Comparative Study of Digital Image Watermarking Based I.J.Cox's Algorithm versus proposed Hybrid DWT-DCT Approach

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Abstract— Quantity of data over the internet is growing day by day due to rapid growth in technology, requirement for security of these data like image, audio, video, text are also increasing. Digital watermarking technique has become more significant in today's era of internet. Digital watermarking is a protector of the information in the form of audio, images and video against the illicit distribution. A robust image watermarking techniques is considered for this paper based on discrete wavelet transform (DWT) and discrete cosine transform (DCT) combined called hybrid watermarking. Two levels and three levels DWT performs the hybrid watermarking followed by respective DCT on the host image. The simulation results are often compared with I.J.Cox's algorithm. By computing a statically parameter like Mean square error (MSE), Peak signal to noise ratio (PSNR) under the various attack like image cropping, noise and resize proposed hybrid approach preserves the best quality image. The proposed hybrid approach gives better Peak signal to noise ratio (PSNR) compared to I.J.Cox's algorithm. The proposed hybrid approach can drive in bigger marks and high quality marks extracted from the embedded watermarking even after attacking condition. The algorithm has been implemented on MATLAB with the graphical user interface (GUI).

Keywords: Digital image watermarking, Discrete wavelet transform (DWT), Discrete Cosine Transform (DCT), I.J.Cox's, PSNR, MSE

1. Introduction

In present years, the allocation of works of art, with images, music, video and textual documents, has become easier. Among the widespread and growing use of the Internet, digital forms of these media are easily accessible. This is clearly useful also it is easier to sell one's art of work. On the other hand, this same property threatens copyright protection. There are a number of methods for protecting possession. One of these is known as digital watermarking. The name "Digital Watermark" was given by Charles Osborne and Andrew Tirkel in December 1992.

Tirkel et. al.[3] established the first successful embedding and extraction of stenographic spread spectrum watermark 1993[1]. Digital watermarking is an efficient method to hide digital data in digital media such as video, audio, image etc to prevent its illicit doubling of data and to ensure copyright protection and security[2].In earlier days manufacturers used watermarking on their products to ensure authenticity. Nowadays, watermarks are mostly used in currencies, papers and postage stamps to prevent it from fraud and forgery. Several important issues exist in watermarking system. Watermarking is a basically four step procedure: Generation, Embedding, Distribution and Extraction. There are various algorithms for digital watermarking. The success of the watermarking method largely depends upon the selection of the watermark structure and inclusion strategy [4].The watermark embedding

technique is done on spatial domain and frequency domain [1,5,6].The watermarking can either be done in spatial domains where the intensity values are modified or in frequency domain where the image coefficients are modified. This paper also follows the transform domain watermarking. Some of the transform based watermarking techniques used are discrete cosine transform (DCT) [8]. and discrete wavelet transform (DWT) [9,10,14.13] However DWT is widely used in digital image watermarking just because of its multi resolution characteristics & spatial localization which are most equivalent to the practical models of human visual system. While DCT has a property of concentrating the useful information data of the image in just few coefficients. Furthermore while using DCT for watermarking; it compresses the image and DWT gives the scalability. The idea of using two transformations is based on the fact that

joint transformation could overcome the limitations of each other, resulting in efficient watermarking. After transformation function in a natural image, low frequency contains the energy of each and every block. if the watermark is embedded in low frequency it makes it perceptible but if it is embedded in to higher frequency then it would not make it perceptible. This paper presents a proposed hybrid approach based on combination of two transforms: DWT and DCT [7,12,15]. Here comparative results for three level of DWT for proposed hybrid approach and I.J.Cox's algorithm. Discrete wavelet transformation has some useful characteristics like spreading of frequencies, spatial localization and the most important multi resolution characteristic which are similar to human visual system (HVS).DCT based watermarking is used for compression on the other hand DWT based watermarking is used for scalability. We need both these quality in our research work, so combined watermarking technique is proposed.

The quality of digital watermarking can calculate with two different parameters: robustness and imperceptibility. Imperceptibility is measured by PSNR of host image and embedded image in dB. High PSNR is preferred as it means to hide the marked image efficiently. This paper organized as Section II covers the related works based on digital watermarking. Section III describe proposed algorithm. Section IV defines Experimental result and sections V describes conclude the paper.

2. Related Work

Digital watermarking is an important field of research and many researchers have suggested a large number of algorithms and compared. The main force on all such algorithms is to hide secrete information (watermark) in host signal in such a way that it provides superior exchange among invisibility and robustness against different attacks. This section presents several types of digital watermarking techniques found in the academic journalism. We do not offer a complete review of the area, but provide an overview of established approaches.

Schyndel, Tirkel, and Osborne [3] generated a watermark using an m-sequence producer. The watermark was either embedded or added to the least significant bit of the original image to construct the watermarked image. The watermark was extract from a suspected image by taking the least significant bits at the suitable position.. Schyndel et al. show that the ensuing image enclosed an undetectable watermark with simple removal actions. The watermark, however, was not robust to additive noise.

In 1997, Cox et al. [1] used First DCT based spread spectrum communication for multimedia watermarking. These methods has become very well-known and have been used by a lot of researchers. In this method, a set of independent and identically distributed Gaussian random sequences are embedded in the large amount perceptually significant frequencies of an image. As in spread spectrum communication the signal power in any occurrence is invisible if the narrow band signal is transmitted over broader bandwidth. That will cause a watermark to extend over all frequencies so that energy in any single frequency is very small. The Cox method is an unfinished method. So, it requires the original image in the extraction process.

Vidyasagar M. Potdar, Song Han, Elizabeth Chang show the survey of latest techniques that are employed in watermarking images is finished [4]. This paper we nearby a comprehensive survey of existing and newly proposed steganographic and watermarking technique. We categorize the technique based on different domains in which data is embedded. This paper lists some advantages of DWT over DCT. It also some disadvantages of DWT such as computational complexity.

Rajesh Kannan Megalingam et al [12] discussed about a novel robust method for digital watermarking in spatial domain. The technique deals with an image in the spatial domain which is watermarked at different strength subsections. This paper evaluation of the estimated novel spatial domain process with frequency domain method. The authors implemented a frequency domain DCT/IDCT based digital watermarking. They also compare the PSNR that can be obtained using the proposed spatial domain watermarking in the DCT/IDCT based watermarking.

Mohmmad Abdullatif *et al*. [5] reviewed the latest research work done on digital image watermarking. It presented the fundamental representation of digital image watermarking for embedding and detection. They discussed the main requirements, application and properties of Digital image watermarking. They also reviews some of the techniques and algorithm used in image watermarking and digital image watermarking attacks are discussed.

Urvi H panchal and Rohit Srivastava [7] present a comprehensive survey on digital watermarking techniques in different domain and their requirements. In this paper shows the survey and classified the different techniques with their requirements, benefits and limitations. Author has been concluded that to minimize distortions and to increase capacity, techniques in frequency domain must be combined with other techniques which have high capacity and strong robustness against different types of attack.

Nikita Kashyap and G. R. SINHA [15] show the 3 level discrete wavelet transform has been implemented. This technique can embed the imperceptible watermark into significant features of the image using alpha blending technique. In this paper implemented a strong image watermarking method for the copyright protection based on 3- level discrete wavelet transform (DWT). In this procedure a multi-bit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. The proposed method is compared with the 1-level and 2-level DWT based image watermarking methods by using arithmetical parameters such as peak signal to noise ratio (PSNR) and mean square error (MSE).

Gu Tianming and Wang Yanjie [9] show the digital watermarking algorithm based on the DWT coefficients. This algorithm does not modify some information of the novel image, but combines the information of low frequency DWT coefficients and the watermark image. In this paper show that the proposed algorithm is robust and secure against a wide range of image processing operation.

3. Proposed Algorithm & Flow chart

Algorithm for Proposed Hybrid Approach (DCT+DWT)

Input Image: $I_{C,}$ w_{mc} = Cover / watermark image
Output Image: w_di = Watermarked image
$wf_{\mathcal{H}}$ = Wavelet filter Haar
$\mathcal{H}$ = Haar
l,h =Low and High Frequency content respectively
ll,lh,hl,hh = Level of dwt
$dw_{2,}$ Idw_2 = Single level discrete 2D wavelet /inverse transform
$n_{a,}$ c_a , r_a , = noise attack, cropping attack, resize attack
r_{io} = recover image.

START:

$[f1, f2] = wf_{\mathcal{H}}(\mathcal{H})$
$[ll,lh,hl,hh] = dw_2(I_C, \mathcal{H})$
$[ll1,lh1,hl1,hh1] = dw_2(ll, \mathcal{H})$
$[ll2,lh2,hl2,hh2] = dw_2(ll1, \mathcal{H})$
$[wf1,wf2] = wf_{\mathcal{H}}(\mathcal{H})$
$[llm,lhm,hlm,hhm] = dw_2(w_{mc},\mathcal{H})$
$[llm1,lhm1,hlm1,hhm1] = dw_2(llm,\mathcal{H})$
$[llm2,lhm2,hlm2,hhm2] = dw_2(llm1,\mathcal{H})$
$w_di = ll2 + (0.1 * lm2)$
$w_di\ 1 = Idw_2(w_di, lh2, hl2, hh2, \mathcal{H})$
$w_di\ 2 = Idw_2(w_di\ 1, lh1, hl1, hh1, \mathcal{H})$
$w_di\ 3 = Idw_2(w_di\ 2, lh,hl,hh, \mathcal{H})$
$c_{a,}n_{ao}$,r_{ao} = c_a , $n_{a,}$ r_a $(w_di\ 3)$
$[k,l,m,n] = dw_2(w_di\ 3, \mathcal{H})$
$[kk, ll, mm, nn] = dw_2(k, \mathcal{H})$
$[kkk,lll,mmm,nnn] = dw_2(kk, \mathcal{H})$
$r_{io} = (kkk - ll2)$
End

Figure 1: Algorithm

3.1 Embedding Watermark

In this section how the watermark is embedded to the cover image as well as watermark extraction process is explained. The flow chart of proposed hybrid approach for embedding watermark to the cover image is shown in figure 1. Following steps are required for the embedding watermark process. Single level DWT transform is applied to the cover image in the initial stage of this process. The cover image is decaying to its four non-overlapping multi resolution coefficients which can be described (1).

$$W_{LL}^{k} = \sum_{s=0}^{N-1}\sum_{t=0}^{N-1} p(s)p(t)W_{LL}^{k-1}(2*u-s)(2*v-t)$$

$$W_{LH}^{k} = \sum_{s=0}^{N-1}\sum_{t=0}^{N-1} p(s)p(t)W_{LL}^{k-1}(2*u-s)(2*v-t)$$

$$W_{HL}^{k} = \sum_{s=0}^{N-1}\sum_{t=0}^{N-1} p(s)p(t)W_{LL}^{k-1}(2*u-s)(2*v-t)$$

$$W_{HH}^{k} = \sum_{s=0}^{N-1}\sum_{t=0}^{N-1} p(s)p(t)W_{LL}^{k-1}(2*u-s)(2*v-t) \quad \} \quad 1$$

Where k =2-D DWT Level, Here k=1
p(n) = Impulse response of low pass filter h(n) = Impulse response of high pass filter W(u,v) =W^0_{LL} = Reference or Original Image

Select W_{LL} coefficient for watermark embedding process.
Divide the W_{LL} in to 4×4 blocks: Starting from left to right and from the top to bottom, divide the W_{LL} set in to 4 × 4 as show in figure 3.A step of wavelet transform decomposes an image into four parts: LL, LH, HL and HH as in figure 3.
A step of wavelet transform decomposes an image into four parts: LL is low frequency coefficient, LH is high frequency coefficient horizontally, HL is high frequency coefficient vertical, and HH is high frequency coefficient diagonally. Watermark should be embedded in low frequency coefficients.

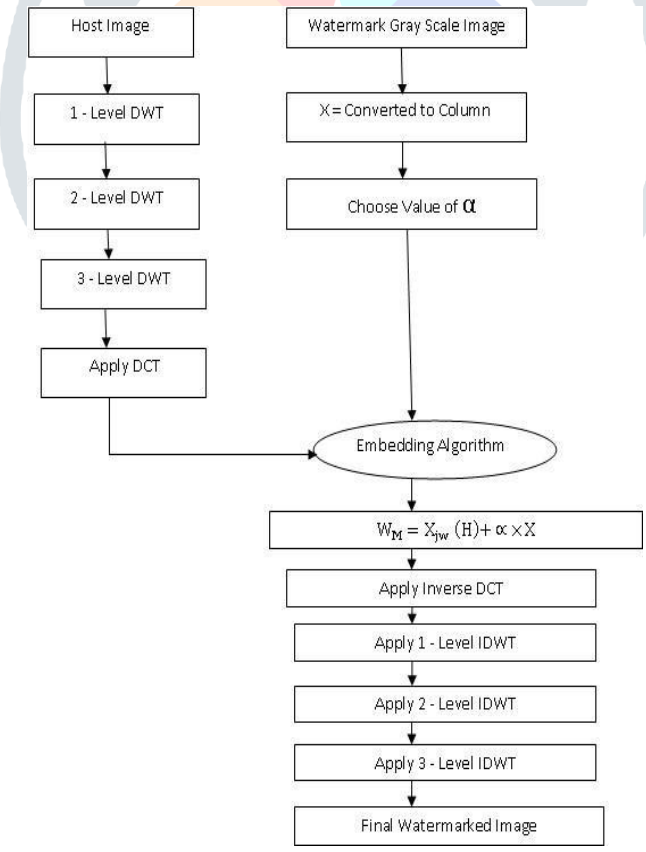

Figure 2: Embedding watermark

After 1st level decomposition size of the original image is reduced by factor 2 so after 3rd level the size of the image in which we hide the watermark will be of 256 × 256.
Discrete Cosine Transform of selected block: After Diving W_{LL} set in to 4 × 4 block, Apply DCT to each block.2D- DCT of the matrix can be calculated from the formula expressed by (2).

$$F(u,v) = \sum_{s=0}^{N-1} \sum_{s=0}^{N-1} p(s,t,u,v) \quad (2)$$

Where the kernel is given by the mathematical expressed in (3).

$$p(s,t,u,v) = a(u)a(v)cos\left[\frac{(2x+1)u\pi}{2N}\right]cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (3)$$

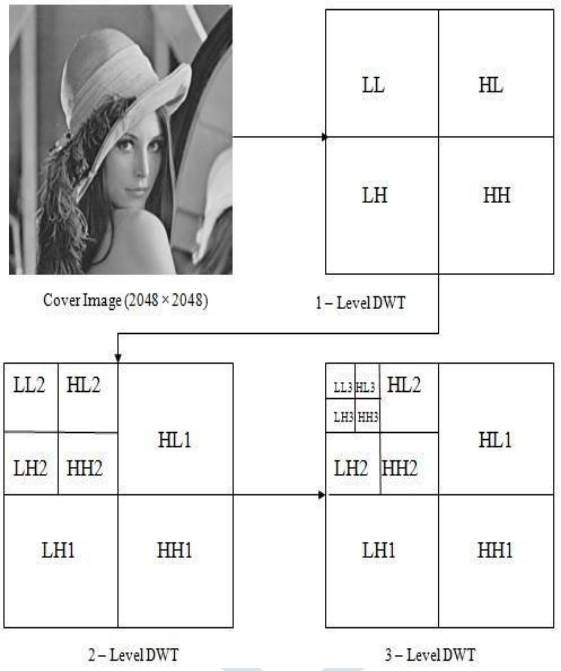

Figure 3: Flow of DWT Level Process

The embedded the watermark bits can apply in lower DCT band. The value of DCT stored in Zig Zag Manner as depict in figure 4.

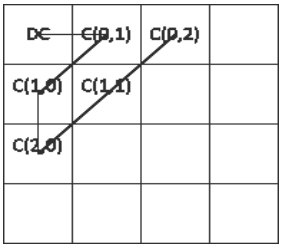

Figure 4: Position of DC low frequency component in DCT block

The embedding 4 × 4 DCT expressed in (4).

$W_M = X_{jw}(H) + \propto \times X$ (4)

Where,
W_M = Watermarked image
X_{jw} = Discrete Cosine Transformation = Scaling Factor X = watermark image converted into column vector
H = Host or cover image
Inverse DCT and inverse DWT are execute at the end of embedding stage. The outcome will be complete watermarked image.

3.2 Extraction Watermark

In figure 5 the proposed extraction watermark block diagram is shown. To extract the watermark from the watermarked image following steps are required.

DWT Transform: Apply 3- level DWT transformation to the watermarked image to decompose it in to four multiresolution coefficient sets. Consider W_{LL} coefficient set.

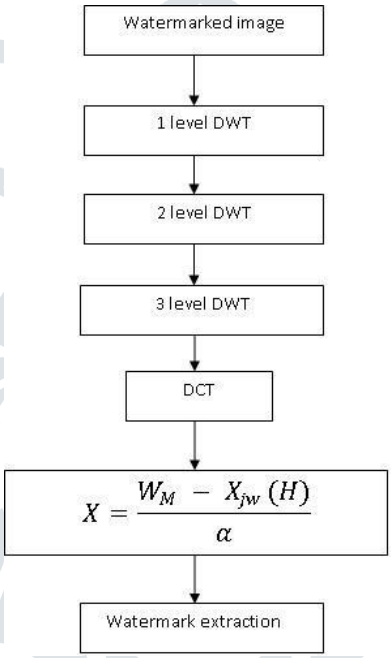

Figure 5: Extraction of watermark

W_{LL} is dividing by 4 × 4 blocks. The 4 × 4 block is Scanning from upper to lower and left to right. Then DCT is applied to each block in the chosen coefficient set.
Then watermark is computed from the Calculate by (5).

$$X = \frac{W_M - X_{jw}(H)}{\alpha} \quad (5)$$

4. Performance Analysis

We have taken standard image Lena.jpg as cover image whose dimensions is 2048 × 2048 which is shown in fig.6(a).256 × 256 watermark is used as shown in figure 6(b).

Figure 6: (a) Original Cover image: Lena.jpg (2048 × 2048)

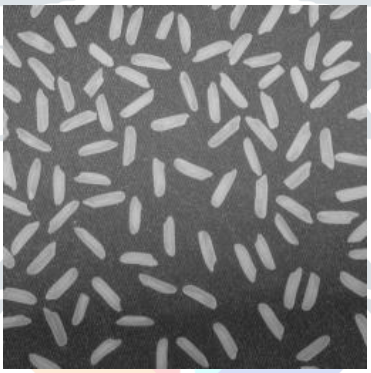

Figure 6: (b) original watermark image (256 × 256)

4.1. Imperceptibility

Imperceptibility means the observed quality of the cover image should not be distorted by the presence of the watermark. The peak signal to noise ratio is used to measure the quality of the watermarked image. The PSNR [17,18,19] is used to calculate the similarity between the original image and watermarked image which can be represented in term mathematically expressed by (6).

$$PSNR = 10\ log_{10}\ \frac{255^2}{MSE} \qquad (6)$$

4.2. MSE

Mean squared error (MSE) is defined as the average squared difference between a reference image and a distorted image in (7).

$$MSE = \frac{\sum_{i=0}^{N-1}\ \sum_{j=0}^{N-1}\ \left[x(i,j) - X_{new(i,j)}\right]^2}{N \times N} \qquad (7)$$

Robustness is the measure of the protection of the watermark against various watermark attacks [16] like cropping, resize, & noise. The robustness of a watermarked method evaluating the similarity of the extracted message to the original one.

A. Noise Attacking

Figure 7: Gaussian noise attack to the original cover image. (a) The name of cover image is lena.jpg whose size is 2048 × 2048. (b) Original watermark image whose size is 256 ×256. (c) Watermarked image for proposed hybrid approach (d) apply Gaussian noise for watermarked image. (e) Extract mark image with Noise attack for proposed hybrid approach.

Table 1: Gaussian noise attack simulation result between proposed hybrid approach and I.J.Cox's algorithm

Types of Noise	Proposed Hybrid approach		I.J.Cox's algorithm	
Gaussian	MSE	PSNR	MSE	PSNR
	0.10	22.44	0.25	13.47

Table 1 shows the PSNR for Proposed hybrid approach is 22.44 dB and MSE is 0.10 with Noise attack, whereas the I.J.Cox's algorithm gives the PSNR 13.47dB and MSE is 0.25 with noise attack for 3 levels DWT.

B. Cropping Attack

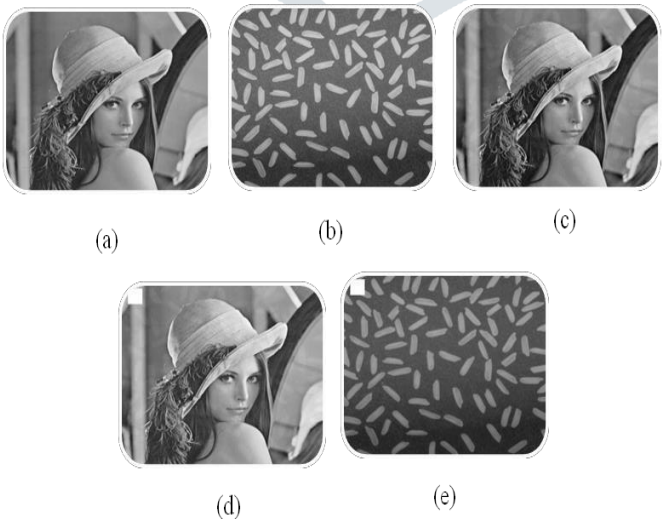

Figure 8: Cropping attack to the original cover image. (a) Original cover image is lena.jpg. (b) Original watermark image.(c) Watermarked image for proposed hybrid approach (d) apply Cropping attack for watermarked image. (e) Extract mark image with cropping attack for proposed hybrid approach.

Table 2: Cropping attack simulation result between proposed hybrid approach and I.J.Cox's algorithm

Cropping Attack	Proposed Hybrid approach		I.J.Cox's algorithm	
	MSE	PSNR	MSE	PSNR
	0.08	25.20	0.37	9.775

The simulation results are given in table II. Table II shows the PSNR for Proposed hybrid approach is 25.20 dB and MSE is 0.08 dB with cropping attack, whereas the I.J.Cox's algorithm gives the PSNR is 9.775 dB and MSE is 0.37 dB with cropping attack for 3 levels DWT.

C. Resize attack

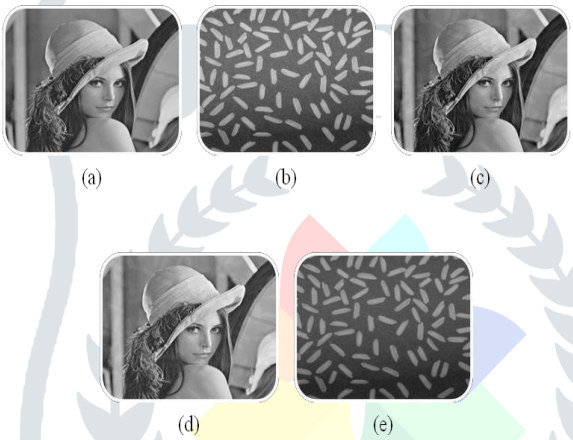

Figure 9: Resize attack to the original cover image. (a) Original cover image is lena.jpg. (b) Original watermark image. (c) Watermarked image for proposed hybrid approach (d) apply Resize attack for watermarked image.1024×1024 (e) Extract mark image with Resize attack for proposed hybrid approach

Table 3: Resize attack simulation result between proposed hybrid approach and I.J.Cox's algorithm

Resize Attack	Proposed Hybrid approach		I.J.Cox's algorithm	
	MSE	PSNR	MSE	PSNR
	0.082	24.98	0.245	14.06

The simulation results are given in the table III for proposed hybrid approach and for I.J.Cox's algorithm. This table shows the PSNR for proposed hybrid approach as 24.98 dB and MSE as 0.082 dB with resize attack, whereas the I.J.Cox's algorithm gives the PSNR as 14.06 dB and MSE as 0.245 dB with resize attack for 3 levels DWT.

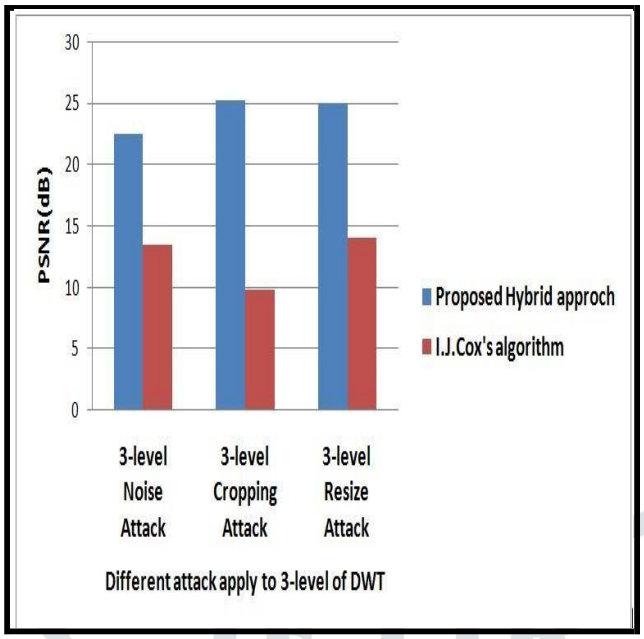

Figure 10: PSNR value at 3 level of DWT for proposed hybrid approach and I.J.Cox's algorithm.

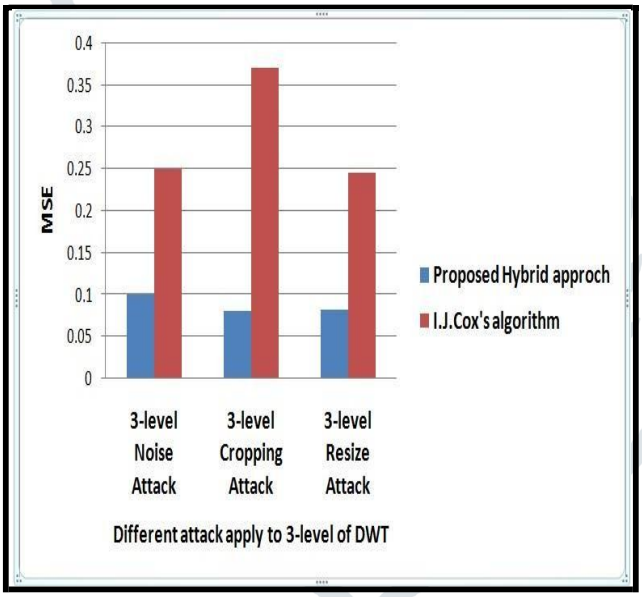

Figure 11: MSE value at 3 level of proposed hybrid approach and I.J.Cox's algorithm.

The Comparative results are summarized in figure 10 and figure 11. It can be said that PSNR value varies largely for lower level and as the level decreases the collision of the mark image in watermarked image increases for both algorithm. But PSNR degrades less for proposed hybrid approach than I.J.Cox's algorithm. The proposed hybrid approach gives 24.98 dB and 25.20dB better pick signal to noise ratio (PSNR) compare to I.J.Cox's algorithm.

5. Conclusion

In this paper DWT-DCT based hybrid approach is used to add watermark image in DWT sub band of original image. In addition to that proposed algorithm is compare with traditional algorithm such as I. J. Cox's for similar environment. In this approach evaluated for 3 levels of DWT. Results of experiment show that watermark image has higher imperceptibility in compare to I. J. Cox's algorithm. Furthermore higher PSNR value supports for better quality of image. Robustness is also used at results to evaluate the performance of image. Results of cropping and noise attack prove that proposed algorithm offer better robustness.

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