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Real - Time Hybrid Contourlet, DCT & SVD Algorithms for Digital Image watermarking, Geometric Applications and Noise Addition

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ABSTRACT: Preserving the security and authenticity of medical images, due to ever-increasing demand in telemedicine hence distribution of medical images between hospitals. To provide imperceptibility and security for patient information due to the usage of EHR. To validate the proposed algorithm against various geometric attacks such as cropping and noise. To propose an algorithm of medical image watermarking provided with embedding and extraction of the watermark which is basically patient information. The high value of PSNR represent that provide good visualization (The image quality is not degraded), which is high enough to visualized the image data and it shows that propose algorithm provide imperceptibility and security of patient information. For Improve performance values of MSE & PSNR to all Embedded images for Robust and NCC & Similarity to all Extraction images for Imperceptible. In this, combination of powerful Three Transforms (CT, DCT, and SVD) for a Hybrid Image Watermarking as a proposed method instead of combination of two Transforms and single Transform, compare the performance evolution with DWT, DCT, and SVD.

KEYWORDS: Contourlet Transform (CT), Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD), and Electronic Health Record (EHR).

I. INTRODUCTION

Digital watermarking is an emerging field in computer science, Digital signal processing and Communication. It is intended by its developers as the solution to the problems of data copyright, content protection and ownership proof. Digital watermarking is technically the process of inserting pieces of information into digital data (audio, video, or still images), which can be detected or extracted later to make an assertion about the data. Recently, several algorithms have used image representations where most information is concentrated in small number of coefficients. Hybrid watermarking method is more potential than Single watermarking method. Single watermarking methods are robust or semi-fragile with limited and bounded. Hybrid watermarking method combines a robust watermark and a semi-fragile watermark.

II. LITERATURE SURVEY

Watermarking can be implemented either in the time or frequency (transform) domain. Transform domain watermarking techniques apply some invertible transforms to the host image before embedding the watermark. Then the coefficients are modified to embed the watermark and finally the inverse transform is applied to obtain the watermarked image. The watermark embedded in the transform domain is irregularly distributed over the area and make more difficult for an attacker to extract or modify the watermark. The transforms commonly used for watermarking are hybrid Image Watermarking Methods are combining two or three transforms like DWT - DCT, DCT - SVD, DWT - SVD, DWT- DCT-SVD, Contourlet – DCT, and Contourlet – SVD ..etc. In this paper hybrid watermarking method combines three transforms such as Contourlet, DCT, and SVD are imperceptible and robust.

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2.1 Contourlet Transform (CT)

The Contourlet Transform is a geometrical transform, can efficiently detect image edges in all directions. It is widely used in various signal processing applications, including image watermarking. CT consists of two major parts, the Laplacian Pyramid (LP) and Directional Filter Bank (DFB) as shown in FIGURE1. The LP is constructed from a pair of filters known as Analysis and Synthesis filters as shown in FIGURE2(a) and (b) respectively. LP decomposition at each level generates a low frequency subband image. The LP decomposes the image into octave radial-like frequency bands to detect the point discontinuities and differences between the original and the prediction, results in a band-pass image. These band pass images are fed into the DFB. CT used here is a combination of a Pyramidal and a Directional Filter Bank known as Pyramidal Directional Filter Bank (PDFB).

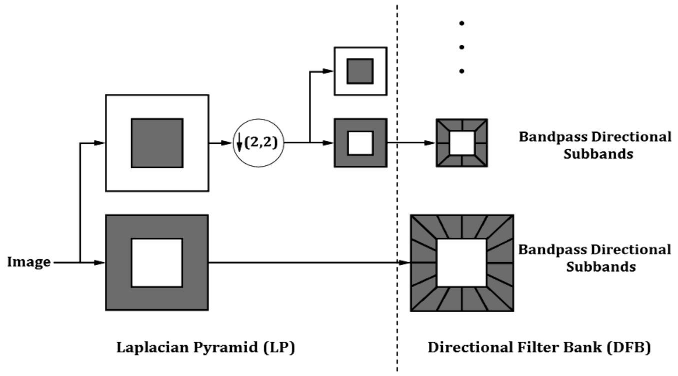
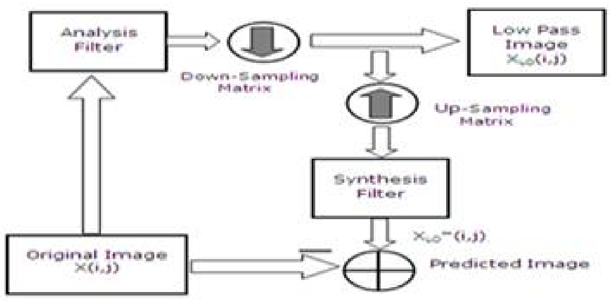
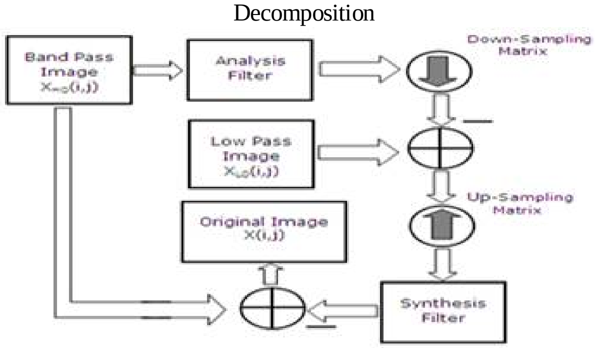


FIGURE 1: The Contourlet Transform.



Decomposition



Reconstruction

FIGURE 2: Single Level Pyramidal Decomposition and Reconstruction.

In CT, HF subband is created by subtracting the G-filtered LF subband from the original image. In this case the HF coefficients affect the LF coefficients, because of this characteristic of LP, the Contourlet Transform is evidently different from DWT. In DWT, HF subband is created by filtering the original image with high-pass filter. These characteristics of CT help in identifying image areas where the watermark can easily embedded. The dual set of ladder

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based filter bank structures help in obtaining sparse expansion of typical images having smooth contours. The point discontinuities are taken care of by the Pyramidal filter bank based on Laplacian, while the linking of these to the liner structures is achieved via DFB. By considering these advantages of CT is used as one of the transform out of three transforms.

2.2 Discrete Cosine Transform (DCT)

A DCT represents the input data points in the form of a sum of cosine functions that are oscillating at different frequencies and magnitudes. There are mainly two types of DCT: one dimensional 1-D DCT and 2-D DCT. Since an image is represented as a two dimensional matrix, for this research work, high compaction 2-D DCT is considered.

The Two-Dimensional DCT: The objective of this document is to study the efficacy of DCT on images. This necessitates the extension of ideas presented in the last section to a two-dimensional space. The 2-D DCT is a direct extension of the 1-D case and is given by

$$C(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for $u,v = 0,1,2,\ldots,N-1$ and $\alpha(u)$ and $\alpha(v)$ are defined . The inverse transform is defined as

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)C(u,v)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for $x,y = 0,1,2,\ldots,N-1$. The 2-D basis functions can be generated by multiplying the horizontally oriented 1-D basis functions (shown in Figure 3) with vertically oriented set of the same functions. The basis functions for $N = 8$ are shown in. Again, it can be noted that the basis functions exhibit a progressive increase in frequency both in the vertical and horizontal direction. The top left basis function of results from multiplication of the DC component with its transpose. Hence, this function assumes a constant value and is referred to as the DC coefficient.

2.3 Singular Value Decomposition (SVD)

Every real matrix A can be decomposed into a product of 3 matrices $\boldsymbol{A} = \boldsymbol{U}\mathrm{D}\boldsymbol{V}^T$, where U and V are orthogonal matrices. The diagonal entries of D are called the singular values of A, the columns of U are called the left singular vectors of A, and the columns of V are called the right singular vectors of A. This decomposition is known as the *Singular Value Decomposition (SVD)* of A, and can be written as

$$A=\lambda_1 U_1 V^T_1 + \lambda_2 U_2 V^T_2 + \ldots + \lambda_r U_r V^T_r$$

where r is the rank of matrix A.

It is important to note that each singular value specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image . In SVD-based watermarking, a common approach is to apply SVD to the whole cover image, and modify all the singular values to embed the watermark data. An important property of this technique is that the largest of the modified singular values change very little for most types of attacks. This property has been explored and extended in this paper as the singular values of watermark are embedded in those of cover object. DSR is applied on singular values as they can enhance the distribution of luminance in each layer. Singular Value Decomposition is a kind of orthogonal transforms used for matrix diagonalization. An image can be viewed as a non-negative real matrix. Let A be an image, and its size be $M\times N$. The SVD of A can be described as follows:

$$A = U\,D\,V^T$$

$$A = [u1 \quad u2 \quad \ldots \quad \ldots \quad uN]\begin{bmatrix} \lambda 1 & & & \\ & \ddots & & \\ & & \ddots & \\ & & & \lambda R \\ & & & & 0 \end{bmatrix}\begin{bmatrix} v1 \\ v2 \\ \vdots \\ \vdots \\ vN \end{bmatrix}$$

where U and V are two $N\times N$ unitary orthogonal matrices that specify the geometry details of the cover image, and D is a $N\times N$ diagonal matrix. The elements of D are nonnegative values in a descending order.

we know that an image can be interpreted as a summation of N eigenimage. The singular value λi indicates the energy intensity in its corresponding eigen image.

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III. IMPLEMENTATION OF HYBRID DIGITAL IMAGE WATERMARKING

Digital watermark is an embedded (hidden) marker in digital multimedia data by watermarking method, the marker is generally unobservable, which can be extracted by special detector. The basic idea for digital watermark is to use human's insensitive perceptual organs and redundancy in digital signal and embed secret information in digital products, such as image, audio frequency and video frequency in order to easily protect its copyright, and in addition, the embedded information survives after attacks so as to perform copyright authentication and protection. Digital watermark doesn't change the basic characteristic and value of the products. Watermarking system is consists of two parts, 1) watermark creation and embedding 2) watermark extraction. The following steps are used to implement the watermarking:

- Watermark Embedding process
- Watermark Extraction process
- Performance Evaluation

3.1. Watermark Embedding Process

Before embedding the watermark in to the original image it will be transformed into coefficients by applying CT, DCT, and SVD. Original image also transformed into coefficients and then both are applied to the embedding algorithm which is known as watermarked image, now inverse transforms are applied to obtain the spatial domain watermarked image as shown in FIGURE 3. Selection of the coefficients to which a watermark is embedded is based on a predefined threshold and the watermark is cast into coefficients whose absolute values are larger than the threshold.

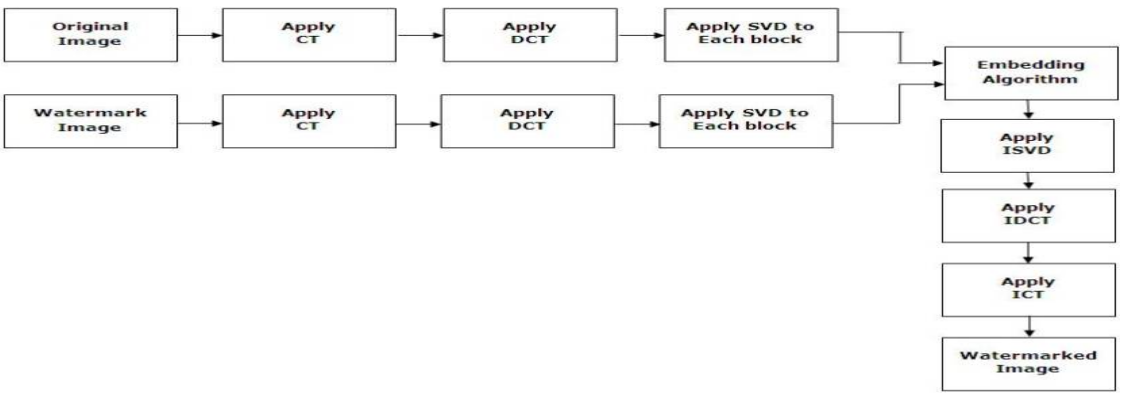

FIGURE 3: Watermark embedding process.

3.2. Watermark Embedding Algorithm

Step 1: Two level contourlet is applied to image and image is divided into nine sub-bands.

Step 2: Sub-bands 2 and 3 of second level are selected for watermark insertion.

Step 3: Apply DCT on each block.

Step 4: Selected sub-bands are divided into $N \times N$ blocks and the DCT of each block is computed. These blocks are denoted as $block_i$, $i = 1, 2, \ldots M$ and $M \leq N_W$, which N_W is the number of watermark bits. If dimensions of watermark logo are denoted as L_W and H_W then $N_W = L_W \times H_W$, is shown that the combination of CT and DCT can crease the quality of watermarked image, is shown that the combination of CT and DCT can increase the robustness of algorithm against both geometric and non-geometric attacks by comparing NC values.

Step 5: If each element of watermark is denoted as W_j, $j = 1, 2, \ldots, N_W$, Two uncorrelated pseudo-random sequences with zero mean are generated, one of them is used for embedding $W_j = 0$ and the other one for $W_j = 1$, which denoted as $PN0$ and $PN1$ respectively.

Step 6: Apply SVD on all blocks: $O_i = U_{oi} \times S_{oi} \times V_{oi}^T$

Step 7: Divide the watermark image into non-overlapping 16×16 blocks.

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Step 8: Apply SVD on all blocks say w, neural network having input O_i and output th, and normalization on each block of w using threshold th.

Step 9: Modify the singular values of O_i : $\bar{S} = S_{oi} + \alpha W$, where α is the watermark strength

Step 10: To embed watermark into the produced blocks, the middle frequency coefficients of each block are selected. This selection is a tradeoff between robustness and imperceptibility of watermark.

Step 11: Perform inverse SVD to get all the modified blocks

Step 12: Perform inverse DCT on each modified block and then merge all the blocks to get the Watermarked image.

Step 13: By Applying inverse DCT (IDCT) to each block after its mid-band coefficients have been modified, the CT of watermarked image is generated.

Step 14: Finally the watermarked image can be produced by using inverse CT

Step 15: Apply Inverse DCT and Inverse CT for reconstruction of watermarked image.

3.3. Watermark Extraction Process

Watermark extraction process deals with the extraction of the watermark in the absence of the original image as shown in FIGURE 4. The aim of the watermark extraction algorithm is to obtain the reliable an estimate of the original watermark from the watermarked image. The extraction process is inverse of the watermark embedding process. One of the advantages of watermarking is its ability to spread the watermark all over the image. If a part of the image is cropped, it may still contain parts of the watermark. These parts of watermark may be extracted by certain mechanism even if the image has been further scaled or rotated.

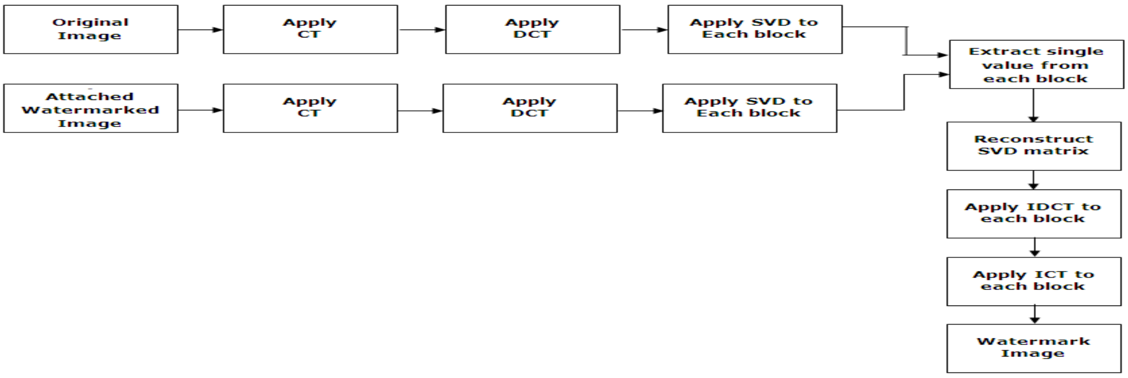

FIGURE 4: Watermark Extraction process.

3.4. Watermark Extraction Algorithm

The process of extracting the digital watermark is comparatively simpler and tedious process and which is explained as below:

Step 1: Two level Contourlet is applied to the watermarked image and to the original image is divided into nine sub-bands.

Step 2: Selected sub-bands are divided into $N \times N$ blocks.

Step 3: Take the watermarked image and partition the image into 16X16 blocks.

Step 4: Apply DCT on each block. Two pseudo-random sequences PN_0 and PN_1 are regenerated by using same seeds as embedding stage. For each block in the selected sub-band, correlations between mid-band coefficients with PN_0 and PN_1 are calculated. If the correlation with the PN_0 is higher than the correlation with PN_1, the watermark bit will be considered as 0, otherwise it will be consideredas1.

Step 5: Apply SVD on each block and Extract the singular values of the watermark

Step 6: To extracting the watermark from the original image, the watermarked image is partitioned into non-overlapping 16 × 16 blocks. At first, SVD followed by DCT are applied on each block. Afterwards, the singular values of the watermark are extracted and inverse of SVD is performed to acquire the extracted watermark.

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Step 7: Perform inverse CT to get the extracted watermark and after watermark extraction, similarity between the original and extracted watermarks is computed.

3.5. Performance Evaluation

An important way of evaluating watermarking algorithms is to compare the amount of distortion introduced into a host image by watermarking algorithm. In order to measure the quality of the image at the output of the decoder, MSE and PSNR are used .

3.5.1 Mean Square Error (MSE)

The error is the amount by which the estimator differs from the quantity to be estimated. A lower value for MSE means lesser error.

$$Mean\ Square\ Error\ (MSE) = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y) - I'(x,y)]^2 \qquad (1)$$

M and N are the dimensions of the images.

3.5.2 Peak Signal to Noise Ratio (PSNR)

The PSNR represents the distortion caused by the watermarking depends on the MSE. This factor evaluates the imperceptibility of the digital watermarking.

$$SNR = 10\log_{10}\left\{\frac{\sum_{x=1}^{M}\sum_{y=1}^{N} I(x,y)^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-I'(x,y)]^2}\right\} \qquad (2)$$

$$PSNR = 20\log_{10}\left(\frac{255}{\sqrt{MSE}}\right) \qquad (3)$$

$I(x,y)$ is the Original image

$I'(x,y)$ Approximation version (Decompressed image)

3.5.3 Normalized Cross Correlation (NCC)

NCC is used to measure the correlation between the watermarked image and the original image. It is defined by the equation 4.

$$NCC = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-\overline{I(x,y)}]\left[I(x,y)-\overline{I'(x,y)}\right]}{\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-\overline{I(x,y)}]^2\sum_{x=1}^{M}\sum_{y=1}^{N}\left[I(x,y)-\overline{I'(x,y)}\right]^2}} \qquad (4)$$

$I(x,y)$ is the Original image; $\overline{I(x,y)}$ is the mean of the original image; $I'(x,y)$ represent the watermarked image, $\overline{I'(x,y)}$ is the mean of the original image having the range of 0 to 1.

3.5.4 Similarity

Similarity is used to find at what range both the original watermark and Extracted watermark are similar to each other defined by equation 5.

$$Similarity = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} W(x,y)\times W'(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N}[W'(x,y)]^2} \qquad (5)$$

Where $W(x,y)$ represent the original logo image, $W'(x,y)$ represent the extracted logo image Similarity is having the value in between the 0 to 1.

IV. ATTACKS ON WATERMARKED IMAGE

Common signal processing procedures such as geometric attacks such as addition of Gaussian noise and cropping is used for the analysis of the watermarked image. In addition, we perform further experiments to evaluate Common signal processing procedures such as geometric attacks such as addition of Gaussian noise and cropping is used for the analysis of the watermarked image. In addition, we perform further experiments to evaluate for the robustness against more commonly used image processing attacks such as geometric attacks such as addition of Gaussian noise and cropping. In this paper we proposed a novel use of the combining of transforms in watermarking digital images. Normalized cross correlation and similarity based method are used to evaluate the effectiveness of the proposed method. Our preliminary results show that the method is robust against some important image processing attacks as shown in Figures.

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Images used for watermarking

For the simulation results a 512x512 pixels image are used

Figure 5: Images used for the simulation**.**

Consider the Medical image of size 512x512 pixels as shown in Figure 5, In our program, the image is transformed through Hybrid transforms **-** CT, DCT, SVD via wrapping and randomly generate an M=262144 length watermark. As noted, the each parameter is set *scale* = [4, 5], strength parameter α =0.7.

Logo used as watermark

A 512x512 logo image with the written letters of VFST and each letter of size 170x170 as a watermark image as shown in Figure 6 is used for embed in to the edge of original image. at edges have high frequencies components compared with other locations.

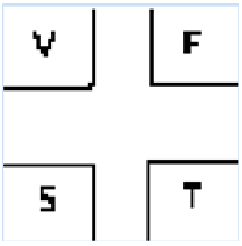

Figure 6: A 512 x 512 Logo image used as watermark for simulation process.

Watermarking: Implementation and evaluation of watermarked image

Watermarked Image Extracted watermark

Figure 7: Image, watermark that embed and extracted from without attacks

Figure 7 shows that the difference image is the absolute difference of the pixel intensities of the noisy image and the original image. The difference image gives the visual modifications of the coefficients. The difference extracted logo is the absolute difference of the pixel intensities of the extracted logo and the original logo. The difference logo image gives the visual modifications of the coefficients. The process can confirm that the recognition of the watermark in the

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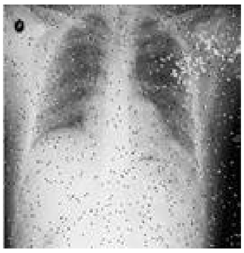
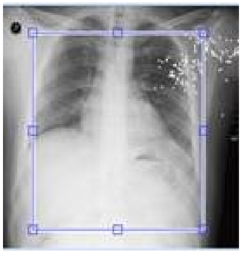
experimental images is giving satisfactory results. The extracted watermark image of size 512x512 pixels. For watermarking evaluation, calculating MSE and PSNR depend upon strength parameter.

Attacks on watermarked image

Common signal processing procedures such as against various geometric attacks such as addition of Gaussian noise and cropping is used for the analysis of the watermarked image. In addition, we perform further experiments to evaluate for the robustness against more commonly used image processing against various geometric attacks such as addition of Gaussian noise and cropping. We can say that even the image pass through different attacks such as Filtering, the logo is get extracted perfectly.


Noisy image


Selection of Cropping


Cropped Image

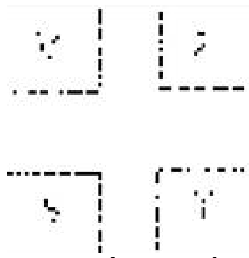

Noisy Extracted watermark

Table 1: Performance evaluation of Simulation Results of Hybrid Digital Image Watermarking using DWT-DCT-SVD Vs CT-DCT-SVD

Transform Type		**HYBRID DWT-DCT-SVD**				**HYBRID CT-DCT-SVD**			
Image after/before attacks	**Dependable Parameters**	**Similarity**	**NCC**	**MSE**	**PSNR[dB]**	**Similarity**	**NCC**	**MSE**	**PSNR[dB]**
Watermarked Image	Strength Parameter (∞)=0.1	0.99513	0.99919	6.8247	39.79	0.99804	0.99998	0.11146	57.6596
Cropping	64*64 size	0.539	0.35439	100.1907	28.1225	0.55819	0.42361	96.874	28.2687
Gaussian Nois	Variance=0.01	0.86271	0.62837	109.1091	27.7522	0.85384	0.81453	4.1344	41.9666

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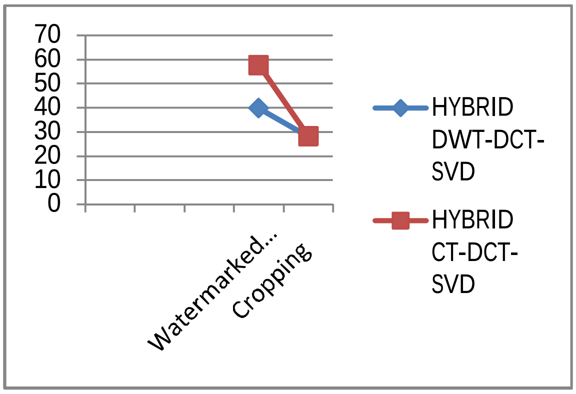
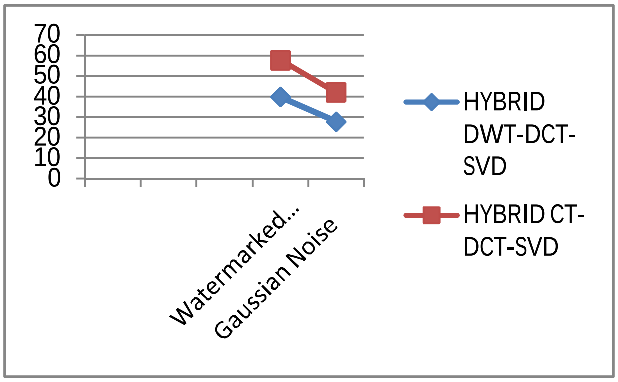
Comparison of PSNR for two hybrid watermarking methods – Adding Noise and cropping





V. CONCLUSION

From the simulation results it is observed that high quality image i.e. Watermarked image with high PSNR is obtained by embedding the watermark high level decomposition. With the increase in the density of variance of Gaussian noise the amount of noise induced in to the image is increased and these affected the quality of image and modify the watermark embedded coefficient of the image. With the increase in density/variance of the noise the PSNR values decreases and the robustness of the watermark is affected, in spite of huge noise addition the recovered watermark is still highly recognizable. The watermarking algorithm sustains the cropping attack; the watermark is highly recoverable even for the cropping block size of 256 x 256. We can say that even the image pass through different attacks such as Geometric, Adding noise the logo is get extracted perfectly. We can say that the embedding algorithm is robust. More over the logo is extracted if the location of embedded is known, so the embedding algorithm is secure. We can say that even the image pass through different attacks such as Geometric, Adding noise the logo get extracted perfectly..

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