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REVERSIBLE IMAGE WATERMARKING USING BIORTHOGONAL WAVELET TRANSFORM AND IMPORTANCE MEASURE MODEL

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ABSTRACT

Image Watermarking is a technique by which a person can attach hidden data into the image by use of embedding and extraction process. In reversible watermarking, after the extraction of the watermark, the cover image can be restored completely. Reversible image watermarking algorithm is proposed in this paper. Initially, the image is resized and applied bi-orthogonal discrete wavelet transform to decompose into bands. The best band suitable for embedding is found with the help of entropy. The best locations in the selected band are found using the importance measure model. Subsequently, the proposed embedding process is carried out to embed the image with a watermark image which is binary. The proposed extraction procedure is carried out after finding out best band and location. The evaluation metric used to evaluate the proposed watermarking technique is carried out with the use of PSNR and NC. The proposed technique obtained good results having an average PSNR value of 31.3 and NC value of 1. The robustness of the proposed watermarking technique is evaluated with the aid of different filtering techniques and good results were achieved in all cases. Comparison is also made with existing technique and from the results; we can see that our technique outperforms other technique by having better PSNR and NC values.

Keywords:- *Reversible Watermarking, Biorthogonal DWT, Entropy, Robustness, Importance Measure, PSNR, NC.*

1. INTRODUCTION

Nowadays, prominent share of the multimedia fabrication and dissemination is carried out digitally. The rapid growth of digital media like Internet and Compact Discs has ushered in a wonderful era where the flow, duplication and modification of digital images have become all the more easier and simpler. Mega distribution of flawless replicas of multimedia data at an accelerated degree has become the order of the day. And this phenomenon has unfortunately resulted in tremendous threats to multimedia safety and copyright security. This has the effect of ringing an alarm bell for authors, when the stark reality dawned upon them, convincing that conservative safety systems, like encryption were incapable of affording the much-needed shelter. This has motivated many investigators to devise alternate methods, one of which is known by the term 'digital watermarking' which is nothing but the art of concealing data in a healthy way and without being noticed by pirates or others of the sort [1, 2]. Of late, watermarking is employed extensively for rights safety, endorsement, and content reliability authentication of intellectual property in digital [3] [4]. By watermarking what is meant is the method of implanting data into multimedia rudiments such as images, audios and videos. This embedded data can be mined and located from the multimedia at a later stage when needed and can be effectively used as a testimony to the proof of rights correlated purposes [5].

Broadly, digital watermarking is carried out with the aim of frustrating illicit reproduction or utilization of digital images [6 - 9]. It is a fantastic technique in which a piece of information such as watermark or digital signature is entrenched into a multimedia object so that this can be made available at a later date to have an affirmation about

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the object. Such objects can be in the form of images, audios or videos [7, 8]. As a rule, digital watermarks are prototypes of bits that are integrated into digital substance and can be identified or mined subsequently when needed. Digital watermarking [7] technology is swiftly spreading its wings in computer science, cryptography, signal processing, Image Processing and communications. It is designed by the architects of this technology as the solution to provide high quality security on top of data encryption and dishevelled rush for safety of digital data. [10]. It refers to the method which implants data in the form of a watermark or digital signature or tag or label into a multimedia object so that watermark can be subsequently identified or mined to make an affirmation of the object. The object may take the shape of an image or audio or video. A simple model of a digital watermark would be a noticeable "seal" placed over an image to distinguish the patent [8].

The fundamental benefit of watermarking is the indivisibility of the content from the watermark. This enables the watermarks appropriate for various programs which are detailed below: Signatures: The watermark does the function of detecting the title-holder of the subject matter. This data extends a helping hand to a prospective client to achieve legal rights for reproducing or publishing the subject from the owner of the subject. Fingerprinting: Watermarks are also employed as invaluable tools for the recognition of the real buyers of the subject. This will go a long way in tracking the source of illegitimate copies. Broadcast and publication monitoring: Though the watermark pinpoints the owner of the subject as is done by signatures, the detection is actually carried out by mechanised techniques supervising television and radio broadcasts, computer networks, and the like and they are always agile and hawk-eyed to find out the time and place of appearance of the content. Authentication: The function of the watermark here is to program data essential for ascertaining the authenticity of the contents. Copy control: The watermark holds out the data on the rules of handling and replicating imposed by the content owner. These may take the form of easy regulations like "this content shall not be copied", or "this content may be copied, subject to no further replications of the copy". Secret communication: The entrenched signal carries out the function of communicating confidential data from one person (or computer) to another, without any intermediary being aware of this.

As a rule, watermarking systems fine-tune an image by implanting client data, and once an adaption is made, it cannot be revoked. It follows that the revival of primary image is not feasible after mining the watermark. Still, it becomes essential for certain programs, involving medical or military images, to retrieve the original from the watermarked image to assess the contents of the image with a greater degree of precision. This calls for innovative approaches such as reversible watermarking techniques which would guarantee reversibility of the original image, when needed [14]. This technique for revertible watermarking required two indispensable stipulations ie (1) after entrenching the watermark into the cover image, the specified image should be defaced to the least (2) after taking out the watermark; the cover image is capable of being re-established entirely. A watermark exhibits number of noteworthy traits. Some of them are (i) its quality of being invisible to the naked eye, (ii) its ability to withstand regular deformations (iii) its wonderful capacity to defy malevolent assault (iv) ability to hold mega data (v) its quality of coexistence with its peers (v) and its quality of simplicity in the process of insertion/detection, altogether avoiding any kind of calculation. So as to be highly beneficial, it is essential for the watermark to exhibit a higher level of vigour to several potential piracies [8, 10]. They comprise sturdiness against solidity,

such as JPEG, dimension and feature ratio alterations, alternation, trimming, deletion of rows and columns, accumulation of sound, sifting, assaults on cryptography and data, and inclusion of different watermarks. This paradox has afforded a shot in the arm for investigators to toil hard towards devising an innovative reversible image watermarking technique to ward off the potential threats there from.

Contributions of the paper:-

- In this paper, reversible watermarking based on biorthogonal DWT and importance measure is proposed.
- The image is resized initially and bi-orthogonal discrete wavelet transform is applied which decomposes the image into CA, CH, CV and CD bands. Of this CA is neglected and entropy of other bands are computed. The band with maximum entropy is selected as the band and from it, the best locations are found out. Here the

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image is divided into blocks and importance measures of all blocks are computed and the best blocks are selected as the locations for embedding.

- Subsequently, the proposed embedding process is carried out to embed the watermark image into the original image to have the watermarked image.
- In the extraction process, initially the watermarked image is employed inverse discrete wavelet transform and the proposed extraction procedure is carried out in the found out location.
- The evaluation metric used to evaluate the proposed watermarking technique is carried out with the use of PSNR and NC.
- The robustness of the proposed watermarking technique is evaluated with the aid of different filtering techniques.
- Comparison is also made with existing techniques.

The rest of the paper is organized as follows: Section 2 gives the literature review. Section 3 describes the proposed technique. Section 4 gives results and discussions. Conclusions are summed up in Section 5.

2. LITERATURE SURVEY

With an eye on affording much-needed copyright and safety to multimedia data, a number of methods have been put forward by experts in the field. Among them, digital watermarking has gained supreme significance, keen enthusiasm being invested on watermarking of digital images. The first half of1990s saw digital watermarking steadily emerging as the cynosure of a substantial number of intellectual investigators, though there were several mechanisms akin to this prior to 1990. Creative writing is flooded with enough number of illustrations [11-12], vouchsafing the vital factors that are a must for devising a high-quality watermarking algorithm. In this regard, let us consider the proposal of Zhang *et al.* [11] introducing the spread spectrum watermarking as an optimization technique with wonderful qualities of easy deprival of the invisibility and the robustness. In addition, quality metric recommended was effortless and surpassed the high-tech metrics to the core and documented watermarking problem as a logical solution. Li *et al.* [12], on the other hand, have devised a reversible watermarking system based on Prediction-error expansion (PEE), flexible implanting, and pixel choice. In their technique, the spotlight was vastly linked regions and pixels, and it was able to take maximum advantage of the spatial surplus snatching a higher level accomplishment over the competing conservative PEE.

Coltuc. D [13] has taken pains to develop a low-deformation transform for forecast –error growth reversible watermarking. The transform recommended produced a reduced amount of deformation than the traditional forecast-error growth for composite predictors like the median edge detector or the gradient-adapted predictor. Chien-Chang Chena *et al.* [14] have given expression to a novel flexible block sized revertible image watermarking scheme. The main feature of the technique was that it was capable of restoring the original image from a watermarked image after extraction of the implanted watermarks. The measure of embedded quantity was calculated by the biggest variance in a block and watermarks implanted into LSB bits of the same variance. From the outcomes of investigation, it was evidenced the new adaptive block size scheme possessed superior competence levels than those of conservative fixed block sized techniques. Kuo-Liang Chung *et al.* [15] were instrumental in devising a distortion decline method for histogram adaptation-based reversible data concealment. They gave shape to a watermark supplement method which could decrease the deformation arising in HM-based RDH technique. Subsequently, co-ordinated scrutiny for standard deformation ratio of the scheme suggested was made available. The swap between the deformation and the number of detached blocks was also experimented. The outcome of investigation was a pointer to the decreased degree of deformation and higher PSNR lower bound advantages of the recommended block-based watermark supplement method. Hsiang-Cheh Huang *et al.* [16] have come out with a histogram-based reversible data hiding with quad tree perception. They advocated a revertible data concealing algorithm that showed supreme strength than traditional algorithm, having identical output image quality after embedding, and analogous ancillary data made available.

Ruchira Naskar*et al.* [17] have gifted a novel method of revertible image watermarking by synchronising logic function based forecast. Their method was a reversible digital image

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watermarking algorithm which was capable of forecasting a pixel greyscale value taking due advantage of its link with pixels in the vicinity, employing coordinate logic operations, and implanting watermark morsels into the forecasting faults. They weighed its performance against other identical programs. Outcomes of the investigation reveal that the cover image deformation caused by the algorithm was lower than that of other high-tech reversible watermarking algorithms. Jun Tang [18] has offered a superior reversible watermarking algorithm based on arbitrary series. Their contribution was an improved digital watermarking algorithm based on arbitrary series into reversible watermarking algorithm. The algorithm made use of the forceful watermarking algorithm of the popular arbitrary series as implanting method. Sobel's edge recognition algorithm was used to dig out the pixel value of edges from the watermarked image. And the conclusive watermarked image was created by exchanging the original image according to the pixel value of the edges for embedding watermark.

3. PROPOSED REVERSIBLE IMAGE WATERMARKING USING BIORTHOGONAL WAVELET TRANSFORM AND IMPORTANCE MEASURE MODEL

In this paper, reversible image watermarking algorithm using bi-orthogonal wavelet transforms and importance measure model is proposed. The two major steps includes in the watermarking algorithm is watermark embedding and watermark extraction. In the embedding process, initially bi-orthogonal discrete wavelet transform is employed to decompose the original input image into different bands and the best band is elected based on the entropy. Subsequently, the selection of proper location is carried out using importance measure model. After finding the best band and the location for embedding, proposed embedding process is carried out where binary image is used as a watermark.

3.1 Selection of Band

Wavelets are mathematical operations that divide information into various frequency segments, and analyse every segment with a firmness corresponding to its grade. They were developed independently from many areas such as image dispensation and image density. They are functions meeting specific statistical conditions and are employed in signifying data or other functions. They are of two types: continuous wavelet transforms (CWT) and discrete wavelet transforms (DWT). The DWT (Discrete Wavelet Transform) converts distinct signal from time domain into time frequency domain using filter banks for constructing the multi-resolution time-frequency plane. For the DWT, unique families of wavelet functions are created like densely supported, orthogonal or biorthogonal and are distinguished by low-pass and high-pass analysis and synthesis filters. The alteration product is set of coefficients co-ordinated in such a way as to enable not only spectrum scrutiny of the signal, but also spectral conduct of the signal in due time.

Wavelets enjoy the trait of softness in both orthogonal and biorthogonal structures [20]. But, some extraordinary qualities are the domain of biorthogonal wavelets and orthogonal wavelets are barred entry to this domain, i.e. precise rebuilding and equilibrium. Biorthogonal Wavelets are families of closely-knit symmetric wavelets [22]. The equilibrium of the filter coefficients is always advantageous since it causes linear stage of the transfer function. In the biorthogonal case, instead of possessing one scaling and wavelet function, there are two scaling functions which can cause several multi-resolution scrutinise, and hence two diverse wavelet functions. Another edge of biorthogonal over other wavelets is that their superior implanting competence when they perform the function of decomposing the image into various routes. These entire traits enable Biorthogonal wavelets emerge as shining stars in the galaxy of watermarking domain [21].

Entropy [23] is a measure of the ambiguity in an arbitrary variable and generally refers to the Shannon entropy where the entropy of a band is estimated. Shannon entropy is the standard volatility in an arbitrary variable, corresponding to the data content. Shannon entropy stipulates a definite limit on the optimum programming or density of any data, without possibility of any loss, and presumes that the diffusion may be symbolized as a sequence of self-reliant and equally disseminated arbitrary variables. The Shannon entropy presents a functional standard for evaluating and matching probability distribution, and provides an index of the data of any array. Entropy (E) is a measure of unpredictability or information content and is given by:

$$E = -\sum_{k} P_k \log_2 P_k \quad (1)$$

Here, p_k is the probability that the difference between two adjacent wavelet pixels is equal to k, and $\log_2$ is the base two logarithms.

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The procedure for selecting the band is explained below. Initially, the original image is resized to pre-defined standard size. Let the original image after resizing be represented by G of size m x n. After resizing, 2D DWT using bi-orthogonal transform is carried out to have approximation (CA) and detailed (CH, CV, CD) coefficient bands. Here, we neglect the CA band coefficients as these cannot be taken for watermark embedding process. From the detailed band, we subsequently find the best band using the entropy value. The entropy values are found out for the CH, CV and CD bands and let it be represented by E_{ch}, E_{cv} and E_{cd} respectively. Based on the entropy, the best band (x) is selected for further processing. The band selection is based the following equations:

$$if\ (E_{ch} \geq E_{cv}\ and\ E_{ch} \geq E_{cd}),\ X = CH \quad (2)$$

$$if\ (E_{cv} \geq E_{ch}\ and\ E_{cv} \geq E_{cd}),\ X = CV \quad (3)$$

$$if\ (E_{cd} \geq E_{cv}\ and\ E_{ch} \geq E_{ch}),\ X = CD \quad (4)$$

That is, the band having the maximum entropy value is taken as the best band and is selected for further processing; hence the above equations can be briefed up and represented as:

$$E_X = Maximum(E_{ch}, E_{cv}, E_{ch}) \quad (5)$$

Here, E_X is the entropy of the selected band X. Hence we have resized the input image to standard size, then applied biorthogonal DWT and found out the best band for embedding with the aid of entropy measure.

3.1 Selection of Location

Once the best band is selected, the nest task is to find the optimal location where the embedding can take place. For this, we make use of importance measure model [19]. The model takes into consideration five parameters of intensity, contrast, location, edginess and texture. From each parameter, respective importance measures are calculated and finally taken squared sum to have the overall importance measure.

The image is initially split into blocks and the importance measure is calculated for each of the block. And those blocks having good overall importance measure is chosen as the location for embedding. Let image input for finding the location be represented as H of dimension $m \times n$. Let the number of blocks be y and each block $(B_i\,;0 < i < y)$ is with dimension $p \times q$ .That is $m \times n = y \times p \times q$. Subsequently the importance measure $(D_i\,;0 < i < y)$ corresponding to each block is computed. The individual importance measure of parameters is computed based on the level of interest that a human eye could have to that region.

a) Intensity

This term refers to the brightness of a point in an image. The blocks of image which are closer to mid intensity of image are the most sensitive to the human eye. Hence, blocks having intensity levels near the mid intensity are given higher priority. The intensity importance measure $(D_{in}^{(i)}\,;0 < i < y)$ of a block in the image $(B_i\,;0 < i < y)$ is computed as:

$$D_{in}^{(i)} = I_{avg}^{(i)} - I_{avg} \quad (6)$$

Where, $I_{avg}^{(i)}$ is the average intensity of the block in consideration (B_i) and I_{avg} is the average intensity of the image.

b) Contrast

Contrast is the difference in luminance and/or colour that makes an object (or its representation in an image or display) distinguishable. In visual perception of the real world, contrast is determined by the difference in the colour and brightness of the object and other objects within the same field of view. A block which has high level of contrast, with respect to its surrounding blocks, attracts the human attention and is perceptually more important. The contrast importance measure $(D_{co}^{(i)}\,;0 < i < y)$ of a block in the image $(B_i\,;0 < i < y)$ is computed as:

$$D_{co}^{(i)} = C_{avg}^{(i)} - C_{avg}^{n} \quad (7)$$

Where, $C_{avg}^{(i)}$ is the average luminance of the block in consideration (B_i) and C_{avg}^{n} is the average luminance of the neighbourhood blocks.

c) Location

The central-quarter of an image is perceptually more important than other areas. Hence, location importance $(D_{lo}^{(i)}\,;0 < i < y)$ of each block $(B_i\,;0 < i < y)$ is measured by computing the ratio of number of pixels in sub image that are lying in the center-quarter of the image $(L_{cq}^{(i)})$ to the total number of pixels in the block $(L^{(i)})$. It can be defined by:

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$$D_{lo}^{(i)} = \frac{L_{cq}^{(i)}}{L^{(i)}} \quad (8)$$

d) *Edginess*

The edginess importance measure $D_{ed}^{(i)}$ is the total number of edge pixels in the block in consideration $(B_i ; 0 < i < y)$. A block which contains prominent edges captures the human attention. Canny edge detection method is employed for finding the edge pixels from the image. The threshold set for the algorithm is 0.7 so that minor edges which usually occur in background are avoided from the edginess importance measure.

e) *Texture*

Normally, flat regions have not attractiveness for human eyes and hence, concentration is made on the textured areas. The texture importance measure $D_{te}^{(i)}$ is computed by variance of pixel values in each block of the image $(B_i ; 0 < i < y)$. High variance value indicates that the sub image is not flat. The measure can be calculated as:

$$D_{te}^{(i)} = \text{var}(T^{(i)}) \quad (9)$$

Where, var represents the variance operator and $T^{(i)}$ is the grey level values of the pixels in the block B_i .

That is we have computed all the parameter importance values. Subsequently the normalised values are taken by dividing by the maximum value so that all values range in between [0, 1]. Suppose the parameter value in consideration is Z and the highest parameter value considering all blocks is A , then normalized value Z' will be $Z' = Z/A$.

After normalization, the importance parameter values corresponding to block B_i are represented by $D_{in}'^{(i)}, D_{co}'^{(i)}, D_{lo}'^{(i)}, D_{ed}'^{(i)}$ *and* $D_{te}'^{(i)}$. Subsequently all normalised importance parameter values are combined to form the combined importance measure of each block $(B_i ; 0 < i < y)$ is given by:

$$D^{(i)} = D_{in}'^{(i)\,2} + D_{co}'^{(i)\,2} + D_{lo}'^{(i)\,2} + D_{ed}'^{(i)\,2} + D_{te}'^{(i)\,2} \quad (10)$$

That is, the importance measure is given by the squared sum of all individual parameters. The importance measure is calculated for all the blocks and the blocks having good importance measure are taken for the embedding process. Normally the image is divided into 16 blocks of which the top four blocks having highest importance measure are taken as the location for embedding.

3.3 Embedding Procedure

The original image is resized and then DWT 2 transformed using biorthogonal transformation. The best band is selected from the derivative bands of CH, CV and CD using the entropy measure. The location for embedding is chosen based on the importance measure model. Subsequently, the watermark is embedded to the original image. The block diagram of the proposed watermarking embedding technique is given in figure 1.

A random value (r) is generated with the same size as that of the band selected (X) . The band selection (based on the entropy) and location selection (based in importance measure) are explained earlier. The watermark image is a binary image having pixel values of 0 or 1 and let the k^{th} bit in the watermark image be represented by W_k where $W_k \in \{0,1\}$. The embedding is carried out in case when the watermark pixel happens to be zero. In this case, the original pixel value in the location is modified with the help of the generated random number. Suppose the original image pixel is represented by S_i , then the embedding process can be defined by:

$$IF(\, W_k = 0)$$
$$THEN,\; S_i = S_i + (k \times r) \quad (11)$$

That is, the original pixel value is modified by adding a random value to the existing value in case that the watermark image pixel is zero. When the watermark bit happens to be one, there is no change in the pixel value.

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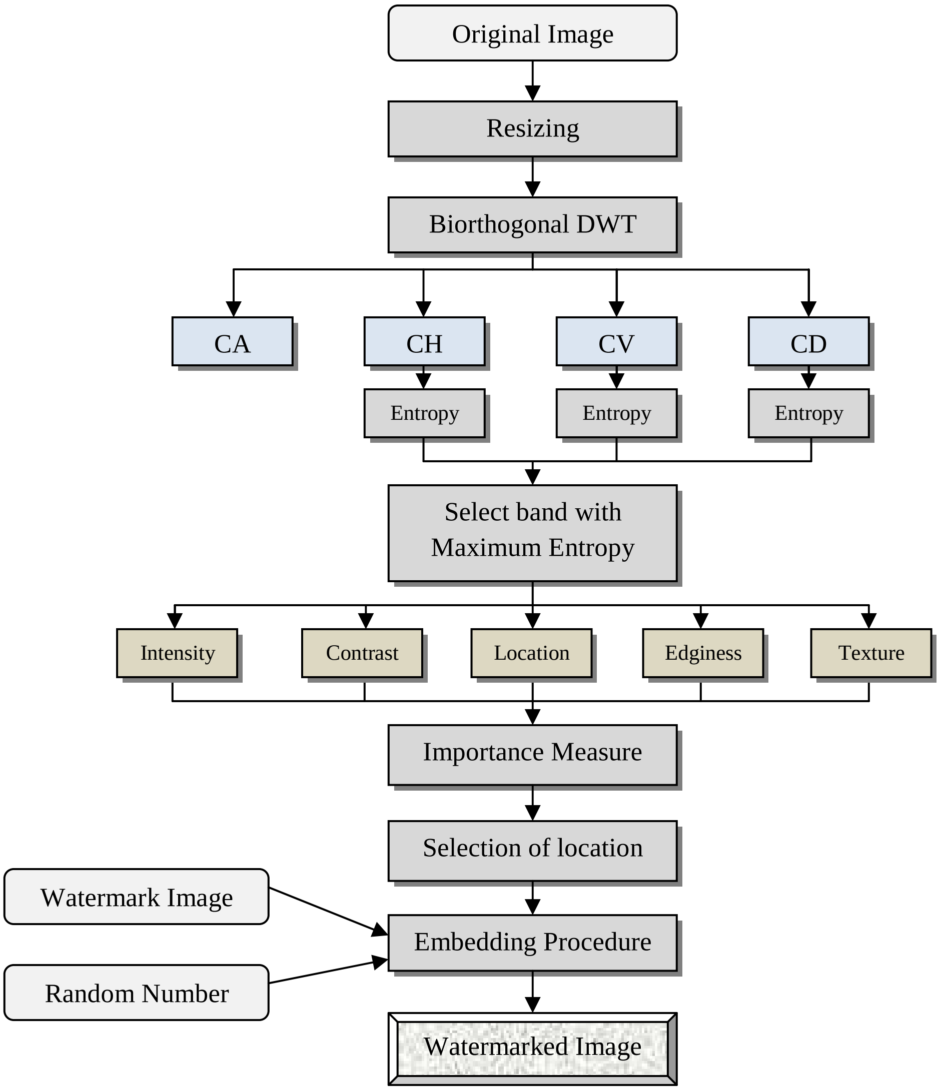

Figure 1: Block Diagram Of The Proposed Watermark Embedding Technique

3.4 Extraction Procedure

In the extraction phase, the watermark image is retrieved from the watermarked image with the use of inverse DWT. Initially, bi-orthogonal transform based IDWT 2 is employed and form it the best band and location is chosen as discussed earlier. Selection of band is based on the entropy in which the band having maximum entropy is selected. Selection of location in based on the importance model where the locations with maximum importance measure are taken.

Subsequently, input from the found out location is taken (V_i) and its correlation with the randomly generated value (r) is taken. Half the correlation value (c_{Vr}) is compared with the mean value (μ_i) and correspondingly the watermark image bits (ϖ_i) are generated based on the condition given below:

$$IF\ \left(\frac{c_{Vr}}{2} > \mu_i\right)$$
$$THEN\quad \varpi_i = 0 \qquad (12)$$
$$ELSE\quad \varpi_i = 1$$

By this method, all the watermark bits are extracted from the watermarked image. The block diagram of the extraction process is given in figure 2.

Journal of Theoretical and Applied Information Technology
28th February 2014. Vol. 60 No.3

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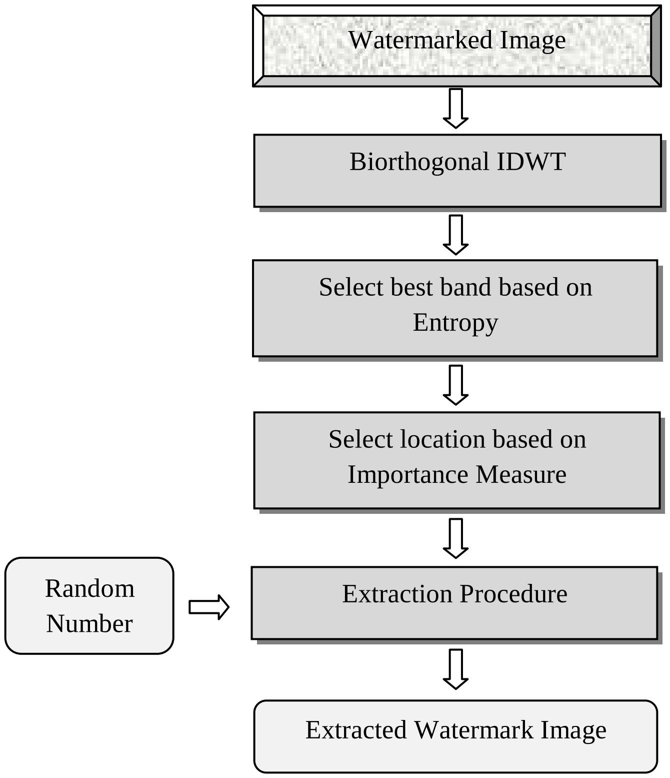

Figure 2: The Block Diagram Of The Proposed Extraction Process

4. RESULTS AND DISCUSSION

The results obtained for the proposed watermarking technique is discussed in this section. Section 4.1 gives the experimental set up and 4.2 gives the description of the evaluation metrics used. Section 4.3 gives the performance analysis and 4.4 give the robustness analysis. Section 4.5 gives the comparative analysis.

4.1 Experimental Set Up

The proposed technique is implemented using MATLAB on a system having the configuration of 6 GB RAM and 2.8 GHz Intel i-7 processor.

4.2 Evaluation Metrics

The evaluation metric used to evaluate the proposed watermarking technique is carried out with the use of Peak Signal to Noise Ratio (PSNR) and Normalised Correlation (NC). The quality is evaluated by the use of PSNR criterion in between the original images with the watermarked images and the extracting fidelity is compared using the NC value with original watermark and the extracted watermark. PSNR is used to measure the invisibility of the embedded watermark in carrier image. NC is used to measure the similarity between the extracted watermark and the original watermark.

The definition of PSNR and NC is given in the following equations.

$$PSNR = 10\log_{10}\frac{E^2_{max}\times W_w \times W_h}{\sum_{x=0}^{W_h-1}\sum_{y=0}^{W_w-1}(W_{jk}-W_{jk}^*)^2} \quad (13)$$

where, W_w and W_h is the width and height of the watermarked image, W_{jk} is the original image pixel value at coordinate (j,k), W_{jk}^* is the watermarked image pixel value at coordinate (j,k) *and* $E^2_{\max}$ is largest energy of the image pixels .

$$NC = \frac{\sum_{i=0}^{W_h}\sum_{j=0}^{W_w} W(j,k)\times E_w(j,k)}{\sum_{i=0}^{W_h}\sum_{j=0}^{W_w}(W(j,k))^2} \quad (14)$$

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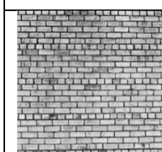
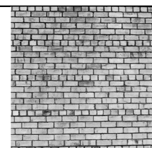
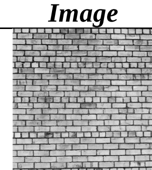
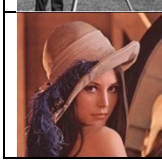
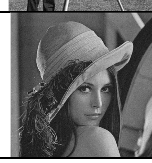
Where, $E_W(j,k)$ is the extracted watermark image.

4.3 Performance Analysis

The proposed technique is evaluated making use of three standard images of DB-95 image, cameraman image and Lena image. The experimental results of the proposed watermarking techniques with the images are given in table 1. In table 1, the image used, watermark image used, watermarked image obtained, extracted watermark image obtained, obtained reversible watermarked image along with PSNR and NC values are given. From the obtained PSNR and NC values, we can see that our proposed technique have performed well. Average PSNR value came about 30.13 and average NC came about 1.

Table 1: Experimental Results Obtained For The Proposed Watermarking Technique

Input image	***Watermark image***	***Watermarked image***	***Extracted Watermark image***	***Reversible Watermarked Image***	***PSNR (dB)***	***NC***
					30.02	1
					30.375	1
					30.005	1

4.4 Robustness Analysis

The robustness of the proposed watermarking technique is evaluated with the aid of different filtering techniques. The algorithm is said to be robust only if the proposed technique can be able to extract the watermark information after applying the different filtering techniques. The filters that we employ are unsharp filter, blurring filter and noise filter. For each filter, we take three cases. In case of unsharp filter, the three cases are 0.2, 0.4 and 0.6. In case of blurring filter, we take cases of 3, 4 and 5. And in case of noise filter, three cases are 0.2, 0.3 and 0.4. Table 2 shows the PSNR and NC values obtained for various filters. From the observation, we can see that the proposed technique achieved good robustness by performing well for all filters achieving good PSNR and NC values.

Table 2: PSNR And NC Values Obtained For Various Filters

		PSNR			NC		
		1st case	*2nd case*	*3rd case*	*1st case*	*2nd case*	*3rd case*
Image 1	*Unsharp*	27.781	27.870	27.920	0.489	0.714	0.628
	Blurring	28.954	28.955	28.942	0.513	0.502	0.496
	Noise	27.852	27.792	27.908	0.579	0.569	0.489
Image 2	*Unsharp*	27.930	28.054	28.191	0.500	0.495	0.627
	Blurring	29.286	29.277	29.249	0.512	0.530	0.507
	Noise	27.944	27.886	27.854	0.532	0.563	0.529
Image 3	*Unsharp*	27.358	27.477	27.626	0.769	0.729	0.622
	Blurring	28.901	28.822	28.757	0.502	0.498	0.490
	Noise	27.276	27.163	27.122	0.532	0.489	0.484

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4.5 Comparative Analysis

Here our proposed technique is compared with the existing technique [24]. Figure 3 and 4 gives the average PSNR and NC values respectively for different filtering techniques for both the techniques. From the figures, it is clear that our proposed technique performs well by achieving better PSNR and NC values compared to existing technique.

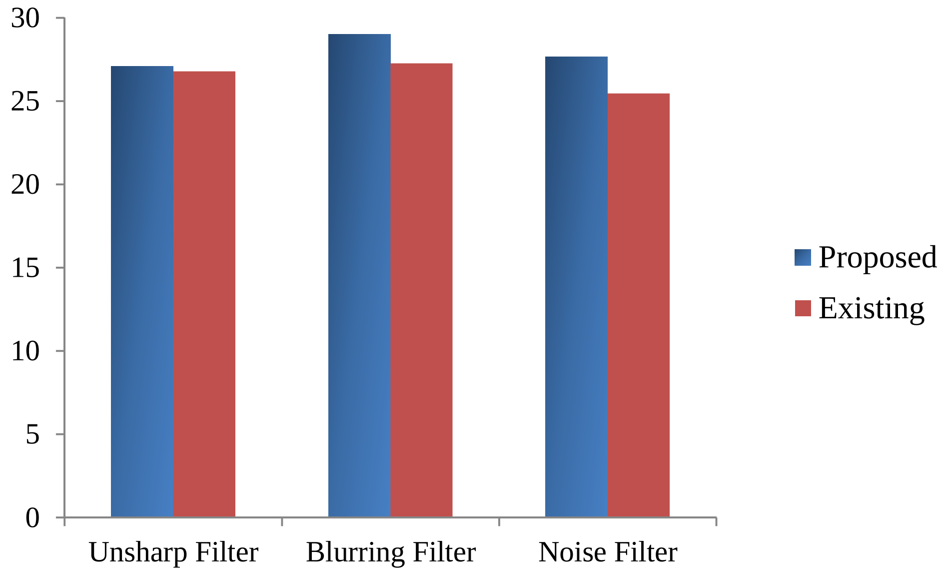


Figure 3: Average PSNR Values

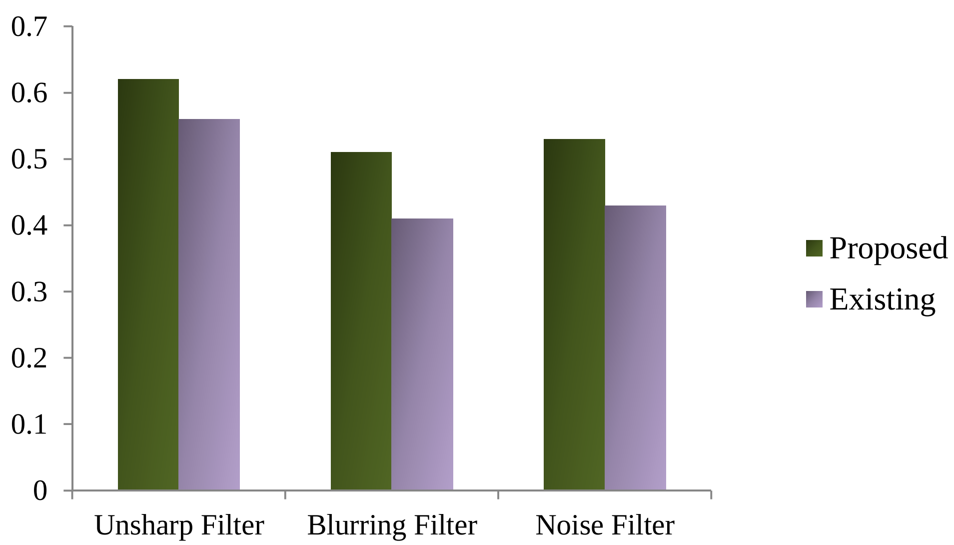


Figure 4: Average NC Values

5. CONCLUSION

Reversible image watermarking algorithm based on bi-orthogonal wavelet transforms and importance measure model is proposed in this paper. Watermark embedding and watermark extraction are the two important steps in the watermarking algorithm. Initially, the image is resized and applied bi-orthogonal discrete wavelet transform. The band for embedding is selected

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based on the entropy and locations are selected using the importance measure model. The proposed embedding process is carried out for embedding the image with a binary watermark image. Watermark image is extracted using the proposed extraction technique. The evaluation metric used to evaluate the proposed watermarking technique is carried out with the use of PSNR and NC. The proposed technique obtained good results having an average PSNR value of 31.3 and NC value of 1. The robustness of the proposed watermarking technique is evaluated with the aid of different filtering techniques and good results were achieved in all cases. Comparison is also made with existing technique and from the results; we can see that our technique outperforms other technique by having better PSNR and NC values.

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