, the mark can be reliably extracted without resorting to the original uncorrupted image. Experimental results demonstrate that the watermark is robust to several signal processing techniques (Gaussian noise is used in this paper). The contours of the original image can be extracted easily by using of SSPCE (single step parallel contour extraction) method from watermarked image with accepted level of distortion.

***Keywords*—**Digital watermarking, DCT & DWT transforms, image compression.

I. Introduction

SEVERAL watermarking techniques were developed and a large amount of methods were proposed, but still the most of known ways to protect data are far from ideal. The digital data of the various types such as text, images, audio, and video can be processed by the watermarking procedure. Two main methods for embedding are used, namely the spatial and the frequency domain. The spatial domain techniques are more vulnerable in common image attacks such as filtering or JPEG compression. The frequency-domain approaches are the most popular for image watermarking. In these schemes, the image is being transformed via some common frequency transform and watermarking is achieved by altering the transform coefficients of the image. The transforms that are usually used are the DCT, DFT and the DWT [1]–[4]. Image watermarking techniques proposed so far can be divided into two main groups: those which embed the watermark directly in the spatial domain [5], [6] and those operating in a transformed domain, e.g. the frequency domain [7], [8]. The simulation is done using Matlab programming to add and extract watermarks.

The watermark embedding was performed in the transform domain. According to the proposed model, in the DCT domain largest coefficients was replaced by the linear combination of the watermark. A set of embedding parameters was investigated. The quality of the resulted watermarked images was measured and analyzed before and after corrupted by Gaussian noise. Recommendations for the embedding system were stated. Some method of watermark extraction were used. Results were analyzed. Watermark robustness against Gaussian noise attacks was verified. Number of detection experiments with accordance to embedding parameters was made. The spectrum image (high-pass filter coefficients) was considered as a possible way to detect embedded watermark.

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II. Discrete Cosine Transform

The DCT is a very popular transform function used in signal processing. It transforms a signal from spatial domain to frequency domain. Due to good performance, it has been used in JPEG standard for image compression. DCT has been applied in many fields such as data compression, pattern recognition, and image processing, and so on. The DCT transform and its inverse manner can be expressed as follows:

$$F(u,v)=\frac{4C(u)C(v)}{n^2}\sum_{j=0}^{n-1}\sum_{k=0}^{n-1} f(j,k)\cos[\frac{(2j+1)u\pi}{2n}]\cos[\frac{(2k+1)v\pi}{2n}] \quad (1)$$

$$f(j,k)=\sum_{u=0}^{n-1}\sum_{v=0}^{n-1} C(u)C(v)F(u,v)\cos[\frac{(2j+1)u\pi}{2n}]\cos[\frac{(2k+1)v\pi}{2n}] \quad (2)$$

III. Discrete Wavelet Transform

The Wavelet analysis is an exciting new method for solving difficult problems in mathematics, physics, and engineering, with modern applications as diverse as wave propagation, data compression, signal processing, image processing, pattern recognition, computer graphics, the detection of aircraft and submarines and other medical image technology [13], [14]. Wavelets allow complex information such as music, speech, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision.

Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting using the equation (3).

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{a}}\Psi(\frac{t-b}{a}) \tag{3}$$

IV. Zonal Sampling Methods

A lot of zonal sampling methods which was described in [11], shows that the best scheme for compression and contour extraction is as illustrated in Fig. 1. Fit criterion of the algorithm consists in selecting one of the squared block of the spectral images (e.g. shadow region) as LPF filter for image compression and the other coefficients will be taken into account in the contour reconstruction stage as shown in the Fig. 1. This algorithm in this work is referred as algorithm I [11].

This paper compared this zonal method with a another zonal sampling method consists in selecting one block of the spectral images (i.e. shadow region) as LPF for image compression and the other coefficients will be taken into account in the contour reconstruction stage. This algorithm is referred as algorithm II and is shown in Fig. 2 [12].

The forward Wavelet transform is applied to the gray-level image. By using low and high-pass filters after the zonal procedures (algorithms I & II) the two spectral sub-images are obtained. The HPF coefficients are used to embedding process and then inverse transform is done. The forward DCT transform then is applied. The HPF details coefficients are used to embedding process while the LPF of approximation coefficients are used to obtained the compressed image.

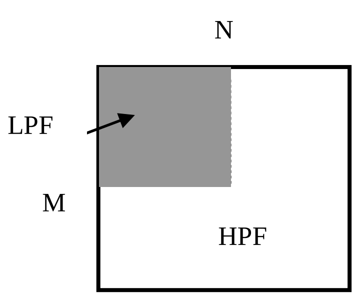

Fig. 1 Zonal sampling method (algorithm I)

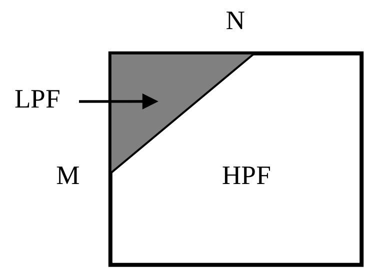

Fig. 2 Zonal sampling method (algorithm II)

V. Description of the Algorithm

The forward Wavelet transform is applied to the gray-level image. By using zonal procedures (algorithms I & II) the two spectral sub-images are obtained. The part of digital water mark is embedded to the N largest values in details coefficients using the following equation

$$New\_coefficient = (Coefficient\_of\_HPF) * ((1+\alpha W) \tag{4}$$

where α is parameter determined the coefficient value and the W is watermark bits.

The inverse transform is taken to the combined low and high pass filters images. Then DCT transform is applied to the obtained gray-level image. By using zonal procedures (algorithms I & II) the two spectral sub-images are obtained. The remains digital water mark is now embedded to the N largest values in details coefficients using the equation (4).

Finally, the Gaussian noise is added to the watermarked image. The SSPCE (single step parallel contour extraction) method is applied to the binary image which is obtained by suitable threshold value applied to the noisy digital watermarked image [9], [10]. Flowchart of the proposed embedded digital watermark & contour extraction and image compression is depicted in Fig. 3.

The extraction step of watermark from host image is similar to the process of the embedded algorithm. The watermarked image must be transformed to frequency domain by DCT approach. The part of N largest coefficients of the spectral image (HPF) are determined. The inverse transform is applied to extract the part of watermark using the formula

$$X = [\frac{Coefficient\_of\_HPF(Watermarked\_Imge)}{Coefficient\_of\_\_HPF(Original)} - 1]/\alpha \tag{5}$$

where X is extracted watermark bits.

The forward Wavelet transform is applied to determine the remains N largest coefficients of the spectral image (details coefficients). The inverse wavelet transform is applied to extract the remains part of watermark equation (5). Flowchart of the digital watermark extraction is depicted in Fig. 4. The analysed algorithms use method of contour extraction called (SSPCE) with 3x3 pixels window structure. By using the central pixel the object contours is extracted and the all possible edge direction is found which connects the central pixel with one of the remaining pixels surrounding it [13], [14].

As a further test, the Tools image was corrupted by the addition of Gaussian noise, thus obtaining the blurring image. A zero-mean Gaussian noise with standard deviation less than 0.5 was used. Though the image degradation is so heavy that it cannot be accepted in practical applications, the mark is still easily recovered.

VI. Applied Measures

The proposed image compression and contour extraction method is related to the data compression and extraction problems. To evaluate its compression ability, the following compression ratio was introduced if each pixel is implemented by eight bits.

$$bpp = \frac{S*8}{(n*m)} \tag{6}$$

where:

NOZ - number of zero coefficients

S - Coefficients number in the desired zonal used as LPF filter;

n * m - size of the image.

The mean square error (MSE) and peak signal-to-noise ratio (PSNR) criterions were used to evaluate the distortion introduced during the image compression and contour extraction procedures. The MSE criterion is defined by the following equation:

$$MSE(I,\tilde{I}) = \frac{1}{(n*m)} \sum_{i=0}^{n} \sum_{j=0}^{m} (I(i,j) - (\tilde{I}(i,j))^2 \tag{7}$$

where I and $\tilde{I}$ are the grey-level and reconstructed images respectively.

The PSNR is defined by the following formula:

$$PSNR(I,\tilde{I}) = 10\log_{10} \frac{(L-1)^2}{MSE(I,\tilde{I})} \tag{8}$$

where L is the grey-level number.

VII. Experiments Results

To visualize the experimental results a set of two test images & two digital watermark images is selected. Selected images are shown in Figure 5 (related results are shown in the Fig. 6 to Fig. 9 and in Table I & Table II).

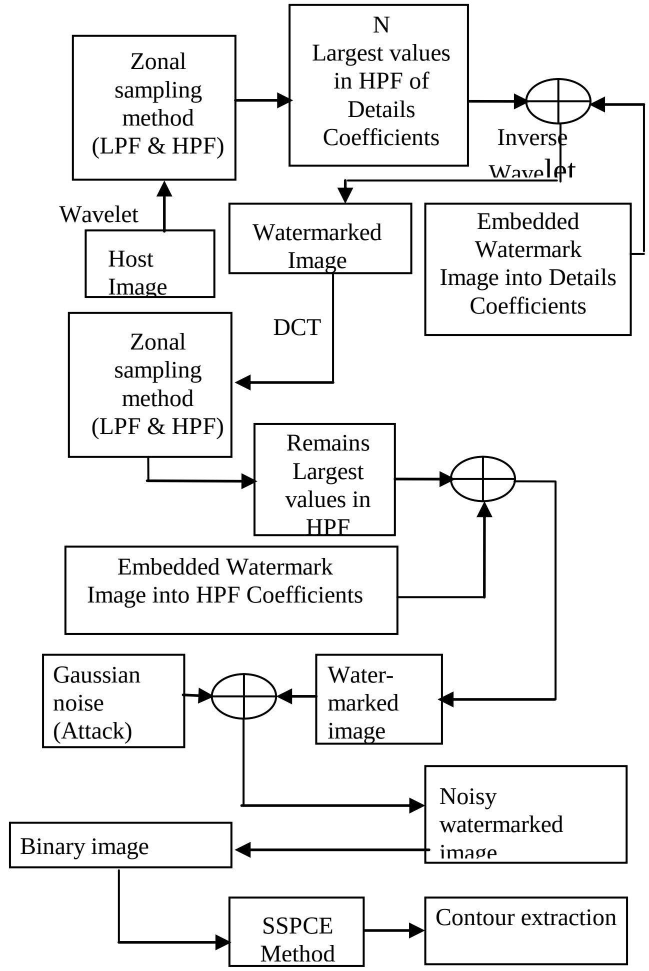

Fig. 3 Flowchart of the Embedded digital Watermark & contour extraction

a) b)

Fig. 4 Test images: a) Host (Tools), and b) Watermark

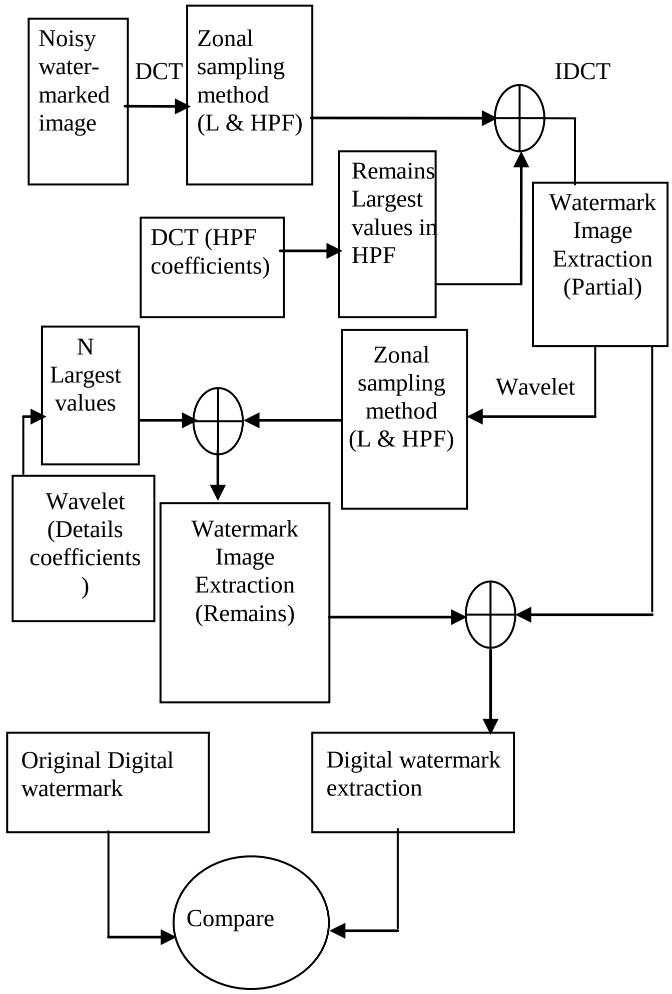

Fig. 5 Flowchart of the digital watermark extraction

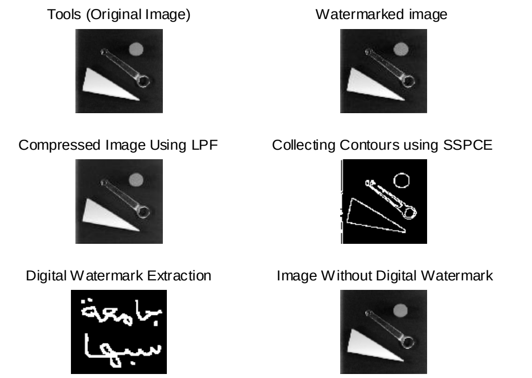

Fig. 6 Results using algorithm I by DCT

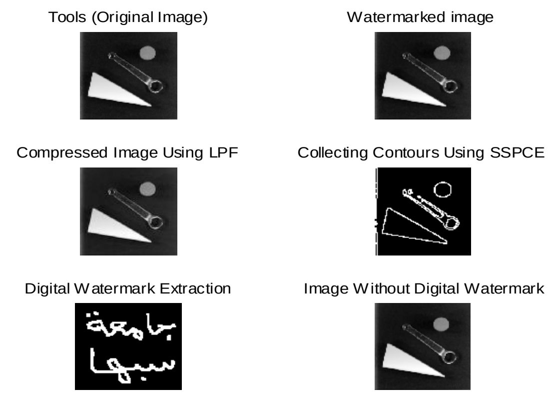

Fig. 7 Results using algorithm I by DCT & Wavelet

TABLE I

$\sigma = 0.1$ USING ALGORITHM I (N=M=122 FOR DCT & 128 FOR WAVELET) WITH BPP=1.8169 & CORRELATION=1.00

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0460	61.4998
Noisy Watermarked (DCT)	0.0460	61.4998
Compressed (DCT)	7.2608	39.5209
Without watermark (DCT)	2.8147x 10^-27	313.6364
Watermarked (DCT & WAVELET)	4.4387	41.6582
Noisy Watermarked (DCT & WAVELET)	4.4387	41.6582
Compressed (DCT & WAVELET)	8.2255	38.9792
Without watermark (DCT & WAVELET)	4.3897	41.7064

TABLE II

$\sigma = 0.1$ USING ALGORITHM II (N=M=172 FOR DCT & 128 FOR WAVELET) WITH BPP=1.8162 & CORRELATION=1.00

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0458	61.5258
Noisy Watermarked (DCT)	0.0458	61.5258
Compressed	7.1686	39.5765
Without watermark (DCT)	2.8907e-027	313.5208
Watermarked (DCT & WAVELET)	10.6422	37.8605
Noisy Watermarked (DCT & WAVELET)	10.6422	37.8605
Compressed (DCT & WAVELET)	9.4818	38.3619
Without watermark (DCT & WAVELET)	10.5608	37.8939

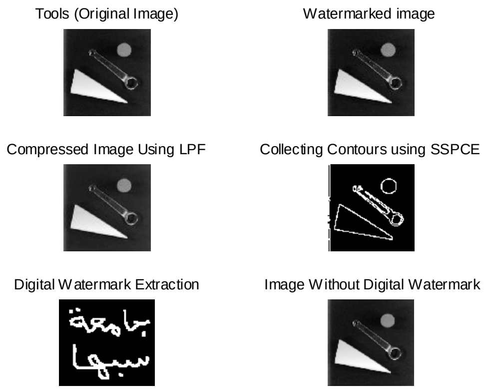

Fig. 8 Results using algorithm II by DCT

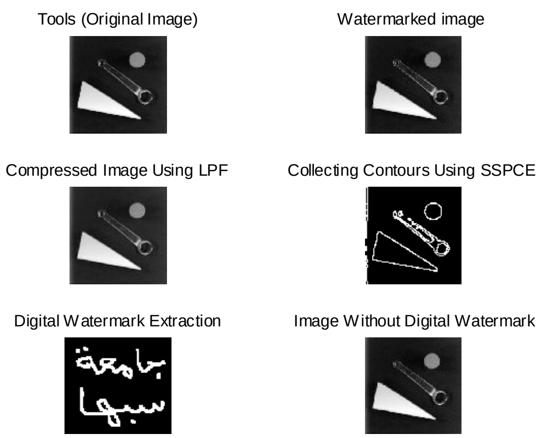

Fig. 9 Results using algorithm II by DCT & Wavelet

$\sigma = 0.37$ USING ALGORITHM I (N=M=122) WITH BPP = 1.8169 & CORRELATION = 0.7343

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0460	61.4998
Noisy Watermarked (DCT)	0.1016	58.0637
Compressed (DCT)	7.2608	39.5209
Without watermark (DCT)	0.0406	62.0480
Watermarked (DCT & WAVELET)	4.6354	41.4699
Noisy Watermarked (DCT & WAVELET)	4.3424	41.7535
Compressed (DCT & WAVELET)	8.2255	38.9792
Without watermark (DCT & WAVELET)	4.3897	41.7064

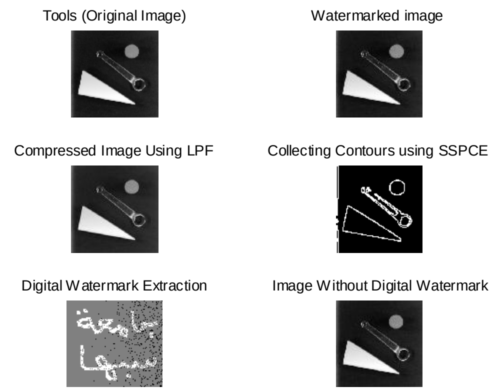

Fig. 14 Results using algorithm I by DCT

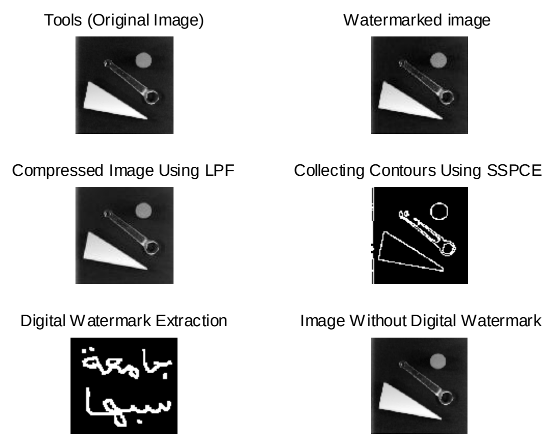

Fig.15 Results using algorithm I by DCT & Wavelet

$\sigma = 0.37$ USING ALGORITHM II (N=M=172) WITH BPP = 1.8162 & CORRELATION = 0.7298

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0458	61.5258
Noisy Watermarked (DCT)	0.1013	58.0739
Compressed (DCT)	7.1686	39.5765
Without watermark (DCT)	0.0398	62.1345
Watermarked (DCT & WAVELET)	10.9413	37.7401
Noisy Watermarked (DCT & WAVELET)	9.9705	38.1436
Compressed (DCT & WAVELET)	9.4818	38.3619
Without watermark (DCT & WAVELET)	10.5608	37.8939

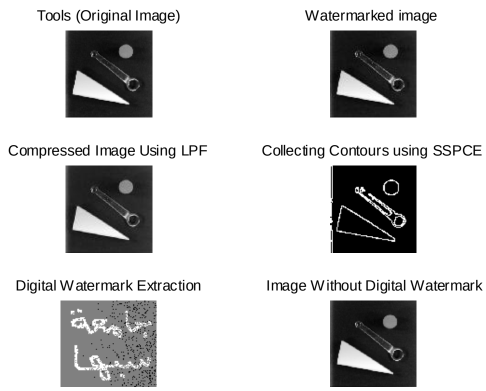

Fig. 16 Results using algorithm II by DCT

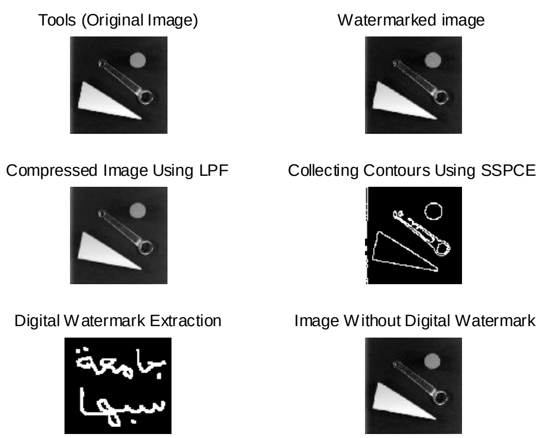

Fig. 17 Results using algorithm II by DCT & Wavelet

$\sigma = 0.4$ USING ALGORITHM I (N=M=122) WITH BPP = 1.8169 & CORRELATION = 0.4533

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0460	61.4998
Noisy Watermarked (DCT)	0.2308	54.4992
Compressed (DCT)	7.2608	39.5209
Without watermark (DCT)	0.1077	57.8080
Watermarked (DCT & WAVELET)	4.6630	41.4441
Noisy Watermarked (DCT & WAVELET)	4.2761	41.8203
Compressed (DCT & WAVELET)	8.2255	38.9792
Without watermark (DCT & WAVELET)	4.3897	41.7064

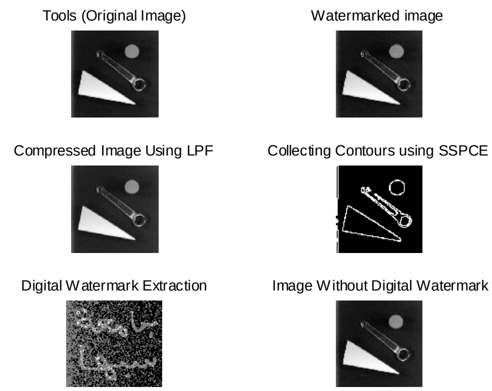

Fig. 18 Results using algorithm I (N=M=122) by DCT

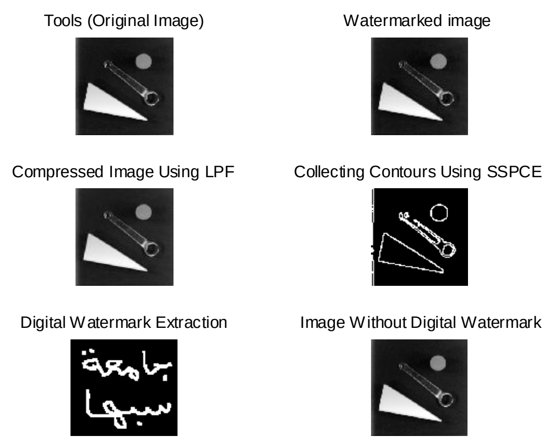

Fig.19 Results using algorithm I (N=M=122) by DCT & Wavelet

$\sigma = 0.4$ USING ALGORITHM II (N=M=172) WITH BPP = 1.8162 & CORRELATION = 0.4429 & 1 RESPECTIVELY

Measures / Images	*MSE*	*PSNR [db]*
Watermarked (DCT)	0.0458	61.5258
Noisy Watermarked (DCT)	0.2306	54.5030
Compressed (DCT)	7.1686	39.5765
Without watermark (DCT)	0.1059	57.8838
Watermarked (DCT & WAVELET)	10.9816	37.7241
Noisy Watermarked (DCT & WAVELET)	9.5102	38.3489
Compressed (DCT & WAVELET)	9.4818	38.3619
Without watermark (DCT & WAVELET)	10.5608	37.8939

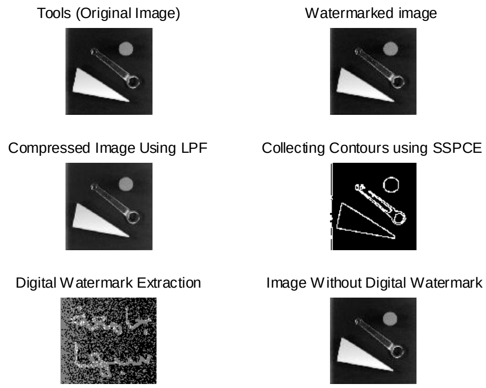

Fig. 20 Results using algorithm II by DCT

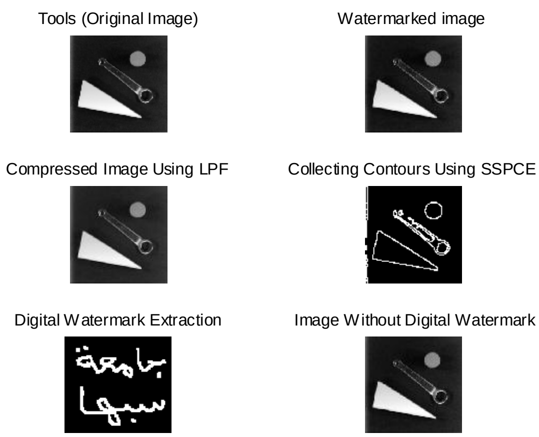

Fig. 21 Results using algorithm II by DCT & Wavelet

VIII. Conclusion

In this paper a watermarking algorithm for digital images operating in the frequency domain is presented. A binary digital watermark image is embedded in a selected set of DCT & Wavelet coefficients. Experimental results demonstrate that the watermark is robust to Gaussian noise. The results show that this kind of algorithms has a satisfactory performance under image corrupted by Gaussian noise. Comparison results among two algorithms of zonal sampling method have also been presented. In this paper, we implemented different watermarking algorithms using MATLAB programming based on DCT & Wavelet transforms. Simulation results show that using second algorithm of zonal sampling method the quality of the host image after digital watermark extraction can be improved by about o.1 decibel if we used DCT only; while using double transforms & second algorithm of zonal sampling method the quality of the host image after digital watermark extraction can be improved by about 4 decibels. Also the extracted contours may obtained from digital watermarked image using SSPCE contour extraction method with accepted level of reconstruction.

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