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Hybrid and Invisible Digital Image Watermarking Technique Using IWT-DCT and Hopfield Neural Network

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Abstract
According to the characteristic of HVS (Human Visual System) and the association memory ability of neural network, an adaptive image watermarking algorithm based on neural network is proposed invisible image watermarking is secret embedding scheme for hiding of secret image into cover image file and the purpose of invisible watermarking is copyrights protection. Wavelet transformation-based image watermarking techniques provide better robustness for statistical attacks in comparison to Discrete Cosine Transform domain-based image watermarking. The joined method of IWT (Integer Wavelet Transform) and DCT (Discrete Cosine Transform) gives benefits of the two procedures. The IWT have impediment of portion misfortune in embedding which increments mean square estimate as SIM and results diminishing PSNR. The capacity of drawing in is improved by pretreatment and re-treatment of image scrambling and Hopfield neural network. The proposed algorithm presents hybrid integer wavelet transform and discrete cosine transform based watermarking technique to obtain increased imperceptibility and robustness compared to IWT-DCT based watermarking technique. The proposed watermarking technique reduces the fractional loss compared to DWT based watermarking.

Keywords
IWT, DCT, HVS, Hopfield Neural Network.

I. Introduction

Undetectable watermarking is valuable for secret correspondence and copyrights. A secret data hiding in a media so that no one will guess its existence into this media; is called invisible watermarking [1]. The examination issues of undetectable watermarking system are expanding the indistinctness and robustness. There are numerous procedures proposed by analysts for expanding the strength of watermarking system. To sustain antipiracy technologies, Firm anti-piracy legal laws are needed for support of all these applications because no extra system and mechanism is incorporated in these devices when a person can be caught making illegal use of it [2]. The cognizant covering of information inside other image is called image watermarking. Another way is to putting away and sending information in a specific system to make it secure from accidental beneficiaries or use is called cryptography [3] however cryptography doesn't conceal the uncertainty of mystery stowing away. Imperceptible watermarking approach is grouped into spatial domain watermarking and frequency domain watermarking. Frequency domain watermarking shows preferable robustness over spatial domain watermarking [4]. In a digital image, data is imbedded into loud area of image for concealing mystery watermark in less detectable pieces of image and for this shifting block level image watermarking plan is proposed and broke down [5]. Discrete wavelet transform deteriorates image into 4 unique frequency groups which is called LL, LH, HL and HH where LL sub band addresses qualities of image while HH sub band addresses Commotion in image [6]. In discrete cosine transform, image is changed over from spatial domain to frequency domain where low frequency parts are upper left corner of DCT coefficient matrix and frequency range increments slantingly from upper passed on corner to base right corner of DCT coefficient matrix [7]. Integer wavelet transform strategy and hereditary calculation based image steganography have improved results for robustness against visual attacks contrasted with discrete wavelet transform [8],[9].

The image transformed by wavelet, a large portion of its energy is moved in low-frequency sub-band, in the event that watermark is embedded straightforwardly in low frequency sub-band, and the straightforwardness of image containing watermark will ignore. In the event that watermark is embedded straightforwardly in high frequency sub-band, a ton of high frequency data is lost while containing watermark image in the wake of sifting, and the calculation robustness will decline. The correlation between's coefficients is bigger in low frequency sub-band, and then it separated further by discrete cosine transform (DCT). After DCT, most of the energy in low frequency sub-band focused on few low frequency coefficients, so a large portion of the energy is concentrated about the entire image. The image changed greater assuming these coefficients corrected inconsistent; in this manner, it ought to ensure that these coefficients didn't alter. Since the high coefficients isn't delicate in the eye, the high frequency parts in low frequency sub-band are the ideal provincial of embedded watermark [7], the inconsistencies about watermarking robustness and straightforwardness can be tackled [10].

The proposed algorithm presents hybrid integer wavelet transform and discrete cosine transform based watermarking procedure to acquire expanded indistinctness and robustness contrasted with IWT-DCT based watermarking strategy. The IWT is a type of DWT (Discrete Wavelet Transform) that coefficients are all quantized to closest integer values.

II. Scheme design

A. *Neural Network Training*

There are numerous types of strategies for the watermark signal preprocessing. The watermark is upset to cause the watermark calculation to have great robustness, so the watermark will have arbitrariness. The examination shows that the capability of watermarking calculation's shearing [11] and controlling will be further developed through significant watermark image is mixed. There are just adding and deduct activity in relative transform. So, the estimation for taking modulus is stayed away from. The activity is quick [12]. There are succinct scientific articulations in its inverter change, and process duration of cycle isn't handled in the decoding system. The image is totally mixed exclusively for 10 time's iterative cycle. So, the relative transform is utilized in the watermark signal pretreatment. The Hopfield network as a neural network possesses the cooperative memory capability, the deficient, and contaminated and contortion of the data information can be made once more into a total model through their own great adaptation to non-critical failure. Assume the watermark signal W is binary images of N×N, as pixel values. The training process of neural networks is as follows: $W = \{W(i,j), 1 \leqslant i,j \leqslant N, w(i,j) \in \{0,1\}\}$

The watermark signal is coded. First 0 of binary image watermark is changed to -1, because the values 0 is not applicable in hopfield neural network, 1 is not changed, then W' is gotten; Then W' will be divided into each overlapping size for the n1× n2 sub-blocks, among which the m piece is,$W'_m(1 \leqslant m \leqslant \frac{N}{n_1} \times \frac{N}{n_2})$, W'_m will be last translated into one-dimension signal R, based on certain key.The hopfield network training mode set R is gotten. The structure of hopfield network is shown in Fig.1.

$$R = \left\{r_m(k), 1 \leqslant k \leqslant n_1 \times n_2 | r_m((i-1) \times n_1 + j) = w^{"}(i,j)\right\} \tag{1}$$

The hopfield network's neuron number as n1 × n2 is built and the weights of network node are initialized. The network weights are adjusted according to certain rules, and the mode is stored in network. The network weights adjusted well as KEY of scrambling, and KEY is saved in order to extract watermark. The output of network is vector R or matrix W'', this is the final scrambled watermark stream.

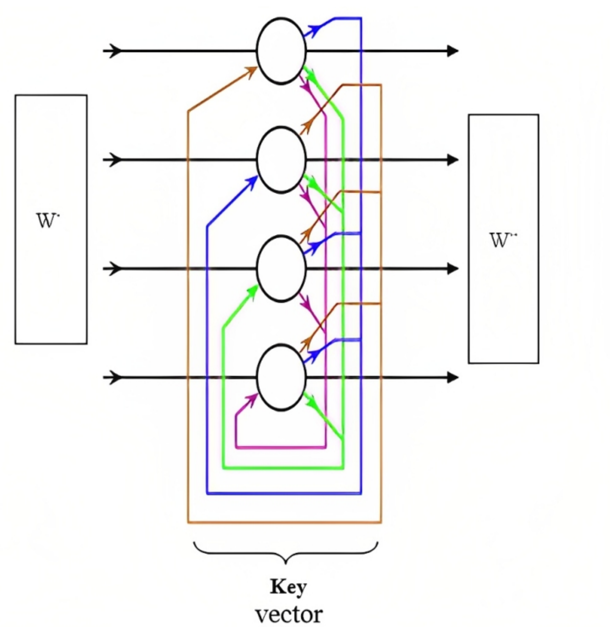

Fig. 1. Hopfield Network Structure

B. Embedding Process

It is finished up from the exploration that many embedding image are embed in the HL sub band and HH sub band of the detail coefficients of wavelet transform for boost robustness against statistical attacks and robustness against visual attacks or impalpability. Coefficients of HH sub band of a degree of IWT are chosen for embedding image embedding for accomplishing better the robustness against attacks. After this, on the arrangement of decided HH coefficients of wavelet transform, discrete cosine transform is applied and embedding image is embedded utilizing trading of mid-band coefficients. The LL sub groups connote the attributes of image while HH sub groups imply the clamor level in image. For imperceptible image stowing away, HH frequency sub groups are chosen for stowing away contrasted with Low frequency groups in light of the fact that embedding in HH doesn't change the vital qualities of image. The point by point embedding system of proposed method is made sense of as following.

1) The watermarking image as the training signal input hopfield network in order to finish the watermark storage;

2) The watermark signal R is gotten after the watermark signal doing scrambling transform. The affine transform is used as scrambling transform, the key is scrambling times, and then the watermark pretreatment is completed.

3) The original image is read and transformed using integer wavelet transform which decomposes image into 4 different frequency bands. Integer wavelet transform is applied again on all above sub-bands for decomposing into 16 sub-bands and four HH2 (HH sub-bands at level two) sub-bands is selected. Integer wavelet transform is applied again on selected four HH2 sub-bands for decomposing into 16 sub-bands and four HH3 (HH sub-bands at level 3 i.e. HH31, HH32, HH33 and HH34) sub-bands are selected. These diagonal coefficients (HH sub-bands) are selected achieving better imperceptibility and robustness in order to achieve least distortion in cover image in embedding of secret Image. Selected 4 HH sub bands for embedding are shown in Fig. 2.

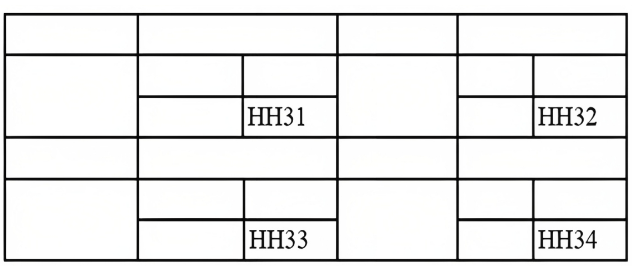

Fig. 2. Four Selected HH sub-bands for embedding

4) Perform discrete cosine transform at 8×8 block level on all above selected HH3 sub-bands and 3×3 blocks of IWT-DCT domain is achieved, A block of 8×8 DCT coefficients matrix is shown in Fig. 3

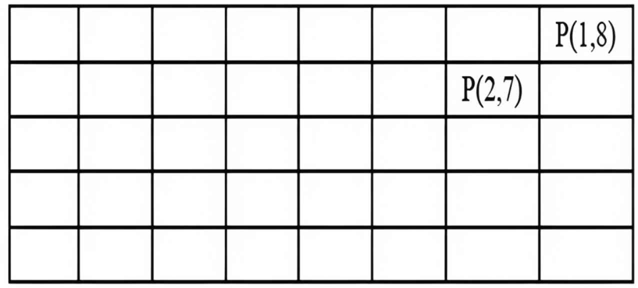

Fig. 3. A block of 8×8 DCT Coefficients Matrix

5) A bit of scrambled watermark is embedded in DCT block matrix as follows:

$if\ W^{''}(i,j) = 1\ then\ if\ P_{OI}(1,8) < P_{OI}(2,7)$
$then\ swap\ P_{WI}(1,8)\ with\ P_{OI}(1,8)$
$if\ W^{''}(i,j) = 0\ then\ if\ P_{OI}(1,8) \geq P_{OI}(2,7)$
$then\ swap\ P_{WI}(1,8)\ with\ P_{OI}(1,8)$
$W^{''}(i,j)$:The scrambled watermark bit
P_{OI}:The original image coefficient

6) Apply inverse discrete cosine transform on each embedded block.

7) Apply inverse integer wavelet transform to get watermarked image in spatial domain.

The watermark embedding procedure is shown in Fig. 4.

C. Extracting Process

According to the embedding process, watermark can be extracted through the corresponding inverse operation as follows:

1) The watermarked image and the original image are processed by three- level IWT, DCT is performed on selected HH3 sub-band coefficients block of each image, then specific DCT coefficients of each block {(P (1,8) and P (2,7)} for two images are selected.

2) The scrambled watermark bit is extracted according to the following algorithm:

$if\ P_{WI}(1,8) > P_{WI}(2,7)\ then\ W^{''}(i,j) = 1$
$else\ if\ P_{WI}(1,8) > P_{OI}(1,8)\ then\ W^{''}(i,j) = 1$
$if\ P_{WI}(1,8) \leq P_{WI}(2,7)\ then\ W^{''}(i,j) = 0$
$else\ if\ P_{WI}(1,8) \leq P_{OI}(1,8)\ then\ W^{''}(i,j) = 0$
$W^{''}(i,j)$:The extracted watermark bit
P_{WI}:The watermarked image coefficient

3) The extracted watermark is gotten through the extracted watermark signal R' is processed by hopfield network according to the key inverse scrambling. Watermark post-processing process is that at the beginning of the watermark signal extracted is blocked and transformed according to watermark training methods. The input set is gotten. R' is put into hopfield network what storages the original watermark. Through

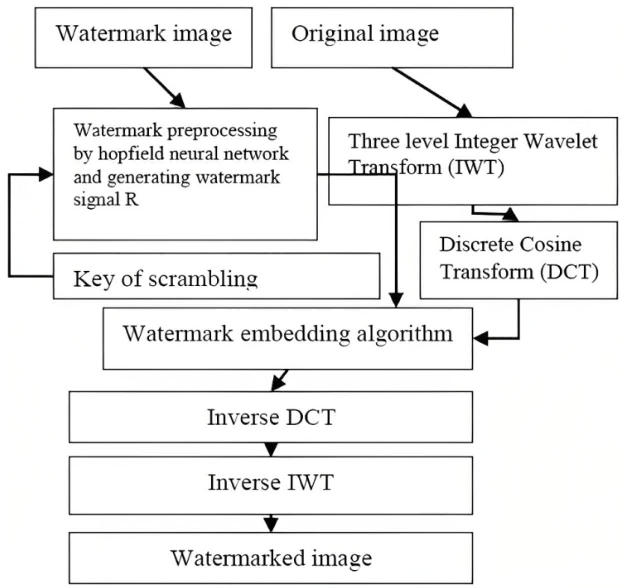

Fig. 4. Watermark Embedding Process

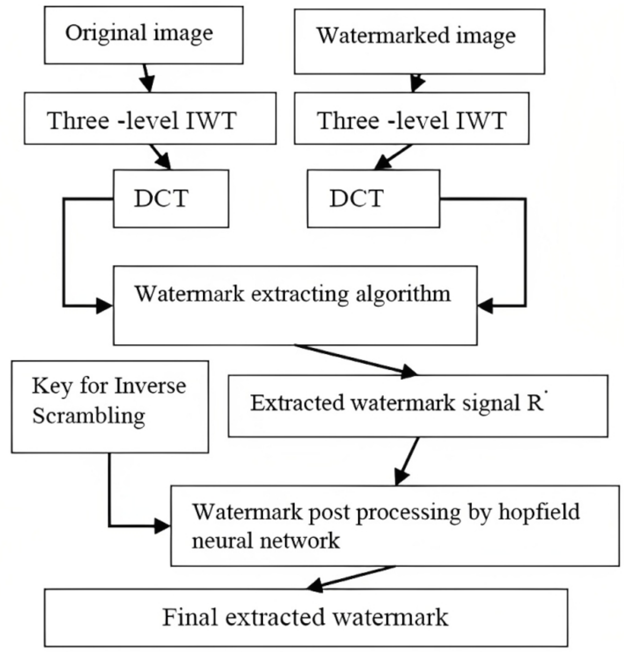

Fig. 5. Watermark Extracting Process

the hopfield neural network of associative memory process, the final extracted watermark is gotten through transformed and restructures according to inverse process. The watermark embedding procedure is shown in Fig. 5.

III. Implementations and Result

The original and watermarked images have been displayed in Figs.6-11. Barbara, Baboon, and Cameraman images have been utilized to execute the watermarking calculation. Original watermark is a twofold image and its size is 64 × 64. The original watermark image is displayed in Fig.12 The performed attacks on the watermarked images are as per the following: Gaussian noise; median filtering 3*3; low pass filtering; cropping 25% and resizing 1/5 the image; jpeg compression with quality elements of 10, 25, and 75, lastly jpeg 2000 compression with bit rate 3.

$$SIM(OW,EW) = \frac{OW.EW}{OW^2} \times 100 \quad (2)$$

$$PSNR = 10log(\frac{255}{\sum_{ij}(OI(i,j) - WI(i,j))})^2 \quad (3)$$

The gauge of similitude (SIM) or mean square estimate, as mentioned in abstract, between the extracted watermark image and the original watermark image as equation (2), along the peak sign to noise ratio (PSNR) of watermarked image (WI), and original image (OI) image will be determined having played out every last one of the referenced attacks on the watermarked image, and results have been integrated in Tables (I-III). In equation (2) OW is the original watermark and EW is the Extracted Watermark image from separating watermark calculation. Dot operation in this equation is explanatory sum of product of respective entries. The highlighted rows in each Tables show our better algorithm robustness versus previous methods. The reason of comparison of our algorithm with our previous methods is, these methods have better adaptation and robustness versus other methods from other researchers.

IV. Conclusion

Proposed method achieved PSNR more than mentioned methods of DWT-DCT. PSNR signify robustness against visual and statistical attacks for invisible watermarking. So IWT based watermarking process is more imperceptible and robust for visual attacks. In the proposed work, watermark is embedded in high frequency band or edge and noise information not in characteristics and shapes information of cover image. Further proposed technique may be verified for robustness of statistical attacks in future. PSNR of recovered watermarked image is higher compared to existing DWT-DCT technique so loss of secret information is also reduced using proposed technique due to avoid of fraction loss in Integer wavelet transform. The watermark signal is preprocessed by scrambling technology. Integer wavelet transform plays most roles in the robustness of algorithm, because the integer values of coefficients have more margins tolerate about watermarking attacks to prevent removing the watermark image. DCT plays the role of transparency of watermark in our algorithm. The robustness of the algorithms can be improved through the extracted watermark on post-processing that using the associative memory function of neural network. Implementation results show that the Barbara image with more edge attribute has better robustness versus compression attacks. The Baboon image with more texture features has more robustness versus noise attack. The Cameraman image with less edge and texture attributes has more robustness versus filtering and compression attacks. IWT-DCT combination has more efficient than DWT-DCT combination, this is the major fact, we can conclude from implementation results, compare to our previous methods. Our final conclusion is, we must find more efficient wavelet and neural network to overcome our algorithm weaknesses.

Fig. 6. Original Barbara Image

TABLE I.
IMPLEMENTATION RESULTS AND COMPARISONS FOR BARBARA IMAGE

Kinds of Attack on Barbara image	Proposed Method		Method in [13]		Method in [14]	
	PSNR	SIM	PSN	SIM	PSNR	SIM
Gaussian Noise	32.9	93.8	27	98.3	31.3	92.3
Low Pass Filter	40.9	90.7	25.8	92.8	29	88.8
Median Pass Filter	50.0	96.9	27.4	95.7	34.7	97.6
Scaling 1/5	24.2	77.9	20.0	86.3	17.5	81.0
Jpeg 75%	52.0	100	37.4	98.9	39	97.5
Jpeg 25%	43.5	95.5	34.7	94.5	36.9	93.8
Jpeg 10%	35.4	90.6	28.2	91.2	32.6	89.9
Jpeg 2000 with bitrate 3	27.6	86.1	19.4	88.1	25.1	88.7

Fig. 7. Watermarked Barbara Image

TABLE II.
IMPLEMENTATION RESULTS AND COMPARISONS FOR BABOON IMAGE

Kinds of Attack on Barbara image	Proposed Method		Method in [13]		Method in [14]	
	PSNR	SIM	PSN	SIM	PSNR	SIM
Gaussian Noise	32.0	93.8	27.5	93.7	35.3	94
Low Pass Filter	36.2	90.5	25.0	89.0	35.3	93.9
Median Pass Filter	38.2	95.6	28.8	95.2	32.9	97.5
Scaling 1/5	19.8	74.6	18.4	83.0	20.7	82.4
Jpeg 75%	44.6	96.0	37.2	97.9	40.5	97
Jpeg 25%	39.0	92.2	32.1	91.7	38.8	94.5
Jpeg 10%	31.3	90.8	26.1	88.3	33.4	91.7
Jpeg 2000 with bitrate 3	28.1	84.9	19.2	85.1	27.1	89.6

CONFLICT OF INTEREST

The author have no conflict of relevant interest to this article.

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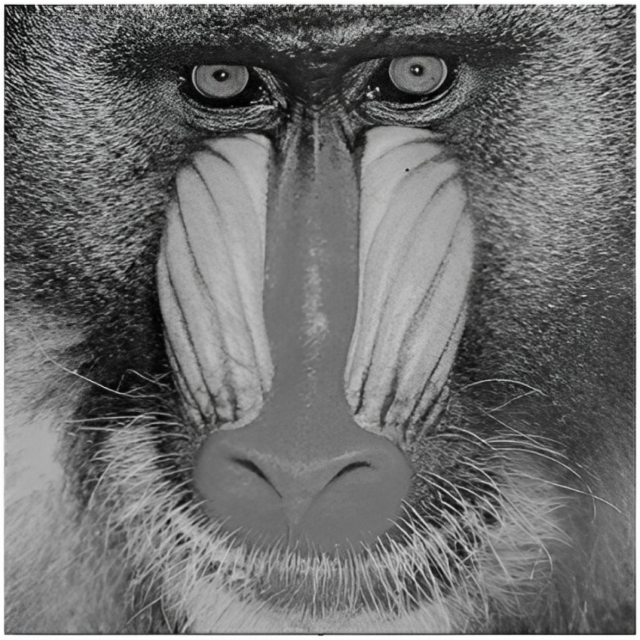

Fig. 8. Original Baboon Image

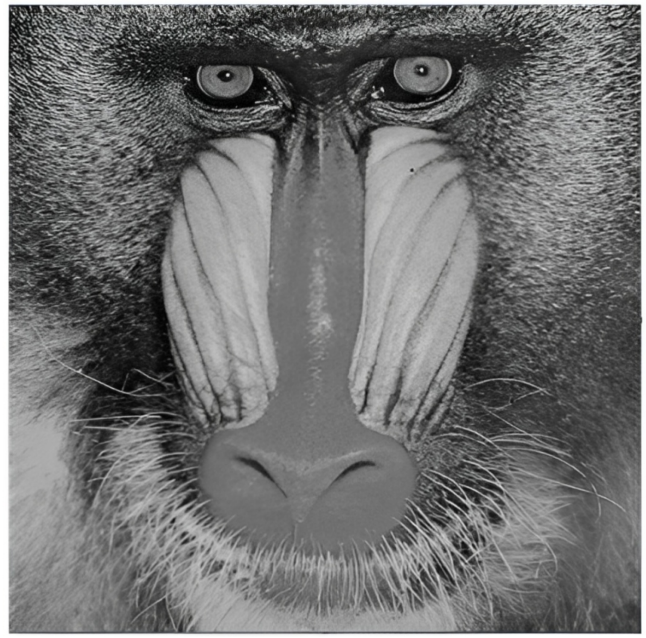

Fig. 9. Watermarked Baboon Image

TABLE III.
IMPLEMENTATION RESULTS AND COMPARISONS FOR CAMERAMAN IMAGE

Kinds of Attack on Barbara image	Proposed Method		Method in [14]		Method in [15]	
	PSNR	SIM	PSN	SIM	PSNR	SIM
Gaussian Noise	32.2	94.8	31.5	93.7	32.15	94.4
Low Pass Filter	33.8	94.8	30	89.5	31	92.5
Median Pass Filter	36.7	92.7	36.2	94.2	30.0	88.1
Scaling 1/5	26.1	76.5	26.8	82.1	27.3	84.5
Jpeg 75%	47.5	98.7	39.3	97.7	-	-
Jpeg 25%	37.8	95.3	36.4	92.2	33.0	90.0
Jpeg 10%	33.9	89.05	35.4	90	24.2	87.2
Jpeg 2000 with bitrate 3	30.9	86.2	29.0	87.1	22.0	83.0

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Fig. 10. Original Cameraman Image

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Fig. 11. Watermarked Cameraman Image

Fig. 12. Original Watermark