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RESEARCH ARTICLE

An Advanced Watermarking and Compression of Images using SPIHT Compression

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Abstract—Everyday very huge amount of data is embedded on digital media or distributed over the internet. One way to overcome illegal duplication of the data is to insert information known as watermark, into potentially vulnerable data in such a way that it is impossible to separate the watermark from the data. A watermark is a form, image or text that is impressed onto digital media, which provides evidence of its authenticity. Another most common issue today is the storage, manipulation, and transfer of digital images. The files that comprise these images, however, can be quite large and can quickly take up precious memory space on the computer's hard drive. In multimedia application, most of the images are in color. And color images contain lot of data redundancy and require a large amount of storage space. This project concentrates on implementing watermark in image as well as video and also reducing the size of the data by compressing it using SPIHT (Set Partitioning In Hierarchical Trees) compression. The main consideration for any watermarking scheme is its robustness to various attacks. Experimental results demonstrate that it is robust by calculating normalized cross co-relation (NCCR), mean square error (MSE) and the peak signal to noise ratio (PSNR) between the watermark image and extracted image.

Keywords–Digital Watermarking, Wavelets Transform, Robust Watermarking, SPIHT Compression, Attacks

I. INTRODUCTION

An enormous amount of data is embedded on the internet in the form of the digital image, audio, and video and so on, because digital media are easy to copy and transmit. Issues related to digital media are copyright protected, content authentication, proof of ownership, etc. The copyright protection of the digital media is very important because it has identified the protection of intellectual property rights. If a copyright has some problems such as copied, modified and attack, the other person is claiming that they had owned the multimedia objects. Copyright protects is usually embedded with information about the multimedia that is the copyright of owner. The watermarking technique provides one of the best solutions among them. This technique embeds information [10] so that it is not easily perceptible; Human visual system not able to see any information embedded in the contents.

The embedded watermark should not degrade the quality of the image [5] and should be perceptually invisible to maintain its protective secrecy. The important issues in the watermarking system are the watermark must be robust enough to resist common image processing attacks, geometric attacks and not be easily removable. Only authorized user is able to extract the watermark

As security of the digital media is a must so is the efficient use of band over the internet to send the digital data. The combination of integer lifting wavelet transform with set partitioning in hierarchical trees algorithm has been widely used in the field of image compression. Based on this algorithm, the paper presents an image coding algorithm with lower memory and higher speed. The algorithm further takes Human Visual System into consideration and modifies SPIHT algorithm[1] in according to the characteristic of weighted wavelet coefficients. Hence this watermarked image can be efficiently compressed and transmitted with lesser data size by using SPIHT compression. A reliable watermark extraction is developed for extracting watermark from distorted images. Experimental results and comparison with NCCR, MSE and PSNR values shows the robustness and the better performance of the proposed algorithm.

II. REQUIREMENTS OF WATERMARKING SCHEME

Generally, a practical watermarking system embeds some copyright information into the host data as a proof of rightful ownership and must meet requirements. In watermarking systems watermark is embedded inside a cover object sometimes with a secret key also with the help of embedding algorithm as shown in figure 1[2].

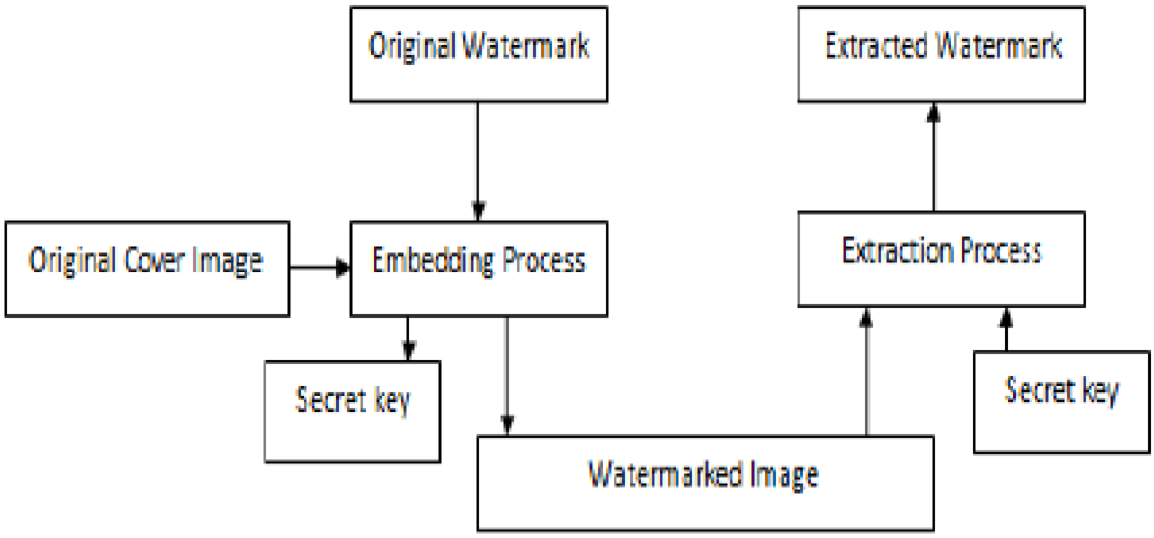


Figure 1: Digital image watermarking scheme

The most important requirements for digital watermarking are summarized below [2].

Transparency: This refers to the perceptual similarity between the original image and the watermarked image. The watermark may degrade the quality of the content, but in some applications a little degradation may accepted to have higher robustness or lower cost.

Robustness: It is the most important requirement of watermarking that a watermark can survive after common signal processing operations and various geometric attacks.

Capacity: The amount of information that can be embedded in a watermarked image is called data payload.

Security: It must not be possible to retrieve or even modify the watermark without knowledge of the secret watermark key.

III. DISCRETE WAVELET TRANSFORM

Discrete Wavelet Transform (DWT)[8], which is based on sub-band coding, is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required. Wavelets have their energy concentrated in time and are well suited for the analysis of transient, time-varying signals. Wavelet based transform gained popularity recently since the property of multiresolution analysis that it provides.

The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in Figure 2. In this figure, the low-pass and high-pass filters are denoted by h(n) and g(n), respectively. This depicts the two levels of the 2D DWT decomposition. At each level, the high-pass filter generates detailed image pixel information, while the low-pass filter produces the coarse approximations of the input image. At the end of each low-pass and high-pass filtering, the outputs are down-sampled by two (↓ 2). In order to compute 2D DWT, 1D DWT is applied twice in both horizontal and vertical dimension. In other words, a 2D DWT can be performed by first performing a 1D DWT on each row, which is referred to as horizontal filtering, of the image followed by a 1D DWT on each column, which is called vertical filtering AND the second level 2D wavelet based transforms [6] is as shown in figure 2 and 3.

3.1 *Selection of best Embeddable location*

The higher level subbands are more significant than the lower level subbands. They contain most of the energy coefficients so embedding in higher level subbands is providing more robustness. On the other hand lower level subbands have minor energy coefficients so watermark in these subbands are defenceless to attacks. The higher level approximation subband (LL2 subband) is not suitable for embedding a watermark since it is a low-frequency band that contains important information about an image and easily causes image distortions. On the second level, embedding a watermark in the diagonal subband (HH2 subband) is also not suitable, since the subband can easily be eliminated, for example by lossy compression as it has a minor energy coefficient. So the middle frequency subbands (Vertical & Horizontal) of higher level are the best choice for embedding.

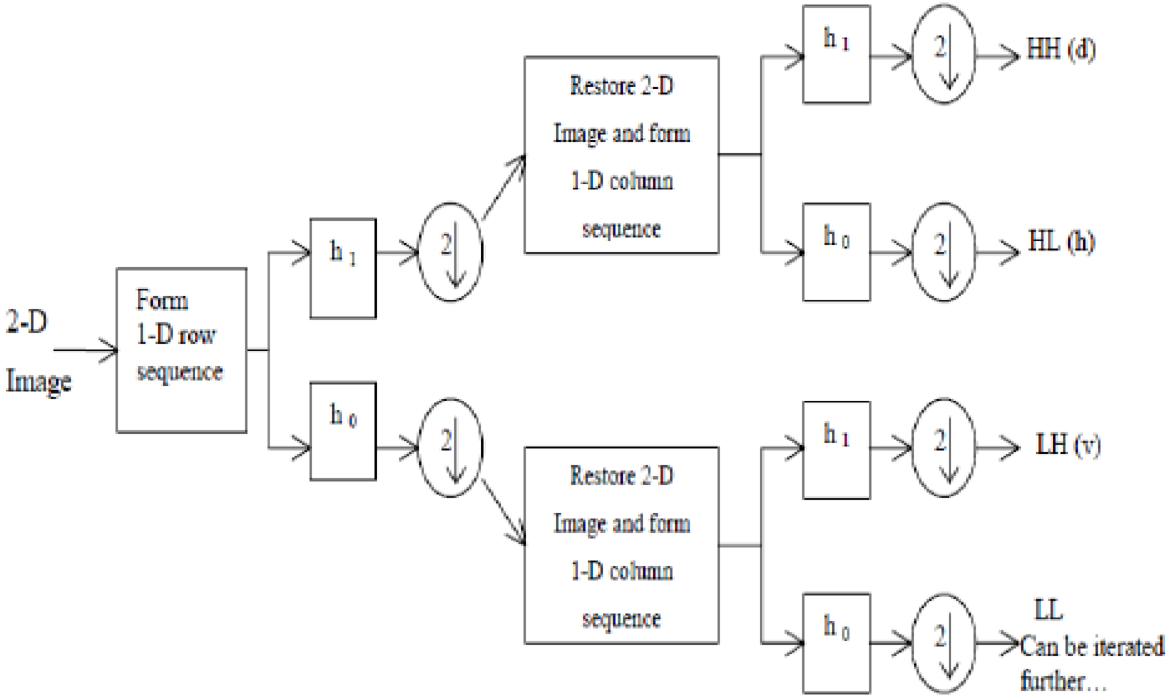


Figure 2: Single level analysis filter bank for 2-D DWT

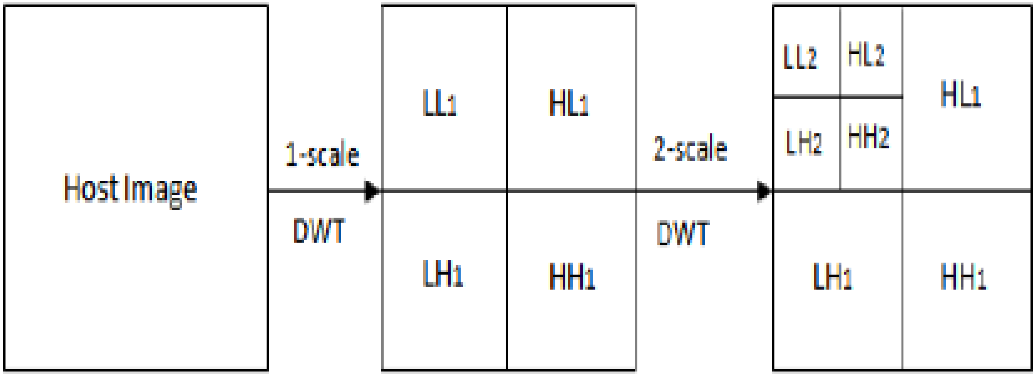


Figure 3: Two level 2D Wavelet based transforms

Further the LH2 subband has more significant coefficients than the HL2 subband. For this reason, it would be suitable to embed the watermark in the middle frequency band LH2 instead of HL2.

3.2 *The Biorthogonal Wavelet Transform*

Wavelets can be orthogonal (orthonormal) or biorthogonal. Most of the wavelets used in watermarking were orthogonal wavelets. The method in introduces a semi-fragile watermarking technique that uses orthogonal wavelets. The biorthogonal wavelet transform is an invertible transform. The property of perfect reconstruction and symmetric wavelet functions exist in biorthogonal wavelets because they have two sets of low pass filters (for reconstruction), and high pass filters (for decomposition). One set is the dual of the other. On
the contrary, there is only one set in orthogonal wavelets. In biorthogonal wavelets, the decomposition and reconstruction filters are obtained from two distinct scaling functions associated with two multiresolution analyses in duality. Another advantageous property of biorthogonal over orthogonal wavelets is that they have the higher embedding capacity if they are used to decompose the image into different channels [7]. All mentioned properties make biorthogonal wavelets promising in the watermarking domain.

IV.SPIHT

SPIHT is a wavelet-based image compression coder. It first converts the image into its wavelet transform and then transmits information about the wavelet coefficients. The decoder uses the received signal to reconstruct the wavelet and performs an inverse wavelet transform to recover the image. SPIHT and its predecessor(the embedded zero tree wavelet coder) were significant breakthroughs in still image compression in that they offered significantly improved quality over vector quantization, JPEG, and wavelets combined with quantization, while not requiring training and producing an embedded bit-stream. SPIHT displays exceptional characteristics over several properties all at once. SPIHT is a method of coding and decoding the wavelet transform of an image. By coding and transmitting information about the wavelet coefficients, it is possible for a decoder to perform an inverse transformation on the wavelet and reconstruct the original image. The entire wavelet coefficient does not need to be transmitted in order to recover the image. Instead, when the decoder receives more information about the original wavelet transform, the inverse-transformation will yield a better quality reconstruction (i.e., higher peak signal to noise ratio) of the original image. SPIHT generates excellent image quality and performance due to several properties of the coding algorithm. They are partial ordering by coefficient value, taking advantage of redundancies between different wavelet scales and transmitting data in bit-plane order. Following a wavelet transformation, SPIHT divides the wavelet into spatial orientation trees[3] Fig.4.1. SPIHT codes a wavelet by transmitting information about the significance of a pixel. By stating whether or not a pixel is above some threshold, information about that pixel's value is implied. Furthermore, SPIHT transmits information stating whether a pixel or any of its descendants are above a threshold. If the statement proves false, then all of its descendants are known to be below that threshold level and they do not need to be considered during the rest of the current pass. At the end of each pass the threshold is divided by two and the algorithm continues. By proceeding in this manner, information about the most significant bits of the wavelet coefficients will always precede information on lower order significant bits, which is referred to as bit-plane ordering.

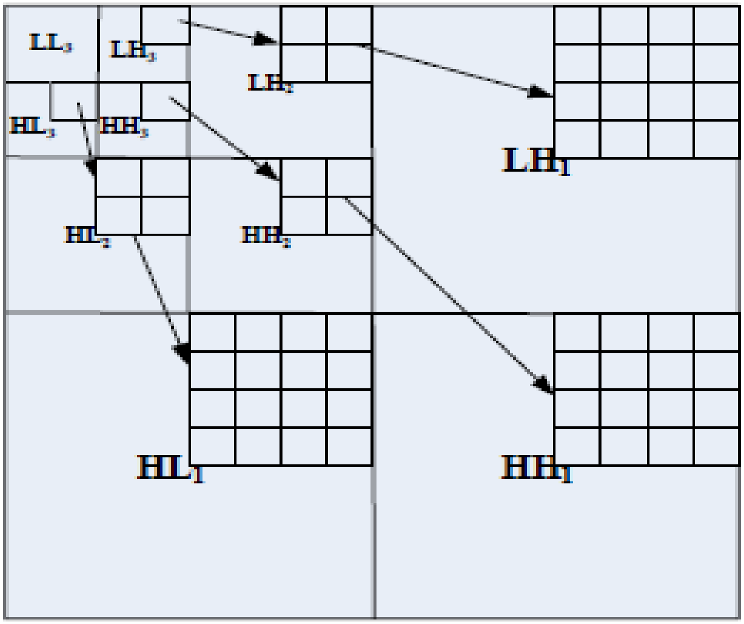


Figure 4.1: Zerotree in a 3-level decomposition

Within each bit-plane data is transmitted in three lists[11]: The list of insignificant pixels (LIP), the list of insignificant sets (LIS), and the list of significant pixels (LSP). In addition to transmitting wavelet coefficients in a bit-plane ordering, the SPIHT algorithm develops an individual order to transmit information within each bit-plane. The ordering is implicitly created from the threshold information discussed above and by a set of rules which both the encoder and decoder agree upon. Thus, each image will transmit wavelet coefficients in an entirely different order. Slightly better PSNR are achieved by using this dynamic ordering of the wavelet coefficients.

In the SPIHT each stage [3], output bit stream includes all bits which are created in the sorting process and refining process. In some stage, changing bit stream output order can improve the truncation transmission the image quality, but the simply change certainly cannot enhance the non-truncation transmission the image quality.The new encoding algorithm flow is as shown in figure 4.2.

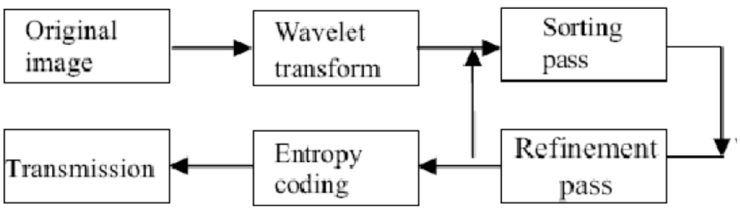


Figure 4.2: SPIHT algorithm flow

V. PERFORMANCE EVALUATION

Peak Signal-to-Noise Ratio (PSNR): Peak signal to noise ratio (PSNR) [9] is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is the most easily defined via the Mean Squared Error (MSE) for two $m \times n$ images I and K, where one of the images is considered as a noisy approximation of the other. MSE and PSNR can be estimated equations (3) and (4).

$$MSE = \frac{1}{m \cdot n} \sum \sum \| I(i,j) - K(i,j) \| 2 \quad \text{——} \quad (3)$$

$$PSNR(dB) = 10 \log_{10} \cdot (255^2 / MSE) \quad \text{——} \quad (4)$$

*Normalized cross correlation (NCCR)***:** NCCR is the correlation between the watermark image W and extracted watermark image W'. If the value of NC is closer to 1, W and W' are more similar. NC can be estimated the following equation (5).

$$NC = \frac{\sum_i \sum_j W(i,j) \cdot W'(i,j)}{\sum_i \sum_j [W(i,j)]^2} \quad \text{——} \quad (5)$$

Compression Ratio (CR): The compression ratio (CR) of the compressed watermarked image is measured by taking the ratio of the image bytes to the compressed bytes of image as in equation (6)

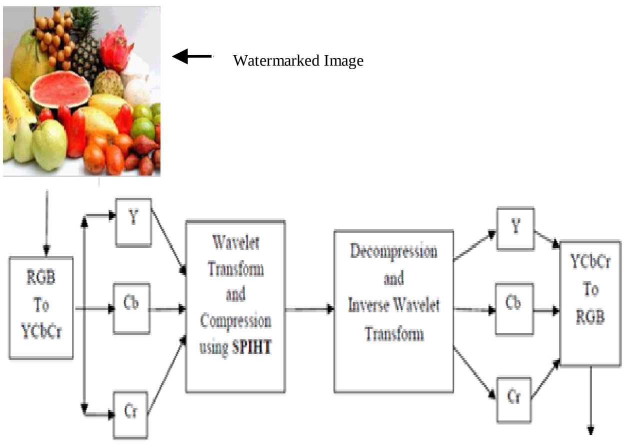
$$CR = \frac{\text{image size before compression}}{\text{image size after compression}} \quad \text{——} (6)$$

VI. PROPOSED METHOD

The main objective of the proposed method is to present the novel robust & imperceptible watermarking technique using biorthogonal wavelet transform. In embedding process first separate the R, G & B channels of the color image and the blue channel is selected for the embedding because this channel is more resistant to changes compared to red and green channels and the human eye is less sensitive to the blue channel, a perceptually invisible watermark embedded in the blue channel can contain more energy than a perceptually invisible watermark embedded in the luminance channel of a colour image. The blue channel is decomposed into n-level using biorthogonal wavelet transform. The property of perfect reconstruction and symmetric wavelet functions exist in biorthogonal wavelets [4]. Let select a bitmap image of size 64 x 64 as watermark and convert it into a 1-D vector. Two PN sequences are selected for embedding watermark bit 0 & 1 in mid frequency subbands of higher level decomposition of the channel. By using an additive watermarking technique to construct the image as:

$LH_{2'} = LH_2 + alpha * PN\ (0)$
$HL_{2'} = HL_2 + alpha * PN\ (1)$
Where $LH_{2'}$ and $HL_{2'}$ watermarked subbands
LH_2 and HL_2 watermarked subbands
Alpha=Embedding strength

Finally reconstruct the watermarked image using inverse biorthogonal wavelet transform. Now calculate the Mean Squared Error & Peak Signal to Noise Ratio between original cover image and watermarked image to evaluate the perceptual similarity between these two images by using equation 1 & 2.



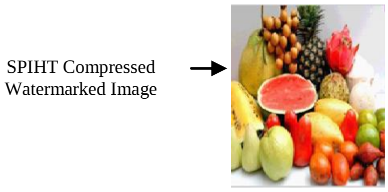


Figure 5: Method of SPIHT Color Image Compression

Watermarked image as shown in figure 5[9] is converted to YCbCr format. **YCbCr** or **Y′CbCr**, sometimes written YCBCR or Y′CBCR, is a family of color spaces used as a part of the color image pipeline in video and digital photography systems. Y′ is the luma component and CB and CR are the blue difference and red-difference chroma components. Y′ (with prime) is distinguished from Y which is luminance, meaning that light intensity is non-linearly encoded using gamma correction. After converting wavelet analysis is done for Y, CB, and CR. Then the data is compressed using SPIHT [11] algorithm.

In extraction process the end user separates the R, G & B channels of the watermarked image. The blue channel is decomposed into n-level using biorthogonal wavelet transform. Generate the PN (0) & PN (1) signal similarly to the embedding process and select the threshold value. By using these signals extracts the original watermark from HL_2’ and LH_2’ subbands. At last the Normalized Cross correlation between original and extracted watermark is calculated using equation 5.

VI. EXPERIMENTAL RESULTS

The *elephant.jpg* color image of size 256X256 is selected as a cover image and *best.bmp* bitmap image of size 64X64 is chosen as a watermark. Figure 7(a) shows the original cover image & 1-level decomposed blue channel using biorthogonal wavelet transform. Figure 7(b) shows 2-level decomposition and the original watermark *best.bmp*. Figure 7(c) shows the watermarked image and YCbCr converted watermarked image. Figure 7(d) shows the SPIHT image and the reconstructed image. Figure 7(e) shows blue plane of compressed image and the extracted watermark.

Figure 7(a): Original cover image & 1-level decomposed blue channel using wavelet transform.

Figure 7(b): 2-level decomposed blue channel & watermark image

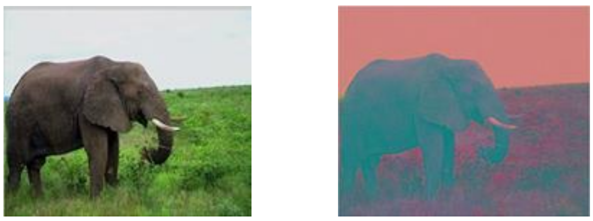


Figure 7(c): Watermarked image & YCbCr converted watermarked image

Figure 7(d): SPIHT image & SPIHT compressed watermarked image

Figure 7(e): Blue plane of SPIHT compressed image & extracted watermark

Alpha=0. 1	Alpha=0. 5	Alpha=1. 0
PSNR=28.43	PSNR=28.47	PSNR=28.43
MSE=93.26	MSE=92.34	MSE=93.25
NCCR=0.6611	NCCR=0.6635	NCCR=0.6702

Figure 8: watermarked image at a different embedding factor

Figure 8 shows various values obtained for different embedding factor (alpha) values.

The efficiency to extract the watermark is further tested by applying different levels of Gaussian noise, salt and pepper noise. The robustness of the method is further test by comparing the results by plotting graphs with various values of Alpha, MSE, PSNR, NCCR, Compression rate and different levels of Noise density with the below plots as shown in figure 9(a),9(b),9(c),9(d),9(e),9(f) and 9(g).

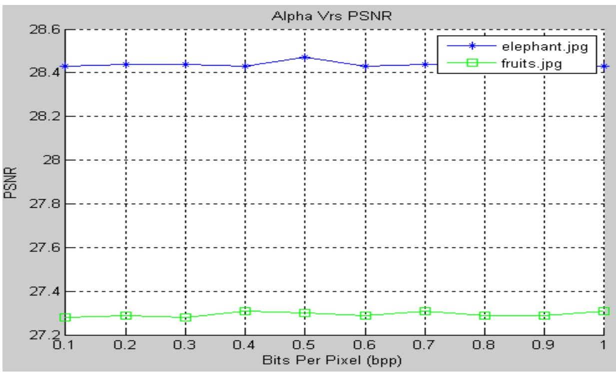


Figure 9: (a) Plot of Alpha Vs PSNR

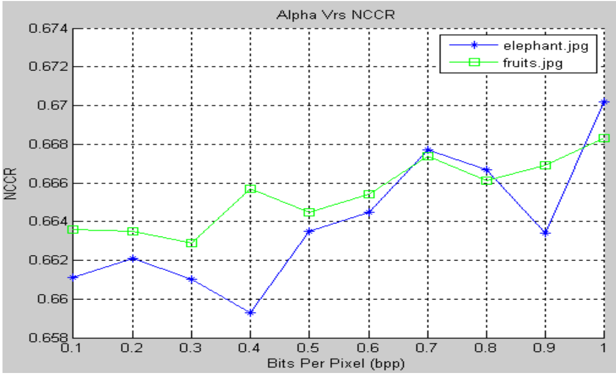


Figure 9: (b) Plot of Alpha Vs NCCR

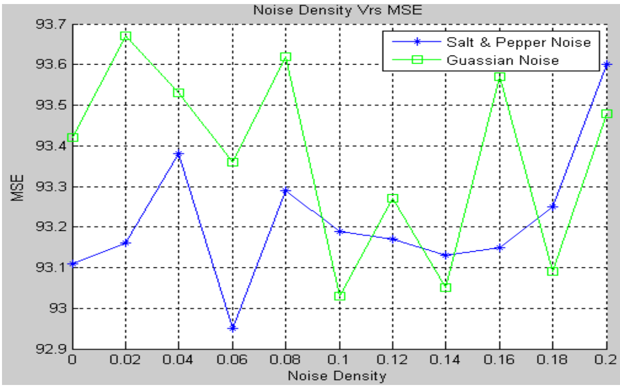


Figure 9: (c) Noise Density Vs MSE

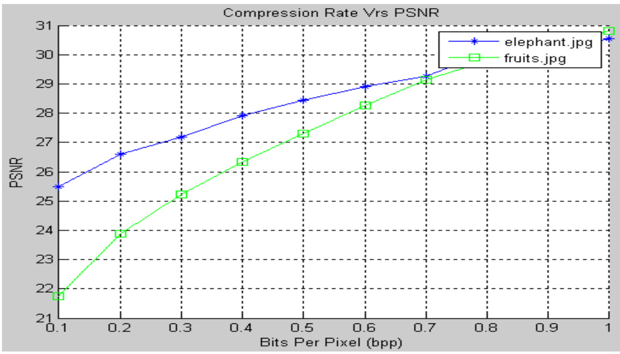


Figure 9: (d) Compression Rate Vs PSNR

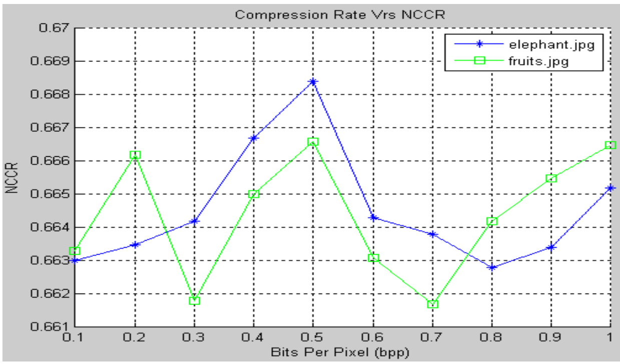


Figure 9: (e) Compression Rate Vs NCCR

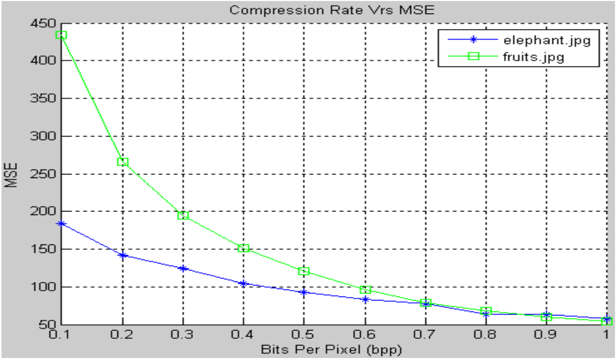


Figure 9: (f) Compression Rate Vs Noise Density

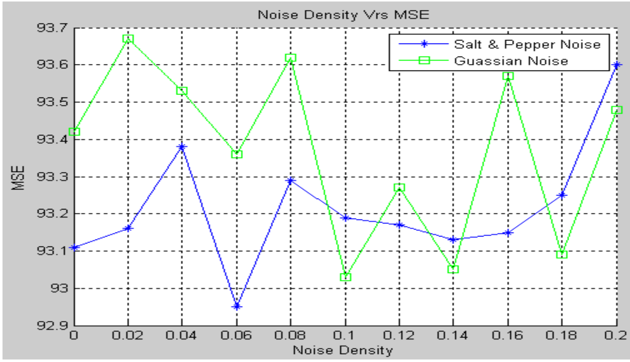


Figure 9: (g) Noise Density Vs MSE

VII. Conclusion

This method provides a robust watermarking technique which makes use of bi-orthogonal wavelet transforms and a high efficient lossless compression method, using SPIHT compression. The technique makes use of DWT; with this technique the watermark is extracted even if the watermarked image is compressed or attacked. First, the embedded watermark should not degrade the quality of the image and should be perceptually invisible to maintain its protective secrecy. Second, the watermark must be robust enough to resist common image processing attacks and not be easily removable; only the owner of the image is able to extract the watermark. The SPIHT algorithm is applied for luminance (Y) and chrominance (Cb,Cr) part of RGB to YCbCr transformed image which help is preserving the true color of the image. Reconstructed image is verified using human vision and different parameters such as PSNR, MSE and NCCR.

The performance of the proposed method is tested by applying different geometric and image processing attacks, such as salt and pepper noise, Gaussian noise. The method is found to be robust with different levels of compression rates and embedding factor.

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