ISSN 2250-3153

Performance Analysis for Authentication in Digital Gray Scale Image using DWT Domain

Shveti Sejpal*, Dr. Nikesh Shah**

* Research Scholar, Saurashtra University, Rajkot, Gujarat, India
** Department of Physics, Saurashtra University, Rajkot, Gujarat, India

Abstract- This paper presents a blind digital image watermark embedding technique and its comparative performance analysis based on Discrete Wavelet Transform (DWT) domain for hiding little but important information in cover image. In order to confirm to human perception characteristics, this approach uses two frequency sub-bands HL and HH of DWT to embed a multi-bit watermark image. Here to achieve better robustness and perceptual quality the watermark bits are distributed to the wavelet coefficients of the image edges in every selected sub-band. Here for DWT decomposition simple, orthogonal, symmetric 'Haar' wavelet is used. Here gain factor K=0.55 is selected for testing the performance under several attacks. In DWT domain good perceptual quality is achieved with PSNR value 29.7493, SSIM value 0.9451 and NC value 0.9831. We further demonstrated that our technique is robust against several filter attacks and noise addition.

Index Terms- Digital watermarking, Discrete wavelet Transform, Robustness

I. Introduction

Advances in communication technology, now a day's digital data can be used very easily in an illegal way. It can be modified, copied, and distributed again. It can be easily violated by graphical modification. Digital rights management (DRM) is an important issue in multimedia applications and services. One of the empowering technologies for DRM is digital watermarking [1].The authenticity of content and the Copy right protection, for authors and owners and are the crucial factors to be solved. Digital Watermarking is the solution for these problems. Imperceptibility, Payload Capacity, Robustness and security are four attributes those determine quality of image watermarking scheme. In Digital watermarking number of techniques are used to embed the information into the cover data, without the degradation of the perceptual quality and ensuring that it is difficult to be removed simultaneously [2]. Through transform domain we can achieve higher payload capacity and good robustness. Followings are the applications of digital image watermarking based security solutions can play a key role: fingerprinting, medical images, in distributes systems, securing image data in banking service, protecting enterprise data. Specifically in this paper we have embedded the watermark message in HL and HH band through Discrete Wavelet Transform. This paper is organized in 6 section: Section-II gives survey of work related to DWT, section-III gives Introduction of DWT In section-IV Proposed Technique is presented. Experimentation and results are particularized in section-V while conclusion is drawn in section-VI.

II. RELATED WORK

Earlier as watermark embedding technique Spatial Domain was used. It has the advantage of easy implementation and low computational complexity but it is fragile to some common attacks. Ramani K. et al.[3]proposed the LSB based watermarking technique in spatial domain, here to determine pixels to be use for embedding pseudo random generator is used, based on the given seed or key is the straightforward method, but this is not completely secure algorithm. In order to overcome these shortcomings, the digital watermarking technique based on Discrete Wavelet Transforms has been presented. The HH and LL sub-bands are used to construct the DWT multi watermarking scheme. The combination of the two sub-bands for embedding the watermark provides a system with good robustness in a large scale[4]. M. Chandra has used middle frequency band to add watermark image bits in the cover image [5]. Here our proposed method is more robust compared to this method.

In this paper we have used DWT domain that imperceptibly embeds the image watermark in the cover image such that watermark can be extracted later. Images are the region of similar texture that are connected and gray scale that forms the object. For image analysis Wavelet Transform are best suited. To analyze sharp spikes and discontinuities of the signal wavelet functions are used.

III. Discrete Wavelet Transform

The Discrete Wavelet Transform (DWT) is the most advanced and useful transform domain watermarking technique that is used for signal processing application such as image compression, multi resolution signal processing, etc. images are the non-stationary signal and the wavelet transform is used to analyze the non-stationary signals. [6]It is a hierarchical transform. DWT has the capabilities to study or analyze a signal at different levels i.e. multi resolution analysis [7].

In Discrete Wavelet Transform (DWT) unlike the DCT, no need to divide the input image into non-overlapping 2-D blocks and allows localization in both time frequency and spatial frequency. In DWT signal is decomposed into low pass signal and high pass signal i.e. the image is decomposed into approximation sub-band LL and detail sub-bands, Horizontal band (HL), Vertical band (LH) and diagonal sub-band ((HH). The high frequency contains the edge component information. As the human eye is less sensitive to changes in edges, usually for watermarking high frequency components are used [8].DWT has higher flexibility in choosing the type of wavelet function such as Daubechies, Coiflet, Harr, Marr, Morlet, etc. [9]. DWT algorithm is featured as relatively low complex.

The process can then be repeated to obtain multilevel of wavelet decomposition. The image can be decomposed to 1-level DWT, 2-level DWT, up to N-level DWT.

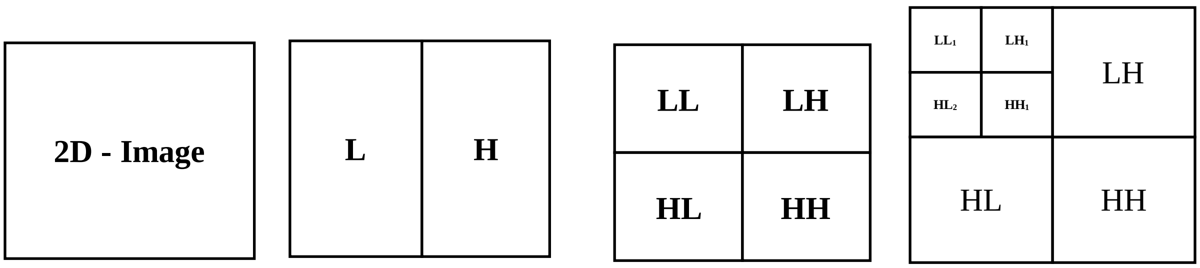


Figure 1: Fundamental process of discrete wavelet transform on image

IV. PROPOSED TECHNIQUE

The proposed method is implemented in DWT domain. An image is a 2-D function f (x, y) (2-D image), where x and y are spatial coordinates, and the amplitude off at any pair of (x, y) is grey level of the image at that point. For example, a grey level image can be represented as:

fij = f(xi,yi)

When x, y and the amplitude value of f are finite and discrete quantities then it is called as digital image. These finite set of the digital values is termed as pixels. Typically, the pixels are stored in computer memory as a matrix of real number [10].

The figure 2 shows the idea of embedding water in the cover image at the sender side. Here cover image is decomposed in to sub bands. The best wavelet sub-band i.e. the detail component bands HL and HH are modified to spread the watermark as the CDMA sequence in the host image. After the watermark is embedded it is transmitted in the channel.

ISSN 2250-3153

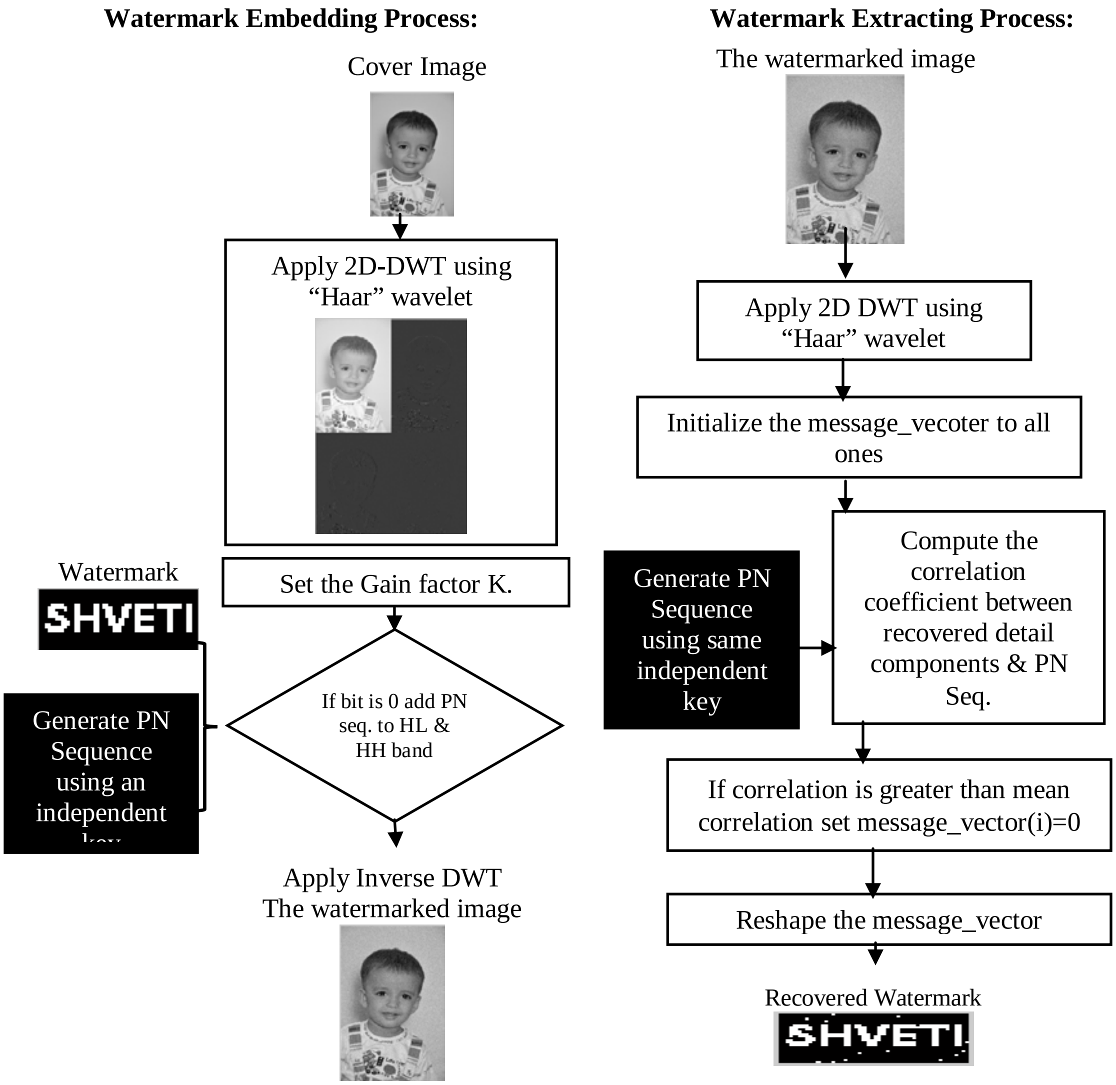


Figure 2: Watermark Embedding and Extracting Process

A. Watermark Embedding Process:

Input: Cover Image, Watermark message, Gain Factor K
Output: Watermarked Image, PSNR.

Step 1: Read the gray scale Cover Image and determine the size of the Cover Image.
[Mc,Nc] = size(cover_object);
Step 2: using “Haar” wavelet apply 2D-DWT to Cover Object to get the four non overlapping sub bands.
[LL,LH,HLHH]=dwt2(cover_object,'haar');
Step 3: Set the Gain Factor to K for embedding.
Step 4: Read in the watermark message and reshape it to a vector (Message_vector).
Step 5: Generate a CDMA PN sequence using an independent state. (Key image as state of the PN sequence)
Step 6: If the watermark bit is black i.e. zero, add the PN sequence to HL and HH sub-bands.
Step 7: Perform one level Inverse DWT with new_HL and new_HH, to generate watermarked image:
watermarked_image = idwt2(LL,LH,new_HL,new_HH,'haar',[Mc,Nc]);
Step 8: Display Watermarked image and PSNR.

B. Watermark Extracting Process:

Input: Watermarked Message, key image
Output: Recovered Watermark

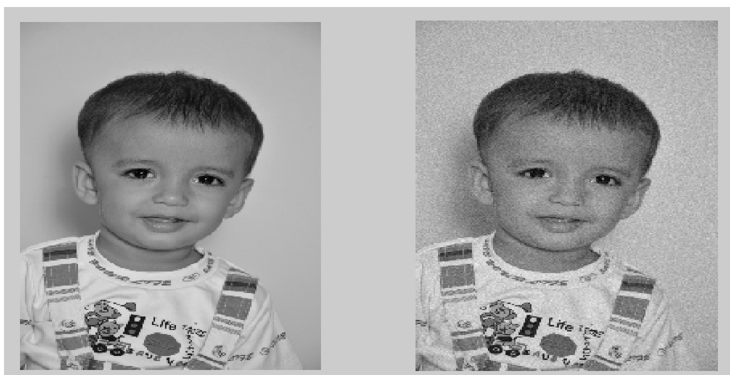
Step 1: Read the watermarked image, and determine the size of the watermarked image.
Step 2: Read the Original Watermark Image, and determine the size of watermark.
Step 3: using “Haar” wavelet apply one level DWT to Watermarked image to separate ‘Recovered HL’ and ‘Recovered HH’ band as [LL, LH, Recovered HL, Recovered HH] = dwt2(Watermarked_image,’Haar’);
Step 4: Initialize the Message_vector to all ones.
Step 5: Generate a CDMA PN sequence using an independent state. (Key image as state of the PN sequence). And compute the correlation coefficient between recovered detail components (Recovered HL, Recovered HH) and PN sequences.
Step 6: Find the mean correlation and compare it with correlation

```
for (i=1:length(message_vector))
        if (correlation(i) > mean(correlation))
                message_vector(i)=0;
        end
end
```

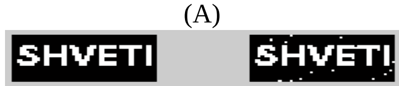
Step 7: Reshape the message_vector and display the recovered watermark.

V. EXPERIMENTATION AND RESULTS

The proposed method is implemented and experiments are carried out using MATLAB. The distinct types of tests are carried out for evaluating the perceptual quality and robustness with high payload capacity for grey scale images of 640 X 426 size and watermark of 23 X 50 size. Figure 3 shows sample output of DWT domain based method with original cover image, Watermarked Image, original watermark and extracted watermark.



(A)



(B)

Figure 3: Sample output of DWT domain based method. (A) Original Cover Image & Watermarked Image. (B) Original Watermark & Extracted Watermark. (Resized the images for display purpose)

In this algorithm during embedding process there is only minimal degradation to cover image and easily the small watermark is retrieved from the watermarked image. In wavelet domain watermarking shows the most promising result. In wavelet domain this algorithm is most simple but yet gives the excellent result.

The objective is to test the quality measures: Perceptual Transparency and Robustness of the watermarking technique. Perceptual transparency means by the presence of watermark the perceived quality of the image should not be degraded. We have used the following visual quality matrix for the sake of comparison of the degradation of the watermarked image.

MSE as signal fidelity measure:

$$MSE(X,Y) = \frac{1}{N}\sum_{i=0}^{N}(Xi - Yi)^2$$

In the literature of image processing, MSE is often converted to a peak signal-to-noise ratio (PSNR) measure [11]

$$PSNR = 10\log_{10}\frac{255^2}{MSE}$$

Structured Similarity Index (SSIM) is used to measure the similarity between two images. SSIM computes three similarity functions: luminance, contrast and structural similarity [10].

$$S(X,Y) = \left(\frac{2\mu_X\mu_Y + C_1}{\mu_X^2 + \mu_Y^2 + C_1}\right).\left(\frac{2\sigma_X\sigma_Y + C_2}{\sigma_X^2 + \sigma_Y^2 + C_2}\right).\left(\frac{\sigma_{XY} + C_3}{\sigma_X\sigma_Y + C_3}\right)$$

Normalized Correlation (NC):

The measure of resistance of watermark against intentional and unintentional attacks is known as Robustness. Normalized correlation is used to measure the similarity and differences between the embedded and recovered watermark.

$$NC(X,Y) = \frac{\sum_{N=0}^{N-1} X[N].Y[N]}{\sqrt{\sum_{N=0}^{N-1} X^2[N] \sum_{N=0}^{N-1} Y^2[N]}}$$

The role of Gain factor in effective information hiding:

For embedding the watermark, the ordering of the sub band can be determined by decomposing the cover image into DWT first level. The decomposing is shown in the figure 4.

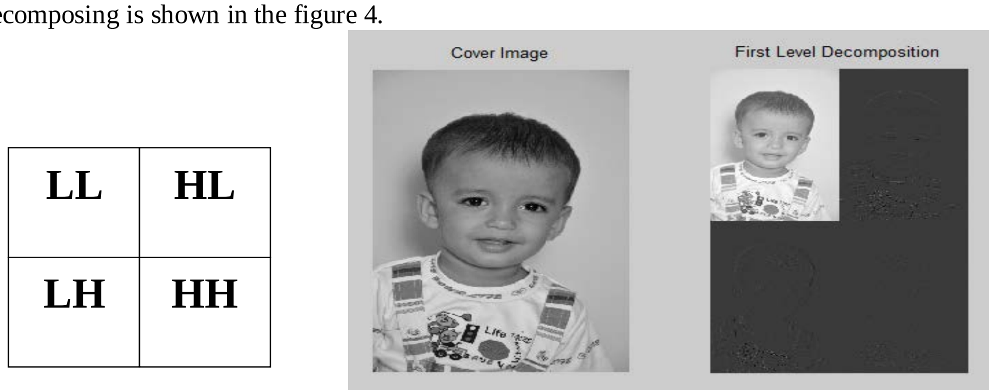


Figure 4: A DWT decomposed image, its 4 bands (LL, HL, LH and HH)

The watermark strength or gain factor, K, have a huge impact on the visual quality of watermarked images and their peak-signal-to-noise-ratios, PSNR, values [12]. The choice of gain factor affects the embedding and extraction of watermark data on watermarked images. The relationship between the gain factor and PSNR (peak Single to Noise) values i.e. the fidelity of the watermark image is summarized in Table 1.

Table 1: PSNR values for Watermarked Image

	K=0.15	K=0.25	K=0.35	K=0.45	K=0.55	K=1	K=3	K=5	K=10
LH&HL	40.9749	36.5758	33.6678	31.4893	29.7493	24.5612	15.4185	11.8374	8.4561
LH&HH	40.9747	36.5757	33.6678	31.4894	29.7493	24.5613	15.4191	11.8377	8.4563
HL&HH	40.9745	36.5768	33.6679	31.4895	29.7493	24.562	15.4188	11.8363	8.4553

From the figure 5 and figure 6 we can see that watermark embedded in HL and HH sub-band combination have high PSNR & SSIM value compared to other sub-band combinations. Figure 8 summarizes the PSNR value decreases as K increases until it reaches its minimum value.

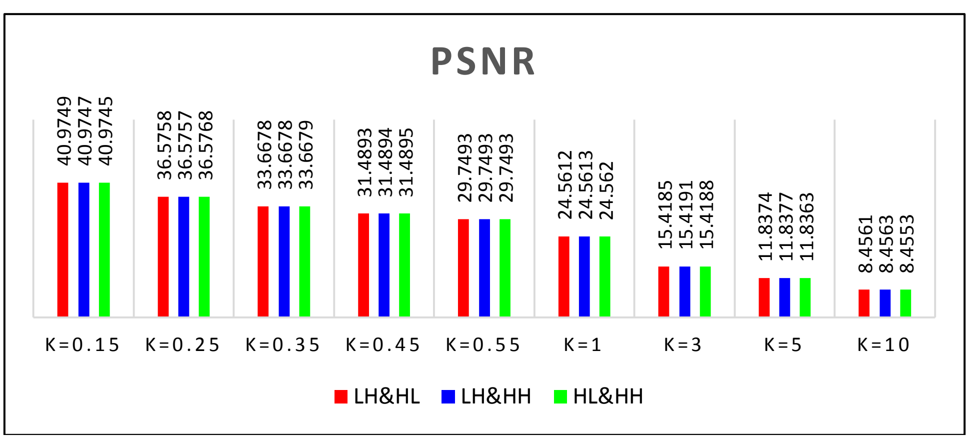


Figure 5: PSNR vs sub-band for various gain factors on watermarked image

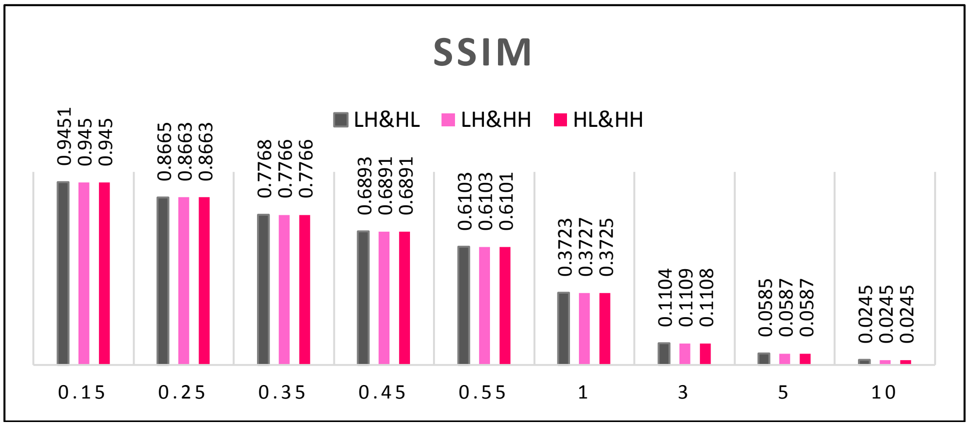


Figure 6: SSIM vs sub-band for various gain factors on watermarked image

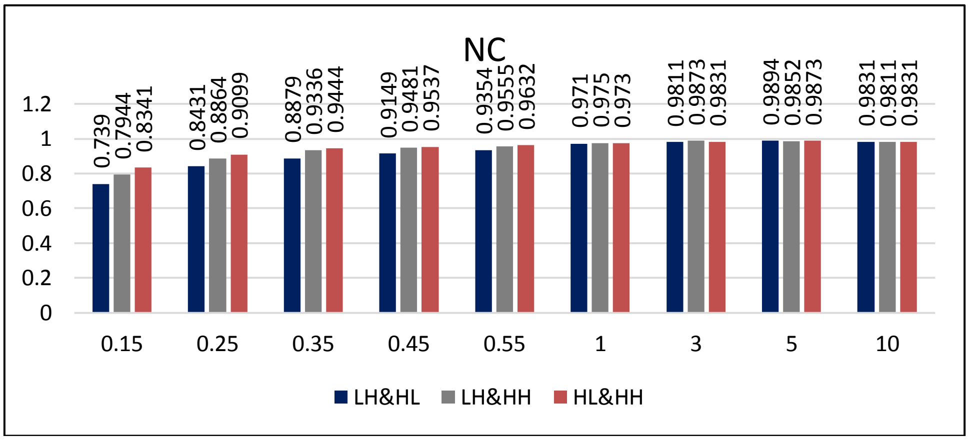


Figure 7: NC vs sub-band for various gain factors on watermarked image

From figure 7 it is clear that NC values of Watermark image are better in HL & HH sub band than other combination of sub bands for all values of gain factor K=0.15 to k=10.

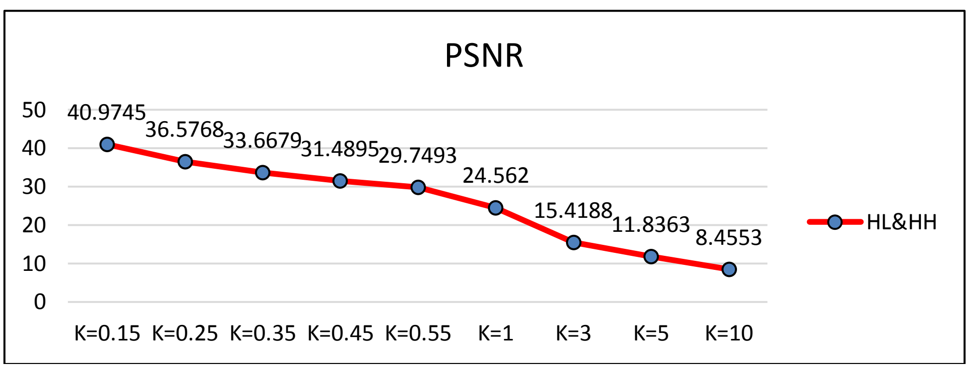


Figure 8: PSNR Vs Gain Factor K

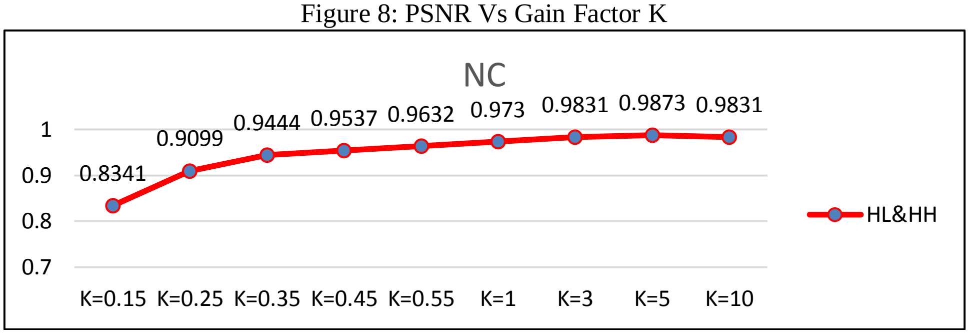
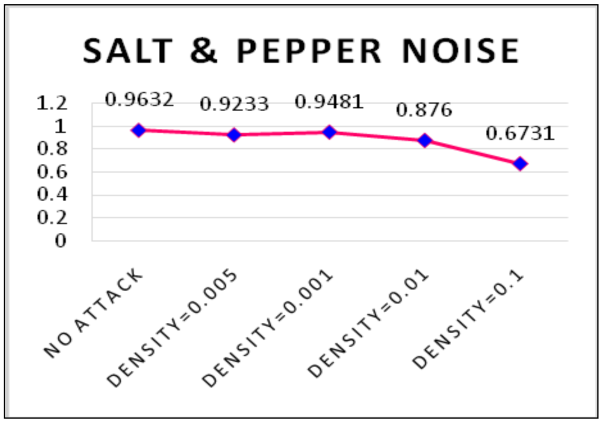


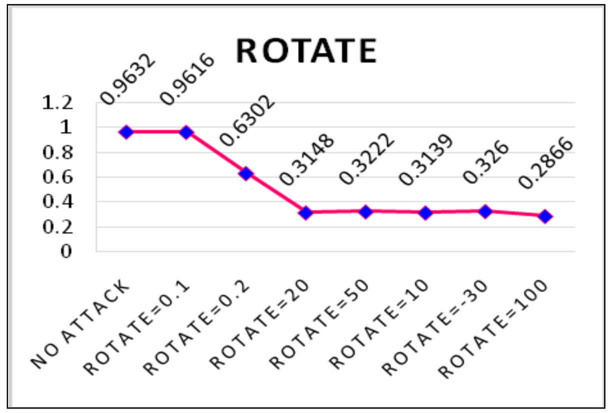
Figure 9: NC Vs Gain Factor K

As shown in the figure 8 and figure 9 The larger value of K degrades the perceptual transparency of the cover image i.e. image Quality but small value of k degrades the robustness of the image under consideration. So for the successful watermark detection the value of the K must be in the reasonable range. Thus K=0.55 is selected for testing the performance under several attacks.

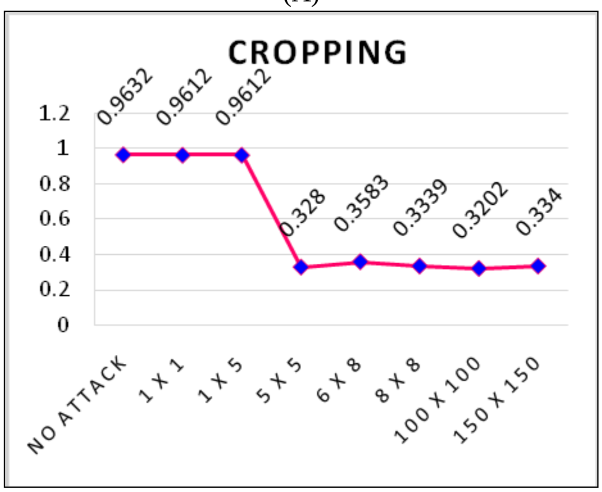
The method is robust in DWT domain (HL & HH sub band) against several possible noise addition and filtering attacks. The details of NC for the image for noise addition and noise filtering attacks are shown in the figure 10. The Proposed method is also found better performing compared to Method [5] for various noise additions and filtering attacks as shown in figure 11.



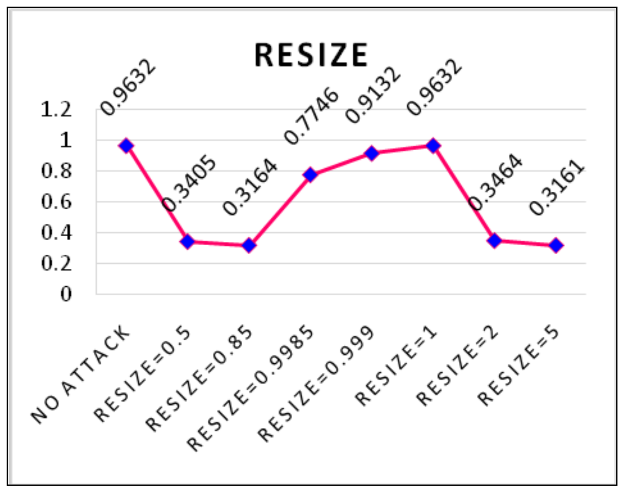
(A)



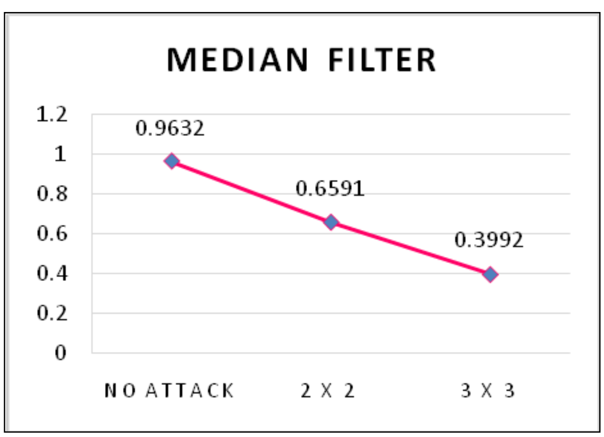
(B)



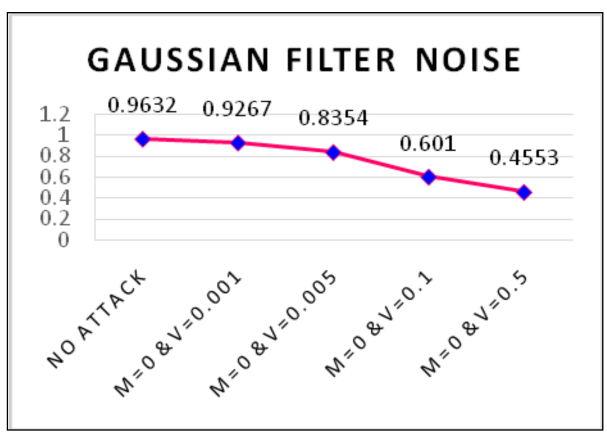
(C)



(D)



(E)



(F)

Figure 10: Robustness against Salt & Pepper Noise, Rotation, Cropping, Resizing, Median Filtering, Gaussian Filter Noise

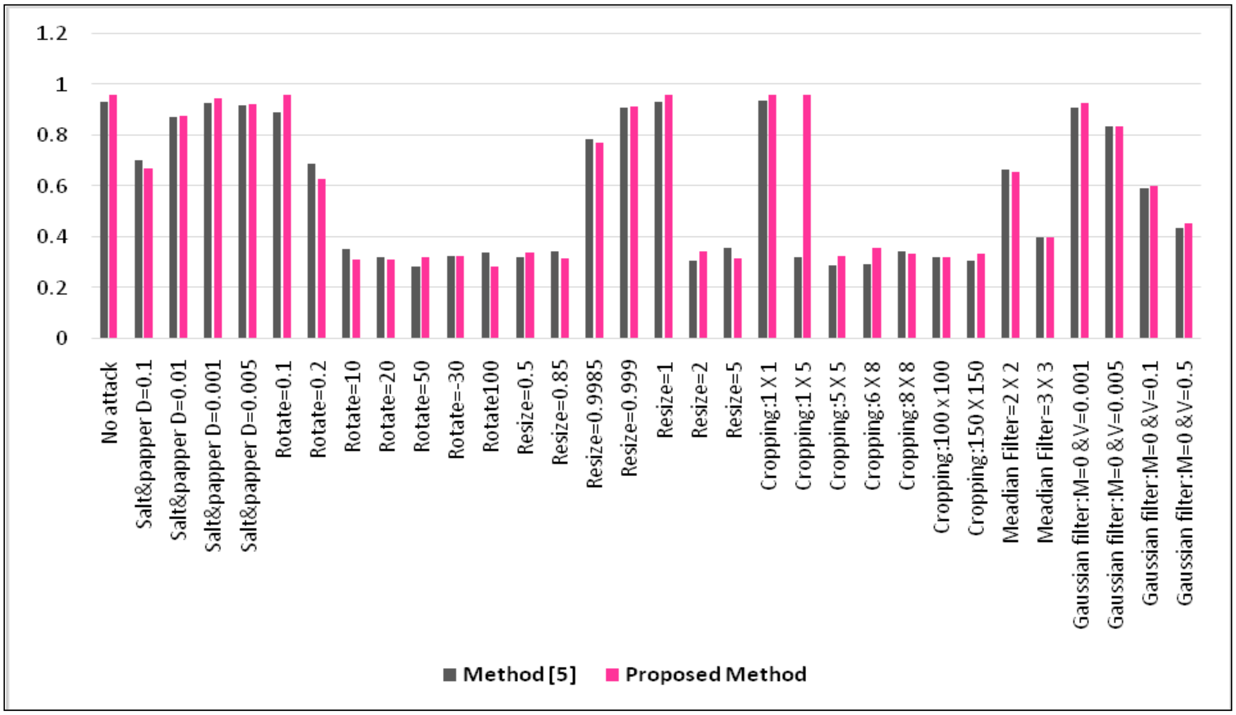


Figure 11: Robustness of proposed method compared to method [5]

VI. CONCLUSION

The challenging issues of Digital watermarking are to achieve imperceptibility, robustness and high embedding capacity. This proposed method fulfils these requirements. The performance of the proposed method is found better than the referenced method using LH & HL sub-bands. The proposed method is robust to various attacks and noise addition. This method can be extended for medical images, colour images and video watermarking. This method can also be extended to several DWT levels for more robustness and security.

REFERENCES

[1] Mohammad-Reza Keyvanpour, FarnooshMerrikh-Bayat, “Robust Dynamic Block-Based Image Watermarking in DWT Domain”, Procedia Computer Science 3 238–242, 2011.

[2] MatthieuUrvoy. Dalila Goudia, and FlorentAutrusseau." Perceptual DFT Watermarking With Improved Detection and Robustness to Geometrical Distortions", IEEE Transactions on Information Forensics and Security, Vol. 9, No. 7, pp. 1108-1119, Jul. 2014.

[3] Ramani K.; Prasad E.V, Varadarajan S.; Subramanyam A,"A Robust Watermarking Scheme for Information Hiding", Advanced Computing and Communications, 16th International Conference, 14-17 pp : 58 – 64, Dec. 2008.

[4] RavalMehul, RegePriti, “Discrete wavelet transform based multiple watermarking schemes”, Conference on convergent technologies for asia-pacific region, vol. 3, pp. 935-938, 2003.

[5] Munesh Chandra, Shikha Pandey, “A DWT Domain Visible Watermarking Techniques for Digital Images”, 2010 International Conference on Electronics and Information Engineering (ICEIE 2010).

[6] Olivier Rioul and Martine Vetterli, “Wavelet and signal processing”, IEEE SP Magazine, October 1991.

[7] Poulami Ghosh, RilokGhosh,Souptik Sinha, ArunaChakroborty “A Novel Digital Watermarking Technique for Video Copyright Protection” CS & IT 06, pp. 601–609, 2012.

[8] TamannaTabassum, S.M. Mohidul Islam “A Digital Video Watermarking Technique Based onIdentical Frame Extraction in 3-Level DWT”, IEEE, 2012.

[9] Gonzalez and Woods, “Digital Image Processing”, Prentice Hall, 2000.

[10] Lijie Cao “Singular Value Decomposition Applied To Digital Image Processing “.

[11] Zhou Wang and Alan C. Bovik, “Mean Squared Error: Love It or Leave It? [A new look at signal fidelity measure]” IEEE SIGNAL PROCESSING MAGAZINE vol. 26, no. 1, pp. 98-117, JANUARY 2009.

[12] A. Salama, R. Atta, R.Rizk, F.Wanes,"A Robust Digital Image Watermarking Technique Based on Wavelet Transform", IEEE International Conference on System Engineering and Technology (ICSET), 2011.

AUTHORS

First Author – Shveti Sejpal, Research Scholar, Saurashtra University, shveti.sejpald@gmail.com.
Second Author – Dr. Nikesh Shah, Professor, Department of Physics, Saurashtra University, snikesh@yahoo.com.

Correspondence Author – Shveti Sejpal, shveti.sejpald@gmail.com