Multiple Watermarking for Images using Back-Propagation Neural Network and DWT

C. Ananth, M. Karthikeyan, N. Mohananthini, S. Saravanan, M. Swathisriranjani

Abstract: An effective multiple watermarking technique supported on neural network into the wavelet transform can be proposed. The wavelet coefficients has been preferred by Human Visual System. In the proposed work focus on Discrete Wavelet Transform based segmented image watermarking techniques using Back-Propagation neural networks. Using improved BPNN, the multiple watermarks are embedded into the original image, which can advance the pace of the learn, reduce the error and the qualified neural networks are extricate multiple watermarks as of the embedded images. The planned strategy achieves a excellent visual effect scheduled the watermarked images as well as high robustness on extracted multiple watermarks.

Keywords: Digital Watermarking, Discrete Wavelet Transform, Back Propagation Neural Network, Segmented Watermarking Technique and Human Visual System.

I. INTRODUCTION

The quick increment in utilization of PCs (Computers), the web, and computerized sight and sound innovation prompts effectively sharing of advanced information/media. Be that as it may, the accessibility of various picture preparing instruments encourages unapproved utilization of such information. Unapproved clients/aggressors can undoubtedly duplicate, erase or change computerized information. This issue of unlawful change/multiplication of advanced information prompts the development of certain systems which can secure the licensed innovation privileges of computerized information/media. As of late, watermarking has been distinguished as a significant device to achieve copyright assurance/confirmation. An advanced watermark can be implanted in host information in the spatial area just as in the recurrence space. In this work, a hybridized method consolidating a Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) has been introduced [1].

In this paper, a watermarking plan has been proposed for installing a computerized watermark in pictures [2]. The method of embeddings a watermark image is done in concealed mode. The exhibited watermarking calculation creates molecule swarm streamlining (PSO) procedure to discover the scaling factor which is important to do the inserting procedure, in like manner, the proposed system can be versatile. The implanting and extraction systems are completed utilizing discrete wavelet change and particular worth deterioration strategies. The proposed strategy discovers application in controlling the copyright encroachment of pictures by embeddings a shrouded watermark image in the picture, which can be grayscale or shading. The watermarked pictures are tried with different assaults so as to guarantee the power of the proposed system. The result of the proposed strategy got is organized to affirm and demonstrate the adequacy of the proposed system.

A tale vague computerized watermarking plan in different change areas is displayed in [3]. Their proposed advanced watermarking plan has more grounded subtlety and vigor. Salam Abdulnabi Thajeel [4] proposed a strong watermarking strategy for shading pictures utilizing various deteriorations to keep the copyright of the proprietor. The Arnold change is used to scramble the watermark image to upgrade security. The given spread picture is exposed to slantlet change, contourlet change, Schur deterioration, and discrete cosine change. In the end, the scrambled watermark is inserted. Exploratory outcomes demonstrate that their proposed plan accomplishes great subtlety and high obstruction against different assaults.

The advanced watermarking innovation, computerized watermarking assault and, advanced watermarking assessment strategy is presented in [5, 6]. The conventional wavelet change and DCT change are chosen for examination tests. The later joins Arnold scrambling and SVD deterioration, which has unrivaled shave opposition. The three principle classes of different watermarking systems, for example, progressive, portioned and composite watermarking are expounded in [7, 8]. Their strategy is upgraded to expand the presentation of pinnacle sign to commotion proportion and standardized connection in various watermarking methods. A tale computerized watermarking system dependent on neural systems for shading pictures is proposed in [9]. Their proposed work conceals a watermark image excited about a shading picture and after that productively collaborates neural systems to think about the qualities of the embedded watermark related to the watermarked picture.

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Able to neural systems having the learn alongside versatile capacities, the prepared neural systems about precisely recuperate the watermark image from the watermarked picture close by picture handling assaults. Broad exploratory outcomes represent that their procedure altogether has the power to be invulnerable to the assaults.

Jose Aguilar and Juan Anderson [10] displayed the coupling of a picture watermarking calculation, called the least critical piece, in the different classes irregular neural systems. For that, they plan a preparation procedure of the watermark design, an installing procedure of the scholarly example in the first picture, and an identifying procedure of this example in the bearer picture. They got generally excellent exhibitions regarding the Peak Signal to Noise Ratio and Noise Generated criteria. Haribabu et. al. [11] proposed a computerized picture watermarking method utilizing auto-encoder based CNN which is hearty to various commotions and assaults like salt and pepper, Gaussian and JPEG impact. Their proposed strategy is the absolute first endeavor of CNN in the area of watermarking. Their proposed technique for watermarking utilizing auto-encoder based CNN (ACNNWM) gives better or on par results.

A tale picture watermarking approach dependent on the human visual framework (HVS) model and neural system strategy are proposed in [12]. The human visual framework model is used to produce the appropriate quality of an installed watermark. The neural system execution has been working to acquire the neighborhood qualities of a picture. Their trial for everyone in a different picture of the watermark image can be acclimated to exhibit the most noteworthy and suitable quality subject to the impalpability restriction.

Another shading watermarking calculation dependent on differential advancement is proposed in [13]. A host shading picture is at first changed from RGB space to YIQ space, which is exceptionally reasonable for the HVS. At that point, apply three-level DWT to luminance part Y and make four diverse recurrence sub-groups. From that point forward, perform SVD on these sub-groups. In the watermark image implanting technique, apply DWT to a watermark picture image after the scrambling encryption preparing. Their new calculation utilizes a differential advancement calculation with versatile improvement to pick the correct scaling factors. Exploratory outcomes demonstrate that their proposed calculation has a superior presentation as far as intangibility and heartiness.

Yuki Nagai et.al. [14] proposed a computerized watermarking innovation for proprietorship approval of profound neural systems. Their proposed methodology doesn't debilitate the exhibition of systems enthusiastic about which a watermark can be put in light of the fact that the watermark is embedded while preparing the host to arrange. Their analyses show to uncover the capability of watermarking profound neural systems as the premise of this new research exertion.

The inserted watermark does not vanish even after parameter pruning or fine-tuning; the watermark image remains entire even after 65% of parameters are clipped. Ryota Namba and Jun Sakuma [15] presented a novel watermarking method, exponential weighting. Their results prove that their watermarking method achieves the highest performance of watermark even under a malicious attempt of unauthorized service providers, such as query and model modification, without sacrificing the predictive concert of the neural network model.

II. PRELIMINARIES

A. Discrete Wavelet Transform (DWT)

DWT is that the decay of an image interested in diverse secondary images of dissimilar dimension motion level. The DWT can be considered poor frequencies, to present deprived frequency resolution as well as superior time resolution.

The DWT is planned at short frequencies, poor time, frequency declaration and high frequency declaration. The benefits of wavelets are that they offer localization in frequency domain and able to separate the fine details in a Signal. This can be used to isolate the fine and coarse details in a signal.

B. Interleaved Watermarking

In interleaved watermarking technique, the host image can be separated keen on two segments furthermore every watermark symbol can be inserted into particular segment. It is also called as segmented watermarking.

C. Human Visual System (HVS)

The coefficients of wavelet are chosen accords to the HVS characteristics. The HVS can explained in conditions of three dissimilar properties such as frequency sensitivity, texture sensitivity and luminance sensitivity. Evaluate the weight factors for wavelet coefficient of novel image by use the model in [16 - 18].

$$q_i(i,j) = a(l,\theta)b(l,i,j)c(l,i,j)^{0.2} \qquad (1)$$

Where θ, l stands for the orientation along with declaration wavelet transform level of the image, (i, j) is discrete wavelet transform coefficient's position. An initial expression obtains interested in relation of the human eye sensitivity to noise transforms depends on the band.

$$a(l,\theta) = \begin{cases} \sqrt{2}, & if \ \theta = 1 \\ 1, & otherwise \end{cases} \cdot \begin{cases} 1.00, & if \ I = 0 \\ 0.32, & if \ I = 1 \\ 0.16, & if \ I = 2 \\ 0.10, & if \ I = 1 \end{cases} \qquad (2)$$

The second term obtains keen on account the confined brightness of the image can be calculated as in Equation (3). It takes into account to the eye is fewer sensitive to noise in regions of the image wherever the intensity is extremely superior or extremely low.

$$b(l,i,j) = 1 + \frac{1}{256} I_3^3 \left(1 + \left[\frac{i}{2^{3-l}}\right], 1 + \left[\frac{j}{2^{3-l}}\right]\right) \qquad (3)$$

Finally, the local texture motion can be calculated as in Equation (4). measure takes into account that the human being eye is fewer sensitive to regions of the image with tough texture, more specifically, to areas near the edges.

$$c(l,i,j) = \sum_{k=0}^{3-l} \frac{1}{16^k} \sum_{\theta=0}^{2} \sum_{x=0}^{1} \sum_{y=0}^{1} \left[1_{k+l}^{\theta}\left(y + \frac{i}{2^k}, x + \frac{j}{2^k}\right)\right]^2 .$$

$$.Var\left\{ I_3^3\left(1+y+\frac{i}{2^{3-l}},1+x+\frac{j}{2^{3-l}}\right)\right\}_{\substack{x=0,1\\y=0,1}} \tag{4}$$

The $q_i(i,j)$ to the quantization of the coefficient to which the watermarking code must be moreover new. The watermark figure is double, this methodology permits adding to each DWT coefficient the best impalpable watermark level.

D. Back Propagation Neural Network

The BPNN are lone kind of supervised learn neural networks and mainly used learning techniques in neural networks. To achieve least mean squared error (MSE) among expected outputs as well as actual outputs through feed-forward and then the BPNN preserve fix the network weights with using gradient descent methods along with MSE.

Figure 1 shows, BP network design has tri-layers, which is input layer, hidden layer as well as output layer. The wavelet coefficient $qi(i, j)$ is selected based on the weight factor. The production of the equation Round $qi(i, j)/Q$, which can be signified when x, is utilized like an input pace of the BPN. Q represented as Quantization value. The primary weights of back propagation neural network are initialised at x values. Compute the output unit (ak) and production of hidden unit (hj) the by using activation functions.
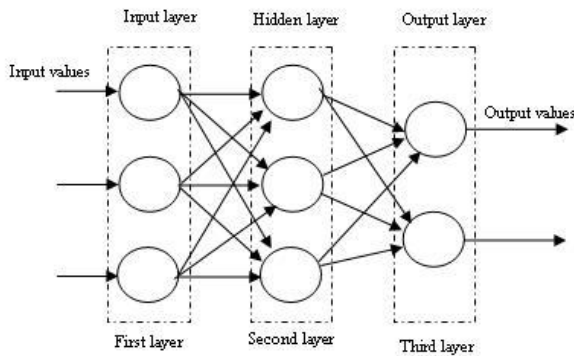

Fig. 1. Structural design of Back Propagation Neural Network

$$h_j = f(\sum_i x_i\ g_{ij}) \tag{5}$$

$$a_k = f(\sum_{j=1}^{p} h_j m_{jk}) \tag{6}$$

Here g_{ij} and m_{jk} are weights in neural network. Evaluate the error (e_k) is

$$e_k = (d_k - a_k)f'(\sum_{j=1}^{p} h_j m_{jk}) \tag{7}$$

Determine the error correction term, update the weight among the output layer along with hidden layer is measured by using equation

$$\Delta(m_{jk}) = \alpha e_k h_j \tag{8}$$

The modified weight can be obtained as follows

$$m_{jk}(new) = m_{jk}(old) + \Delta(m_{jk}) \tag{9}$$

The error information term (e_j) is calculated as follows

$$e_j = \sum_{k=1}^{m} e_k m_{jk}\ f'(\sum_i x_i g_{ij}) \tag{10}$$

On the source of e_j, renew the weight among the hidden layer along with input layer is measured by using equation

$$\Delta(g_{ij)=}\alpha e_j x_i \tag{11}$$

The modified weight can be obtained as follows

$$g_{ij}(new) = g_{ij}(old) + \Delta(g_{ij}) \tag{12}$$

After modify the weight, check attains the closured output. If not replicate the step until genuine output identical the desired output. The BP neural network with the purpose of pace the union to a finest weight task, begin energy coefficient.

A large rate of α may rapidity awake the convergence however outcome is overshooting, slighter value of α has vice-versa result. In leaning rate (α) affect the convergence of BPN. The large learning rate leads to speedy learning although present is oscillation of weights, so avoid there problem any adding a momentum factor to the normal gradient descent learning rate. Then weights updating formula

$$m_{jk}(t+1) = m_{jk}(t) + \alpha e_k h_j + \eta[m_{jk}(t) - m_{jk}(t-1)] \tag{13}$$

$$g_{ij}(t+1) = g_{ij}(t) + \alpha e_j x_i + \eta[g_{ij}(t) - g_{ij}(t-1)] \tag{14}$$

Here η is called the momentum factor. It ranges from $0 < \eta < 1$.

III. PROPOSED METHOD

The proposed method embeds multiple watermarks by decomposing the original image. In the process of the watermark symbol recovery, the practiced neural network can be engaged to take out the multiple watermarks. The image watermark embedding and extracting process are described as bellows:

A. Watermark Embedding Procedure

The obstruct figure of segmented watermarking embedding procedure is revealed in Figure 2.
1. The original image (I) is partitioned into two sub images such as odd sub image (Iodd) and even sub image (Ieven). The odd sub image is odd numerals rows and columns also even sub image is even numerals rows and columns.
2. The odd sub image and columns and even sub image are decomposed by utilized DWT.
3. Discover the weight features $q_l^\theta(i,j)$ for wavelet S coefficients when known in equation (1).
4. The position of watermark embedding coefficient are calculated based on their weight factors, then quantize the DWT coefficient $q_l^\theta(i,j)$ / Q, and utilized that rate as the input of BPN, using back propagation algorithm, the output values can be achieved. T

5. Raining back propagation neural network using output values, along with the initial watermark symbol is inserted into the odd sub image wavelet domain utilized the practiced BPN.
6. The inverse transform of wavelet can be presented to acquire odd watermarked image.
7. Likewise, the subsequent watermark symbol can be inserted into the even sub image wavelet domain using the trained BPN.
8. The inverse transform of wavelet can be presented to acquire even watermarked image
9. The two watermarked images I_{oddsWI} with I_{evnsWI} are combined to get a final watermarked image.

B. Watermarking Extraction procedure

The block diagram of multiple watermark extraction process is shown in Figure 3.

1. The watermarked image can be partitioned keen on two sub images for instance odd watermarked image (I_{oddsWI}) as well as even watermarked image $(I_{evensWI})$
2. The odd watermarked image as well as even watermarked image are decomposed by using DWT.
3. The position of coefficient are find based on their weight factors, where watermark is embedded, which can be utilized in watermark symbol embedding series.
4. Quantize the coefficient of DWT $q_i(i,j)$ / Q, along with use that value when the input of BPN, using back propagation algorithm, the output values can be obtained.
5. Extract the second watermark, by using the even watermarked image and even sub image.
6. Similarly, the initial watermark symbol can be extracted from the odd watermarked image moreover odd sub image.
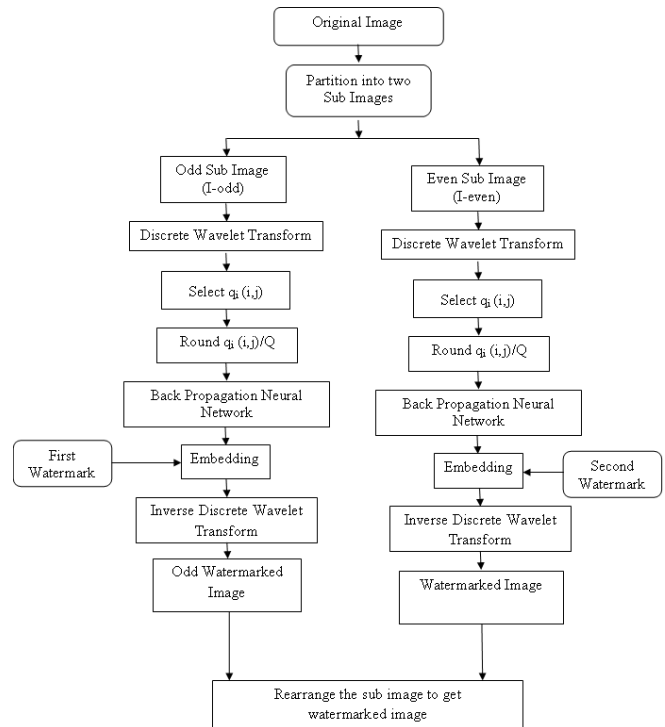

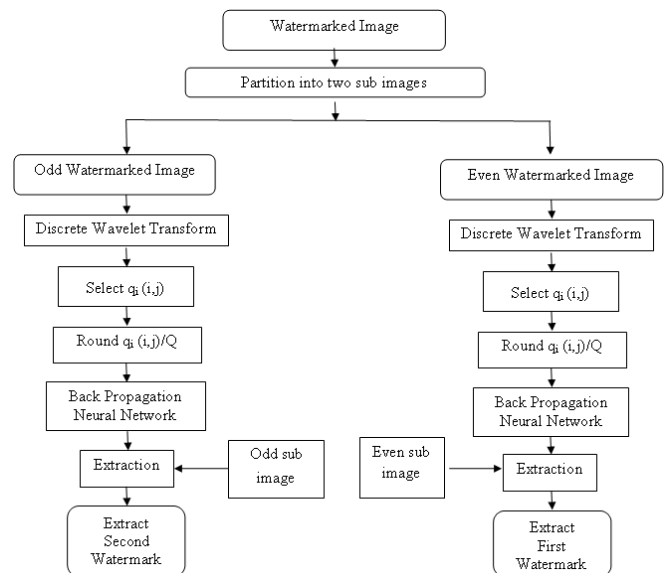**Fig. 2. Watermark Embedding Process**

Fig. 3. Watermark Extraction Process

IV.   EXPERIMENTAL RESULTS

The performance of the segmented watermarking technique and a number of experiments are performed on different images of size 512×512 namely Lena, Medical and Military images as shown in Figure 4 (a - c). The logos of size 48×48 are used as multiple watermarks are shown in Figure 4 (d) and (e).
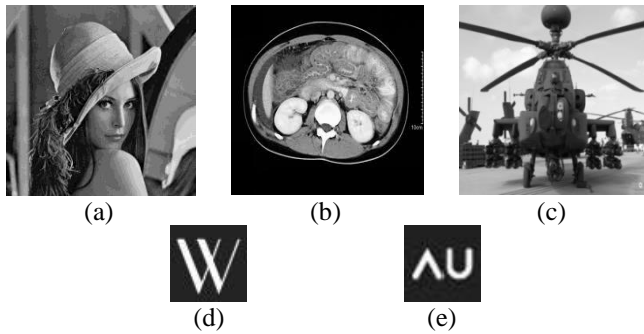
(a)　　　　　　(b)　　　　　　(c)

(d)　　　　　　(e)

**Fig. 4. Common, Medical, Military and Watermark
Images**

Table 1 shows the Peak Signal to Noise Ration (PSNR) and Normalized Correlation (NC) values on segmented watermarking method exclusive of attacks for image of Lena, medical and military images. To demonstrate the robustness, the embedded images are experienced with attacks like, rotation, row-column blanking, cropping and row-column copying, median filtering, wiener filtering, JPEG compression, salt & pepper noise, Gaussian noise, sharpening and smoothing.

**Table – I: PSNR and NC Values on segmented
Watermarking Technique without Attacks**

Images	Segmented Watermarking		
	PSNR (dB)	First Watermark	Second Watermark
Lena	47. 1757	1	1
Medical	46.9631	1	1
Military	46.8817	1	1

Table 2 demonstrates the PSNR value on segmented watermarking method for the image of Lena. Table 3 shows the NC values on successive watermarking technique for the Lena image.

**Table – II: Values of PSNR on Segmented
Watermarking Technique through Attacks**

Attacks	Segmented Watermarking PSNR (dB)
Rotation (600)	12.8657
Gaussian Noise (1%)	22.9232
Row-Column Blanking	14.7173
Row-Column Copying	18. 6990
Median Filtering (3×3)	33.4053
Smoothing	38.0359
Wiener Filtering	20.5549
JPEG Compression (20)	36.3364
Cropping	18.7391
Salt & Pepper Noise (20%)	21.2451
Sharpening	28.8102

**Table – III: Values of NC on successive Watermarking
Technique through Attacks**

Attacks	Successive Watermarking	
	Extracted Watermark	
	1	2
Rotation (600)	0.1364	0.9736
Gaussian Noise (1%)	0.7891	0.9906
Row-Column Blanking	0.0125	1
Row-Column Copying	0.8358	0.9956
Median Filtering (3×3)	0.9916	1
Smoothing	0.9989	1
Cropping	0.3360	0.9970
JPEG compression (20)	1	0.9652
Salt & Pepper Noise (20%)	0.8120	0.9918
Sharpening	0.8000	1

Based on the outcome, the presented method is evident that, in the segmented watermarking achieves additional robustness for rotation, median filtering, wiener filtering, sharpening, cropping, smoothing, row column blanking and row-column copying.

V. PERFORMANCE COMPARISON WITH EXISTING METHOD

Confirm to the efficiency of our presented method, the imperceptibility (PSNR) value is evaluated through existing method for the Lena image [12]. Their method single watermark is embedded into Lena image, but our technique is embedded with two watermarks. The peak-signal-to-noise-ratio value is scheduled in Table 4 and it is plain that the imperceptibility presentation of the presented scheme is advanced to existing scheme [12].

**Table – IV: Comparison of PSNR Values to Existing
Method**

Lena Image	Existing Method [12]	Proposed Method
PSNR(dB)	43.02	47.1757

VI. CONCLUSION

The segmented watermarking technique supported on BP neural network as well as HVS is planned in this paper. The original image is decomposed into wavelet domain, using the improved Back Propagation neural network, which can advance the pace of the learning and reduce the error the practiced neural networks has extract the multiple watermarks as of the watermarked images. The presented watermarking algorithm have been tested with different images. The developments of watermarking algorithms are improved imperceptibility on the watermarked image as well as the robustness of extracted watermark.

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