Enhancing the Optimal Robust Watermarking Algorithm to High Payload

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Abstract: *Digital watermarking is a robust method that allows a person to attach hidden data into the digital audio, video, or image signals and documents. In this paper, we propose a watermarking technique where initially, the watermark is embedded into the HL and LH frequency coefficients in multi-wavelet transform domain after searching the optimal locations in order to improve both quality of watermarked image and robustness of the watermark. Here, the payload along with robustness is improved using Genetic Algorithm (GA) and multi-bit embedding procedure. The experimentation is carried using the different images and the performance of the technique is analyzed using the Perceptual Quality-Dependent Parameter (PSNR) and NC. The proposed technique is evaluated using various compression standards and filtering techniques which yielded good results by having high PSNR and NC values showing the robustness and fidelity of the technique. The technique has achieved a peak PSNR of 38.14 and NC of 0.998. The technique is also compared to previous technique and results show that our proposed technique have performed better. Furthermore, payload analysis is carried out to infer that our proposed technique uses only half the payload when compared to previous technique.*

Keywords: *Watermarking, GA, optimal location, robustness, payload.*

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1. Introduction

These days, because of the fast growth of internet and wireless networks, multimedia security and Digital Rights Management (DRM) are becoming more and more a significant issue [14, 24, 25]. The watermarking system can offer a potential key to manage the unlawful duplication and redeployment of those multimedia data [39, 42, 44, 45, 46]. In digital watermarking, when some information is entrenched within a digital media, then the embedded data turns out into an element of that media. This digital watermarking method is used for numerous points such as broadcast monitoring, data verification and data indexing [33]. Watermarking of image data might be visible, for e.g., a background transparent signature or could be perceptually imperceptible. A visible watermark acts like a restriction but may not be acceptable to users in some conditions. As to make an invisible watermark robust, it should be secure, consistent and contrary to common signal processing operations and intended attacks. The signature improved from the watermarked media is used to recognize the certified owners and the planned receivers as well as to authenticate the data [5, 8, 26, 28, 31, 43].

For sustaining the safety, only the specialized parties are permitted to detect, modify and recover the embedded information. Imperceptibility symbolize that the watermarked data must be perceptually identical to the original un-watermarked data, which is also called as "host data" or "cover data". In some applications this obligation can be relaxed to "unobtrusiveness," denoting that small visible disparities flanked by the watermarked and original data can be endured. A digital watermarking system ought to efficiently suit the trade-offs between contradictory requirements of perceptual transparency, data capacity and robustness against malicious attacks [10, 20, 30]. The word robustness points to that it should be probable to convalesce the embedded information precisely even after the processing of the watermarked data and any such processing is called as an attack. Usually, attacks may be unintentional, such as compression of a legally-obtained watermarked image file or malicious, such as an effort by a multimedia pirate to destroy the embedded information and to foil tracing of illegal copies of watermarked digital information [17, 34]. An efficient watermarking system should have three basic requirements namely, robustness, perceptually invisibility and security. One of the very demanding area of concerning is looking for a new robust watermark embedding approach to attain a finer performance [9].

Typically, the digital watermarking methods are dependent on transform-domain methods such as Discrete Cosine Transform (DCT) [16, 19], Discrete Fourier Transform (DFT) [35] and Discrete Wavelet Transform (DWT) [37, 38], Haar wavelet [1, 6, 41] and more. At present, some digital watermarking methods have been proposed based on wavelet transform. The use of Artificial Intelligence (AI) techniques in the watermarking schemes can improve the presentation in an efficient way. Optimization problem is one of the problems faced by the watermarking technique and can be resolved by using methods such as Genetic Algorithm (GA) [11, 15, 16, 21, 23, 32], Adaptive Tabu Search (ATS) [36] or Support Vector Machine (SVM) [40]. Whilst watermarking systems have fairly low payload necessities, characteristically changeable from some bits in access control, up to at most one hundred bits in verification and fingerprinting problems, information-hiding purposes may insist much elevated payload capacity [27]. Therefore, there is a lively attention to examine the amount to which the hosting capacity of images can be amplified without compromising image fidelity and robustness.

Keeping all these problems discussed, we have presented an efficient image watermarking technique using multi wavelet transform with major steps of watermark embedding and extraction process. Payload is increased with the aid of multi-bit embedding. Robustness and fidelity are the essential requirements of a successful watermarking scheme. GA is used to overcome the problem of searching for an optimal placement of the watermark image so as to achieve the trade-off between robustness and image fidelity is discussed.

The rest of the paper is organized as follows: A brief review of some of the literature works in watermarking technique in wavelet domain is presented in section 2. The proposed efficient image watermarking technique using multi-bit and GA is detailed in section 3. The experimental results and comparative analysis discussion is provided in section 4. Finally, the conclusions are summed up in section 5.

2. Related Works

In the literature, there are already several methods for the process of watermarking on a large set of single attacks in wavelet domains. Some of the recent reference works is illustrated as below. In wavelet domain, Ramakrishnan *et al.* [29] have presented a hybrid image watermarking algorithm which gives both imperceptibility and robustness requirements. Here, the singular values of Wavelet Transformation's HL and LH sub bands have been working to implant the watermark. Also, a scale factor has been used to get better results and manage the strength of the watermark. Experimental results are discussed in terms of PSNR, NC and gain factor to prove the potency of the proposed algorithm. In addition, reversible watermarking techniques have also received a lot of attention recently, where after the watermark has been extracted, the original content can be retrieved without any distortion. According to that, Bandyopadhyay *et al.* [4] have presented a dynamic reversible digital watermarking technique using integer wavelet transforms. Here, the technique was placed in the repeated application of the principle of difference expansion in order to reduce the number of average terms to a single average term and to increase the number of difference terms, so that more bits of the payload can be inserted in the difference terms. Experiments performed on the common benchmark image "Lena" have showed that the technique has achieved a good Perceptual Quality-Dependent Parameter (PSNR) values even at large payload sizes.

Some authors have analyzed their image watermarking techniques with different types of attacks for providing copyright protection even if the images has cracked with malfunctioning users. With this in mind, Ramani *et al.* [18] have proposed a technique, which provides copyright protection for digital images. A logo has been embedded invisibly into the color biomedical image by the watermarking algorithm, which is then decomposed using bi-orthogonal wavelet transform using two PN-sequences. The effectiveness of the algorithm has been tested with different types of image processing operations as well as with geometric attacks such as salt and pepper noise, gaussian noise, poisson noise, compression, rotation, scaling and cropping. As well, Hajjara *et al.* [13] have presented a bi-orthogonal wavelet transform based technique for digital image watermarking. In their technique, an image has been decomposed using the DWT and then a watermark has been embedded into the significant coefficients of the transform. Simulation results have proved that the proposed technique was robust against several malicious attacks.

Visual quality degradation due to the watermark embedding and the extraction process is an important, but often neglected issue to consider in designing a fair watermarking benchmark. By considering this issue, Boato *et al.* [7] have proposed an adaptable benchmarking tool using GA in order to evaluate the robustness of any digital image watermarking system. In order to, acquire an unmarked image with high perceptual quality, a given set of attacks has been selected according to the considered application scenario and the parameters to be assigned to each processing operation has been optimized by GA. Experimental results have showed the efficacy of the proposed evaluation tool. Khalighi *et al.* [21] have proposed a CT based non-blind multi-resolution watermarking technique for still images. In their approach, the watermark was a grayscale image that has been implanted into the highest frequency sub-band of the host image in its contourlet domain. The robustness against several common watermarking attacks such as compression, adding noise, filtering and geometrical transformations has been showed from their experimental results.

The amount of information to conceal in the cover image is restricted because there is a trade-off between imperceptibility and payload of the data to hide. So, increasing the payload in the cover image while watermark remain invisible is a challenging task in watermarking process and has attracted several researchers in the recent past. Thus, Anwar *et al.* [3] have developed an adaptive blind digital image watermarking technique in spatial domain. Initially, both the cover and secret images have been partitioned into equal size blocks. Then, the host for each secret image block has been cleverly chosen using GA. Also, the GA helps in finding the target blocks of the cover image such that with the Least Significant Bit (LSB) embedding, visual quality of the cover image and invisibility of secret image remains least affected. Experimental results have showed the improved imperceptibility i.e., PSNR results of the proposed method when compared to the existing approaches in this domain. Kumsawat [22] have developed an approach for optimization in digital audio watermarking using GA. The watermarks have been implanted into the low frequency coefficients in discrete multi wavelet transform domain. An optimization technique has been developed by means of the GA to search for four best quantization steps in order to enhance both quality of watermarked audio and strength of the watermark.

3. Proposed Technique for Increasing the Payload in Optimal Robust Watermarking Algorithm

Digital watermarking gives potential answer for protecting the intellectual property of digital content which is under the scanner due to increase use of digital multimedia. This section discusses in detail the proposed watermarking algorithm using multi-wavelet domain using GA [12]. We also increase the payload with use of multi-bit embedding. Use of GA finds the best place to insert so as to negate both low frequency attacks and high-frequency attacks giving more robustness.

3.1. Watermark Embedding Module

In this module, the watermarking embedding procedure is discussed. Let the input original image be represented by $P_i(m, n)$, watermark image be represented by $W(m, n)$ and the output watermarked image be represented as $P_0(m, n)$. Initially, the input image $P_i(m, n)$ into various sub-bands such as *HH*, *HL*, *LH* and *LL* sub-bands using multi wavelet transform for the embedding the watermark image.

Among the four sub-bands, choose *HL* and *LH* bands represented by $HL(m, n)$ and $LH(m, n)$sub-bands for embedding the watermark images from the four sub-bands. This is because the approximation coefficients in the embedding region need to be highly stable and should be less responsive to minor variations of the image pixel. And for having poise amid robustness and fidelity, the watermark embedding coefficients are chosen with the aid of artificial intelligent technique.

Steps described below gives the embedding procedure for embedding watermark pixels into the HL and *LH* sub-band. Initially for every pixel in consideration, find out the minimum, mean and maximum values of the neighbour values. Suppose the neighbour hood values of the pixel $P_i(m, n)$ are represented as $N(i, j)$, minimum, mean and maximum among the neighborhood is represented by $min(m, n)$, $mean(m, n)$ and $max(m, n)$.

$$mean(m, n) = \frac{\sum N(i, j)}{k}$$

Where k is the number of neighbouring pixels in consideration:

$$min(m, n) = Minimum\ of\ neighbouring\ pixels\ N(i, j)\ in\ consideration$$

$$max(m, n) = Maximum\ of\ neighbouring\ pixels\ N(i, j)\ in\ consideration$$

Here, as we are embedding two bitwise, first two pixels from the watermark image $N_w[i, j]$ embedded into the *HL* and then the subsequent two bits are embedded to *LH* sub-band respectively. We embed the first two pixels into the *HL* sub-band with the position of one's place in the vector *V* and similarly we embed the second two bit pixel pair into the *LH* band with the next position of one's place. The embedding process is processed in four steps counting for 00, 01, 10 and 11 cases.

- ***Case* 1.** For Embedding the Watermark Pixel '00': If the values in the *HL* and *LH* sub-bands are lesser than minimum, then the values are added with the minimum value else the same value is kept.

If HL(m, n)<min(N(i, j))
then W(m, n)= HL(i, j)+ min(N(i, j))
else
W(m, n)= H (i, j)

- ***Case* 2.** For Embedding the Watermark Pixel '01': If the values in the *HL* and *LH* sub-bands are greater than minimum and lesser than mean, then the values are added to the mean, else the same value is kept.

If HL(m, n)≥min(N(i, j)) and HL(m, n)<mean (N(i, j))
then W(m, n)= mean(N(i, j))
else
W(m, n)= H (i, j)

- ***Case* 3.** For Embedding the Watermark Pixel '10': If the values in the *HL* and *LH* sub-bands are greater than mean and lesser than mean, then the values are subtracted with the mean, else the same value is kept.

If HL(m, n)≥ mean(N(i, j)) and HL(m, n)<max (N(i, j))
then W(m, n)= HL(i, j)-mean(N(i, j))
else
W(m, n)= H (i, j)

- ***Case* 4.** For Embedding the Watermark Pixel '11': If the values in the *HL* and *LH* sub-bands are greater than maximum, then the maximum is subtracted from the value, else the same value is kept.

If HL(m, n)≥ max(N(i, j))
then W(m, n)= HL(i, j)-max(N(i, j))
else
W(m, n)= H (i, j)

After embedding, map the modified sub-bands into its original position and apply the inverse wavelet transform to attain the watermarked image $IN(m, n)$. The block diagram for the watermark embedding process is shown in Figure 1.

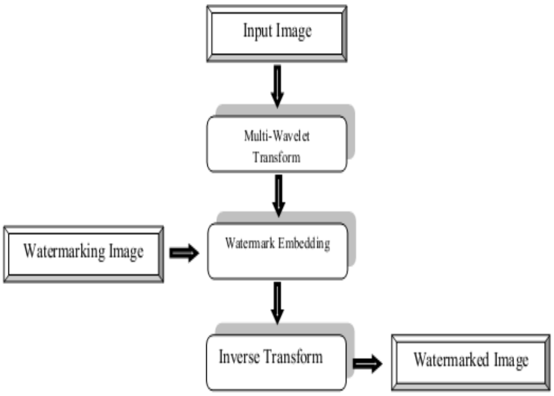


Figure.1. Watermark embedding process.

3.2. Watermark Extracting Module

This module describes the watermark extraction procedure. Let the input watermarked image be represented by *IN*(*m*, *n*) and the extracted watermark image be represented by *EW*(*m*, *n*). The size of the watermarked image is taken as |*IN*(*m*, *n*)|. Here also, initially the input watermarked image is decomposed into *HH*, *HL*, *LH* and *LL* sub-bands using multi wavelet transform for extracting the watermark image.

As described in the earlier section, we select the HL and LH bands represented by *HL*(*m*, *n*) and *LH*(*m*, *n*) sub-bands for extracting the watermark image. Subsequently, extraction is carried out in the watermark pixels from the *HL* and *LH* sub-bands from the corresponding positions as described below.

If the embedded pixel value is greater than the maximum, then the extracted pixel value is 11, else if it is greater than mean, then the extracted pixel value is 10, else if the extracted pixel value is more than minimum, then extracted value is 01, else it is 00.

$$EW(m,n)=\begin{cases}11, \textit{if } \ HL(m,n) > \max N(i,j)\\ 10, \textit{else if } \ HL(m,n) > meanN(i,j)\\ 01, \textit{else if } \ HL(m,n) > \min N(i,j)\\ 00, \textit{else if } \ HL(m,n) \le \min N(i,j)\end{cases} \tag{1}$$

The extracted pixels are placed in the matrix to form the extracted watermark image *EM*(*m*, *n*). The block diagram for the watermark embedding process is shown in Figure 2.

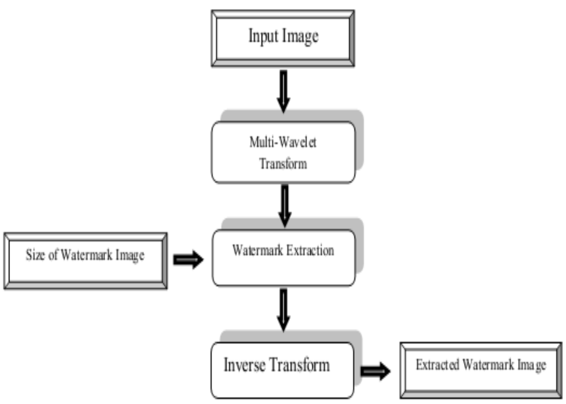


Figure 2. Watermark extraction process.

3.3. Finding Optimal Locations for Embedding the Watermark Image using GA

GA is used to have optimized quality of watermarked image and robustness of the watermark image. GA is used in the watermark embedding and the watermark extracting processes for the optimization purpose. *PSNR* and *NC* parameters are used as the evaluation function in the GA process for relating imperceptibility and robustness of a watermarked image. GA optimization procedure is discussed in detail in the below section.

- *Chromosome Encoding*: The population size carries a vital part in solving the problem statement. The initial population is made by building a population set *V* that has a set of chromosome vectors having half the size of the *HL* or *LH* sub-band. Subsequently, we have placed the one's value with the size of the watermark image in that vector in a random manner. And, the remaining cases are filled down by zero value. Then, the initial set of chromosomes is generated randomly with minimum number. The chromosome encoding set up is clearly shown in Figure 3.

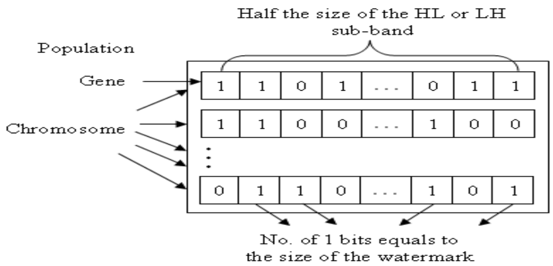


Figure 3. Chromosome encoding.

- *Fitness Function Evaluation*: For every chromosome in the population set, the watermark embedding and extraction process is repeated with respect to the locations defined in the chromosomes. Here, the location of embedding is identified by the bit 1 placed in the chromosome and the embedding and extraction process is carried out using the procedure. Then, we compute the fitness function of the GA that is composed of the *PSNR* along with the similarity measure *NC* value. The fitness value computes with the aid of the following formula:

$$Fitness = PSNP + NC \tag{2}$$

Here, we have considered the *PSNR* and *NC* values for computing the fitness of chromosomes. The ultimate aim of the proposed technique is to maximize the *PSNR* and *NC* value so that, the watermarked image will have the perceptual quality and the extracted watermark signifies the original information embedded in the cover image. According to that, we have incorporated *PSNR* and the 'extracting accurate information from the embedded data-dependent parameter' *NC* in the fitness function that will automatically improves the perceptual quality without affecting the hided information. The definition of *PSNR* and *NC* is given in the following equations.

$$PSNR = 10\log_{10}\frac{E_{\max}^2 \times W_w \times W_h}{\sum_{x=0}^{W_h-1}\sum_{y=0}^{W_w-1}(W_{xy} - W_{xy}{}^*)^2} \tag{3}$$

Where W_w and W_h: Width and height of the watermarked image, W_{xy}: Original image pixel value at coordinate (x, y), W_{xy}^*: Watermarked image pixel value at coordinate (x, y), and $E_{\max}^2$: Largest energy of the image pixels (i.e., E_{max}=255 for 256 gray-level images).

$$NC = \frac{\sum_{i=0}^{N}\sum_{j=0}^{M} N_w(i,j) \times E_{Nw}(i,j)}{\sum_{i=0}^{N}\sum_{j=0}^{M}(N_w(i,j))^2} \tag{4}$$

Where $N_w[i, j]$: Original watermark image, $E_{Nw}[i, j]$: Extracted watermark image, and N and M: Width and height of the watermark image.

- *Selection*: The better set of chromosomes is then selected with highest fitness values of the initial population based on the selection rate.
- *Crossover*: The better set of chromosomes is then utilized to produce offspring by crossover operation. Every two individuals are chosen from the better set of chromosome to produce two new offspring by single crossover point. Figure 4 shows the crossover operation.

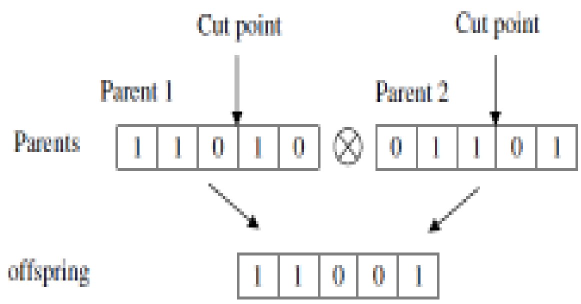


Figure 4. Crossover operation.

- *Mutation*: The obtained new set of individuals is then fed to the mutation operator. Again, we obtain two individuals newly from the single point mutation operator.
- *Termination*: After the completion of cross over and mutation operators, the newly obtained set of chromosomes can be evaluated using the fitness function. Again, the selection, crossover and mutation operators are performed iteratively. The GA process will be iteratively performed until the desired termination is satisfied. The block diagram of proposed watermarking technique using GA is shown in Figure 5.

Table 1. Parameters of the GA.

Parameters	Thresholds
Population Size	50
Crossover Rate	0.2
Mutation Rate	0.04
Number of Generations	50

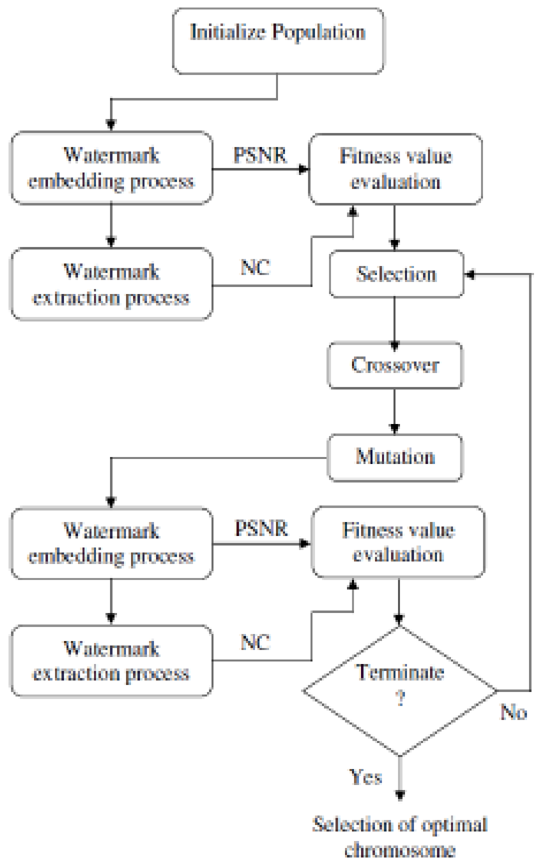


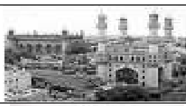
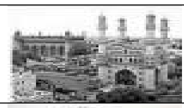
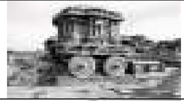
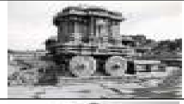
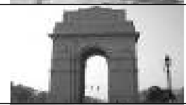
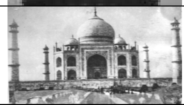
Figure 5. Technique using GA.

4. Experimental Results and Discussion

This section gives the experimental results obtained of our proposed watermarking technique. The proposed technique is implemented in MATLAB on a system having 6 GB RAM and 2.6GHz Intel i-7 processor. For the evaluation purpose, we have made use of Indian Historical buildings along with their names as the watermark image.

PSNR and *NC* metric values are computed to evaluate the proposed technique. 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 *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 experimental results of the proposed watermarking techniques with the Indian historical monument images and the corresponding names are given in Table 2.

Table 2. Experimental results of the proposed watermarking technique.

Sl. No	Input image	Watermark image	Watermarked image	Extracted watermark image	PSNR value (dB)	NC value
1					28.01	0.998
2					32.17	0.997
3					31.05	0.997
4					34.15	0.998
5					30.70	0.998
6					30.83	0.997

4.1. Robustness Analysis

The robustness of the proposed watermarking technique is evaluated with the aid of compression standards and 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 compression in the watermarked image. Here, we have applied the different compression standards and filtering techniques in the watermarked images to analyze the robustness of the watermarking technique in terms of visual quality and the fidelity.

- Compression Standards: Robustness and comparative analysis are done using the compression standards such as SPIHT and JPEG in terms of PSNR and the NC values with different compression ratio.
- SPIHT: Set Partitioning in Hierarchical Trees SPIHT [2] is an image compression algorithm, which exploits the inbuilt resemblances across the sub-bands in the wavelet decomposition of an image. Initially, the SPIHT algorithm extracts the watermark image by compressing the watermarked images that are obtained by employing the relevant algorithms. Then, the performance of the embedding and extraction algorithms is evaluated in terms of PSNR and NC metrics.
- JPEG: is a lossy compression algorithm, which has been developed for minimizing the file size of natural, photographic-like true-color images without degrading the visual quality of the image with respect to human perception. JPEG compression employed in the watermarked images is utilized for robustness comparison [36] and the performance of the watermarking algorithms for diverse compression ratios are calculated from the extracted watermark image by computing the PSNR and NC metrics.

Table 3. PSNR values obtained for various compression standards.

PSNR	Normal	JPEQ	SPHIT
Taj Mahal	30.70	8.33	29.86
India Gate	31.05	7.38	30.57
Lotus Temple	30.84	4.54	30.09
Hampi	32.17	6.61	31.11
Charminar	28.01	6.94	27.47
Qutub Minar	38.15	4.81	35.10

Table 4. NC values obtained for various compression standards.

NC	Normal	JPEQ	SPHIT
Taj Mahal	0.998	0.994	0.997
India Gate	0.997	0.998	0.997
Lotus Temple	0.996	0.997	0.997
Hampi	0.996	0.997	0.997
Charminar	0.997	0.998	0.998
Qutub Minar	0.997	0.997	0.998

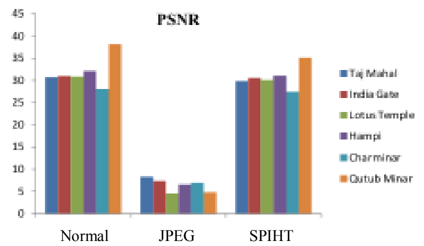


Figure 6. Plot of PSNR values obtained for various compression standards.

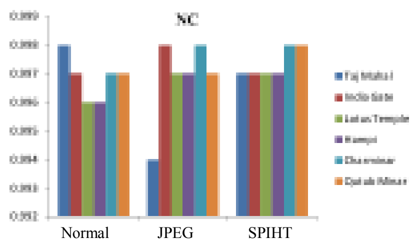


Figure 7. Plot of NC values obtained for various compression standards.

From the Figures 6, 7 and Tables 3, 4 above, we can see that our proposed technique have achieved good results for compression standards attaining a high PSNR and NC values showing the robustness of the proposed technique.

- *Filtering Techniques:* The robustness and the comparative analysis are performed using the different filtering techniques such as Gaussian filter and Average filter in terms of PSNR and the NC values.
- *Gaussian Filter*: A Gaussian filter smoothes an image by computing the weighted averages in a filter box. Gaussian filters are designed in order to give no overshoot to a step function input when reducing the rise and fall time. Gaussian filter has the minimum possible group delay.
- *Average Filter*: Simple averaging can decrease the effect of noise. Improved estimates can be obtained by employing the average of a large number of readings taken from a given noisy but delimited measurement sequence.

Table 5. PSNR values obtained for various filtering techniques.

PSNR	Normal	Gaussian	Average
Taj Mahal	30.70	30.70	30.70
India Gate	31.05	31.05	31.05
Lotus Temple	30.84	30.83	30.84
Hampi	32.17	32.14	32.16
Charminar	28.01	28.00	28.00
Qutub Minar	38.15	38.14	38.14

Table 6. NC values obtained for various filtering techniques.

NC	Normal	Gaussian	Average
Taj Mahal	0.998	0.995	0.996
India Gate	0.997	0.997	0.997
Lotus Temple	0.996	0.996	0.998
Hampi	0.996	0.997	0.998
Charminar	0.997	0.998	0.996
Qutub Minar	0.997	0.997	0.997

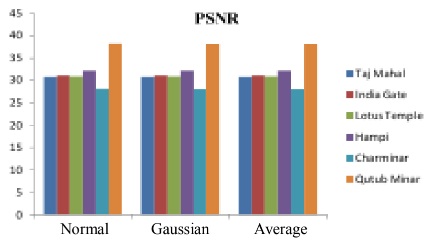


Figure 8. Plot of PSNR values obtained for various filtering techniques.

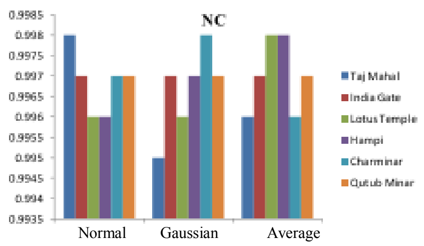


Figure 9. Plot of NC values obtained for various filtering techniques.

From Figures 8 and 9 and Tables 5 and 6 above, we can see that our proposed technique have achieved good results for various filtering techniques attaining a high *PSNR* and *NC* values showing the robustness of the proposed technique.

4.2. Comparative Analysis

In this section, we compare our proposed technique to our base paper technique using the evaluation metrics of *PSNR* and *NC*. Table 7 and Figures 9 and 10 give the values obtained by the respective method.

Table 7. PSNR and NC values obtained for previous technique and proposed technique.

	PSNR		NC	
	Previous Paper	**Proposed Technique**	**Previous Paper**	**Proposed Technique**
Taj Mahal	31.20	30.70	0.94	0.998
India Gate	32.88	31.05	0.96	0.997
Lotus Temple	28.30	30.84	0.92	0.996
Hampi	36.46	32.17	0.96	0.996
Charminar	31.56	28.01	0.93	0.997
Qutub Minar	32.46	38.15	0.93	0.997

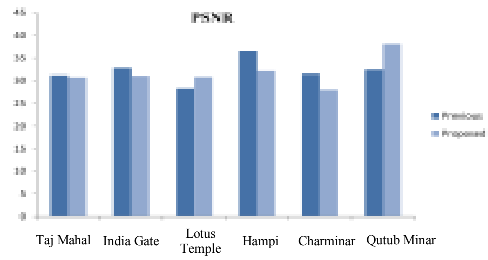


Figure 10. Plot of PSNR values obtained for previous technique and proposed technique.

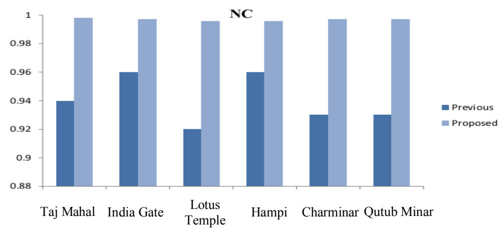


Figure 11. Plot of PSNR values obtained for previous technique and proposed technique.

From the above Table 7 and Figures 10 and 11, we can see that the proposed technique attains better results when compared to technique used in previous paper. Even when *PSNR* values are higher in some cases for previous technique compared to proposed technique, still our proposed technique comes better by having a higher *NC* value.

4.3. Payload Analysis

Payload is the number of location required for the watermarking process and usually the payload will be the number of locations or the size of the watermark image. Our technique using multi-bit embedding reduces the number of location by half and hence successfully reduces the payload. Table 8 and Figure 12 show the payload values obtained for the previous technique and the proposed technique. From the values, it is clear that our proposed technique only uses half the payload when compared to previous technique

Table 8. Payload values for previous technique and proposed technique.

	Payload	
	Previous Paper	Proposed Technique
Taj Mahal	4096	2048
India Gate	4096	2048
Lotus Temple	4096	2048
Hampi	4096	2048
Charminar	4096	2048
Qutub Minar	4096	2048

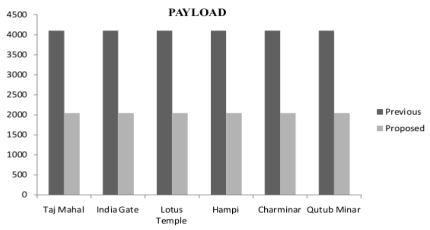


Figure 12. Plot of Payload Analysis for previous technique and proposed technique.

4.4. Comparison with other Techniques

In this section, we compare our method to other methods and the values are given in Table 9. Here, the average *PSNR* and *NC* values obtained for techniques are given.

Table 9. Comparison values with other techniques

Technique	PSNR	NC
ROI Based Watermarking using LSB Technique [39]	24.24	0.86
Reversible Watermarking using Optional Prediction Errorhistogram Modification [40]	26.5	0.51
DWT Based Watermarking[41]	30.62	0.98
Previous Paper	34.14	0.94
Proposed Technique	31.82	0.99

From the Table 9, we can infer that our proposed technique has performed well by achieving good PSNR and NC values.

5. Conclusions

In this paper, we have presented an efficient image watermarking technique using multi-wavelet transform with major steps of watermark embedding and extraction process and here, the payload is increased with the aid of multi-bit embedding. GA is used to find out optimal placement of the watermark image so as to achieve the trade-off between robustness and image fidelity. The experimentation is carried using the different images and the performance of the proposed technique is evaluated using *PSNR* and *NC*. Robustness and fidelity the proposed technique is evaluated using various compression standards such as JPEQ, SPHIT and filtering techniques such as Gaussian, Average filter. Here, all the cases yielded good results by having high *PSNR* and *NC* values showing the robustness and fidelity of the proposed technique. The proposed technique has achieved a peak PSNR of 38.14 and *NC* of 0.998 which shows the effectiveness of the proposed technique. The technique is also compared to previous technique and results show that our proposed technique have performed better. Furthermore, payload analysis is carried out to infer that our proposed technique uses only half the payload when compared to previous technique.

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