An Improved Approach towards Image Watermarking Using Standard Watermarking Techniques

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***Abstract*— The key objective with this paper is to provide a better evaluation of some well-known Digital image watermarking techniques. The standard Watermarking techniques include DCT, DWT and Standard SVD which are accustomed to modify a Digital Image. This paper aims at the collaboration of DWT, CZT and modified SVD to create better results. It really helps to satisfy the robustness and imperceptibility characteristics of a watermarking algorithm. Thus, sole objective of this paper is to improve the visual quality of the watermarked image against common signal processing operations and attacks. Proper analysis of earlier work done on digital images has also been considered in order to obtain satisfactory results. The key focus with this paper is to enhance watermarking techniques using chirp z-transformation and modified SVD.**

***Index Terms*— Watermarking, Chirp z-transformation, DCT, DWT, Modified SVD, Arnold Transform.**

I. INTRODUCTION

Digital watermarking technique has been employed for the protection of digital images from unlawful copying and manipulation. It may be defined as the method of embedding data into a multimedia element such as an image, audio or a video clip[12]. In our proposed work combination of DWT with Chirp Z-Transform and modified SVD has been introduced to protect it from hackers.

The digital watermarking is most trusted technique for copyright protection which hides the copyright information in the digital data through certain algorithm. To trace illegal copies, a distinctive watermark is required based on the location or identity of the recipient in the multimedia network. The sort of information hidden is generally a signature to signify origin or ownership. Copyright control mechanism involves the application of Watermark, where an image owner seeks to avoid illegal copying of the image. Robust watermarks are great for copyright protection, because they stay intact with the image under various manipulations.

II. ARCHITECTURE OF IMAGE WATERMARKING

A digital watermarking system is divided into three distinct steps, embedding, attack and detection. First phase is embedding where an algorithm accepts the host and the data to be embedded, and produces a watermarked signal. The output of embedding the watermark is the watermarked image. Watermarking algorithms could be broadly classified into spatial domain and transform domain such as:-

- First is based on domain of watermark insertion for example, watermarks could be embedded in the pixel/spatial domain or perhaps a transform domain.
- Second is based on visibility of watermark(visible and invisible) and based on watermark detection and extraction which contain blind and non blind techniques.[4]

The spatial domain methods modify the initial image's pixel values directly. But it results in poor robustness against various. On the other hand, in the transform domain such as for instance, discrete cosine transform (DCT) wavelet transforms (WT), singular value decomposition (SVD) and Chirp Z-Transforms (CZT) are more advantageous. Basically, a set of requirements is evaluated for a watermarking scheme to be effective. These requirements could be categorized as imperceptibility, robustness and capacity etc.

A. Discrete Cosine Transform

DCT converts a sign from the spatial to the frequency domain using the cosine waveform. It divides the info energy in bands with low frequency. The DCT allows an image to be separated into different frequency bands, rendering it easier to embed watermark into the center frequency bands of the picture. FL is used to denote the most effective frequency facets of the block, while FH is employed to denote the larger frequency components. FM is chosen as the embedding region as to produce additional resistance to lossy compression techniques [3].

DCT based watermarking techniques are robust in comparison to spatial domain techniques. DCT domain watermarking could be classified into Global DCT watermarking and Block based DCT watermarking. The Discrete Cosine transform has been widely useful for source coding in context of JPEG and MPEG. DCT represents data with regards to frequency space. The major features of DCT include its high energy compaction properties and option of fast algorithms for the computation of transform. The power compaction property of the DCT results in transform coefficients with few coefficient values, thus

rendering it ideal for watermarking. Embedding rules in DCT domain tend to be more robust to JPEG/MPEG.

B. Discrete Wavelet Transform

DWT is actually employed in a wide selection of signal processing applications, such as like in audio and video compression and removal of noise in audio. Wavelets have their energy concentrated with time and are ideal for the analysis of transient time varying signal. To understand the fundamental notion of the DWT we focus about the same dimensional signal. A signal splits into two parts, usually high frequencies and low frequencies. This technique is continuing before signal has been entirely decomposed [3].

Wavelet transform uses wavelets as basis and is just a tool that cuts up data or functions or operation into different frequency components, and then studies each component with a solution matched to its scale. The initial image is decomposed by the lowpass (LP) and highpass (HP) filters accompanied by downsampling to begin rows and then of columns. Result of wavelet decomposition is approximation of original image and three detail signals (horizontal, vertical and diagonal)[6].

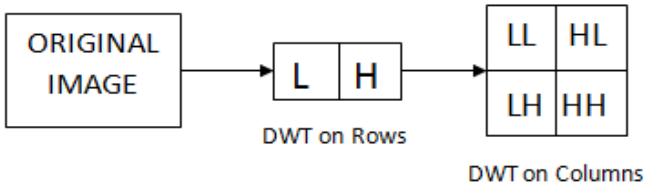


Figure 1. DWT Decomposition

DWT is preferred, because it provides both a simultaneous spatial localization and frequency spread of the watermark within the host image. The hierarchical property of the DWT splits one dimensional signal into two parts, usually high frequencies and low frequencies. This technique is continued before signal has been entirely decomposed.

C. Modified Singular Value Decomposition

SVD is a linear algebra technique mostly used to eradicate mathematical problems. SVD has the ability to efficiently represent the algebraic properties of an image. SVD techniques can be put on any kind of images. If it's a dull scale image the matrix values are believed as intensity values and it could be modified directly or changes could be achieved after transforming images into frequency domain [5] [11] [12].Let A be described as a general real (complex) matrix of order m×n. The singular value decomposition is its factorization [14]. Use of SVD in digital image processing has some advantages which are listed in these three points:

- Singular values an electronic digital image are less affected by any tiny perturbation put into an image, that is, SVs don't change fast.
- Singular values contain intrinsic algebraic image properties, where singular values match the brightness of the image and singular vectors reflect geometry characteristics of the image.
- The proposed work includes Modification of SVD using Arnold Transformation matrix such that it becomes meaningless for the hackers or crackers to obtain any information from the Watermarked Image.

D. Chirp Z-Transform

CZT is definitely an algorithm for evaluating the z-transform of a signal. Z-domain transfer functions may be factored into polynomials with poles and zeros as its roots, where poles model the peak energy concentration of the frequency spectrum and zeros model the troughs of the frequency spectrum. The CZT helps in approximating the transfer function of a method giving a more accurate picture of zeros and poles of this, resulting to a sharper function at an effectively reduced bandwidth.. The three main applications of chirp z-transform are the following:

- Enhancement of poles
- High res, narrow-band frequency analysis
- Time interpolation or sample rate changing
- Imperceptible and a powerful watermarked image obtained, since the spectrum is sharpened and the frequency resolution is appreciably improved.

E. Arnold Transformation

A digital image can be considered as a two unit function f(x, y) in the plane Z. It can be represented as Z = f(x, y) where x, y $\in \{0, 1, 2, 3, \ldots N\text{-}1\}$ and N represents order of digital image. The image matrix can be changed into a new matrix by the Arnold transform which results in a scrambled version to offer security. It is a mapping function which changes a point (x, y) to another point (x^1, y^1) with the following equation [14].

$$\begin{bmatrix} x^1 \\ y^1 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \bmod N$$

III. RELATED WORK

Two-Level DWT decomposes an input Image into different frequency components by the lowpass (LP) and highpass (HP) filters. Result of wavelet decomposition is approximation of original image and three detail signals (horizontal, vertical and diagonal)[6]. The most popular transforms where the frequency domain watermarking algorithms work are Discrete Fourier Transform (FT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). DFT decompose an image into sine and cosine form. DFT gives output in complex value and it requires more frequency rate. Thus, DFT is not used now a days[3]. Discrete Cosine Transform (DCT) converts real data into real spectrum and therefore avoids the problem of redundancy[4]. Image scrambling refers to transformation of the image, which rearranges the spatial position of the pixels according to some rules, and makes image distortion for the goal of security Common ways of scrambling include Arnold transform[2]. The key properties of SVD from the viewpoint of image processing applications includes the singular values of a graphic have very good stability, i.e., whenever a small perturbation is added to a graphic, its singular values don't

change significantly[7]. Chirp-Z-Transformation is an algorithm for evaluating the z-transform of a signal. Z-domain transfer functions can be factored into polynomials with poles and zeros as its roots, where poles model the peak energy concentration of the frequency spectrum and zeros model the troughs of the frequency spectrum.[13]

IV. Problem Evaluation

The problem can be evaluated in two major parts thereby specifying the existing problems found in the current research methodologies and providing appropriate solution to it.

A. Existing Problems

The Problems found in the existing work are explained below:-

- The effect of the multiple attacks on a given watermarked image has been neglected by the most of the existing researchers.
- Most of the researchers have used Standard SVD, the
- use of improved or modified SVD has been ignored in the most of existing research.
- The use of the other watermark scrambling has also been neglected in the majority of the existing research.

B. Problem Definition

Hybridization of DWT, CZT and modified SVD is likely to be proposed. This algorithm combines the advantages of the three transforms, therefore have more robust results. The algorithm can help satisfy the robustness and imperceptibility characteristics of a great watermarking algorithm by greatly improving the visual quality of the watermarked image and being robust against common signal processing operations and attacks. Using Arnold transform to safeguard the watermark further such that it becomes meaningless for the hackers or crackers. Various type of multiple attacks like Gaussian Filter attack, Median Filter Attack, random noise attack and histogram attack are considered to evaluate the effectiveness of the proposed technique.

V. Proposed Algorithm

The proposed algorithm involves two parts, that is, embedding and extraction which is explained in the following steps.

A. Watermark Embedding Algorithm

The Steps are as follows:-

1. Resize the Cover image and split it into red, green and blue channels.
2. Apply DCT on Blue Channel of Cover image.
3. Take Two Levels DWT for its conversion into Blocks like LL, LH, HL and HH.
4. Take CZT and modified SVD (using Arnold matrix AA) on high frequency Subband HH to obtain singular value s and orthogonal values u and v.
5. Convert the input watermark into Black and white using im2bw() then resize it.
6. Apply Arnold transform and modified SVD(using Arnold matrix AA) on output of Step 5.

$$AA=\begin{bmatrix}1 & 1\\ 1 & 2\end{bmatrix}$$

7. Modified SVD gives singular value s_w along with orthogonal vectors u_w and v_w.
8. Modify singular values in step 4 according to the singular values generated in step 7.

$$s' = s + \alpha\, s_w$$

where α is scaling factor (α=0.25)

9. Apply inverse SVD using orthogonal vectors u, v and modified singular value s′.
10. The resultant watermarked Image is obtained after inverse CZT, inverse DWT and inverse DCT.

B. Watermark Extraction Algorithm

The Steps are as follows:-

1. Apply DCT and DWT to watermarked image and Cover such that the resultant is four subbands LL, LH, HL and LL.
2. Compute CZT on high frequency subband HH of Cover and watermarked image.
3. Apply modified SVD (using Arnold Transform) to further decompose the Cover image and Watermarked Image into [u′s′v′] and [usv] components.
4. Apply Arnold Transform and SVD on Watermark to get singular value s'_w and orthogonal vectors u'_w and v'_w.
5. Modify the singular value s′ of Watermarked Image using

$$s'' = (s'-s)/\alpha$$

where α=0.25

6. Combine orthogonal vectors of Watermark with the resultant of Step 5 to obtain extracted Watermark image and apply inverse Arnold to obtain output.

VI. EXPERIMENTAL SETUP

In order to implement the proposed algorithm the MATLAB has been used. The existing technique has been compared with proposed technique which is hybridization of DWT, CZT and modified SVD using the tools available in the MATLAB. Basically, a set of ten images are taken in JPEG format. Both the existing and proposed algorithms have been applied and the results will be discussed under the results section.

TABLE I: Information of images

Set of Images	COVER	WATERMARK	Format of Images
1	LION	DOG	JPEG
2	BIRD	SNOW	JPEG
3	DUCK	BEACH	JPEG
4	PLANE	WATERFALL	JPEG
5	SUNSET	COFFEE	JPEG
6	SEA	TENNIS	JPEG
7	WHALE	HOUSE	JPEG
8	BERRIES	TREE	JPEG
9	TIGER	CAR	JPEG
10	BIKE	HORSE	JPEG

The table shows the set of ten images taken in JPEG format as Cover images and Watermark. The combination of plane as Cover image and waterfall as watermark has been taken in this paper. This combo is evaluated on the basis of parameters like Peak signal to Noise ratio which is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation and Mean Square Error which measures the average of the squares of the "errors".

VII. RESULTS

This section depicts the original Cover image and the watermark over which the proposed algorithm is performed to obtain robust results.

Figure 2. Original Cover Image

This is the original image in which we want to insert a watermark and protect it from attacks in our proposed work.

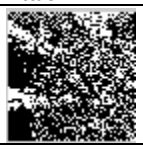
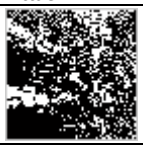
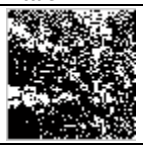
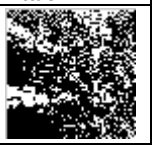
Figure 3. Watermark Image

This is the original watermark to be embedded in the Original Cover image to obtain Watermarked Image.

Figure 4. Watermarked Image

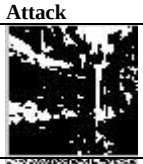
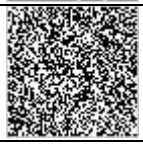
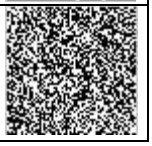
The above figure shows the Watermarked image obtained when watermark is inserted in the Original Cover Image after manipulating the singular value S of the Cover Image with the singular value S' of Watermark and scaling factor α

TABLE II: Extracted Watermark in Existing System

S.No.	Gaussian Attack	Random Noise Attack	Histogram Attack	Median Attack
Extracted Watermark in Existing System				

The above pictures are of EXISTING ALGORITHM. Figure 5(a) depicts the extracted Watermark from the existing algorithm after applying the Gaussian Filter Attack on the Watermarked Image. The figure 5(b) denotes extracted Watermark after Random Noise Attack. Figure 5(c) shows the extracted watermark after applying Histogram attack on the Watermarked image. Similarly, the figure 5(d) specifies the extracted watermark after the application of median filter attack on the Watermarked Image.

TABLE III: Extracted Watermark in Proposed Work

S.No	Gaussian Attack	Random Noise Attack	Histogram Attack	Median Attack
Extracted Watermark in Proposed System				
Arnold Extracted Watermark				

The above pictures depict that the extracted watermark is hardly affected by attacks like Gaussian Filter Attack, random noise attack, median filter attack and histogram attack on the Watermarked Image in the PROPOSED System. Further Arnold extracted watermark is obtained after applying inverse Arnold Transform.

VIII. PERFORMANCE EVALUATION

The quality of the proposed watermarking scheme is evaluated by means of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) by drawing appropriate tables, bar charts and graphs. The Table II proves that the quality metrics of various test images taken in set give better results in proposed work. The average PSNR values range from 48 to 65 which is far better than the existing ones.

The Mean square error gives reduced values as compared to the previously work done. Thus, the proposed work proves to give better results. The Bar Chart indicates the Input images Set on X-axis and the respective values on Y-axis. In Graphs, the blue line indicates the existing algorithm where as the red lines denotes the result of proposed algorithm.

TABLE IV: PSNR VALUES

S.NO.	COVER IMAGE	WATERMARK	EXIXTING	PROPOSED
1	LION	DOG	39.0536	51.8205
2	BIRD	SNOW	37.9151	49.4005
3	DUCK	BEACH	37.6031	49.2196
4	PLANE	WATERFALL	44.3371	64.7710
5	SUNSET	COFFEE	37.4936	46.4523
6	SEA	TENNIS	44.4616	62.2004
7	WHALE	HOUSE	37.4700	49.4005
8	BERRIES	TREE	37.2062	48.3497
9	TIGER	CAR	41.7405	57.2098
10	BIKE	HORSE	37.9119	49.3668

The above table indicates the calculated PSNR values of existing algorithm with respect to the proposed algorithm. The PSNR values are greater than the previous result of existing work. The maximum PSNR value reaches approximately to 65db in proposed system which is way higher than the existing system where its max value is about 45db

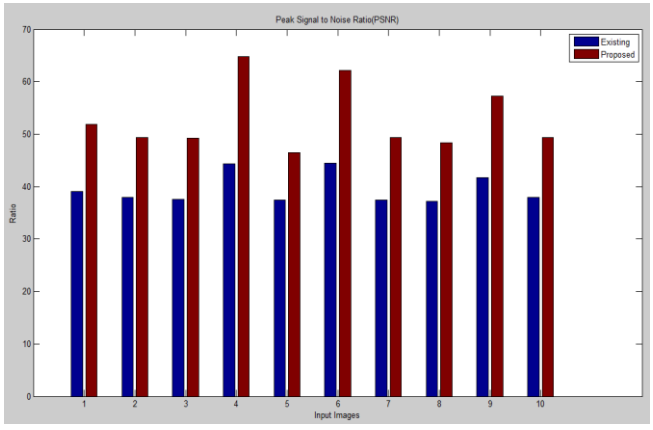


Figure 5. PSNR Analysis

This figure denotes the bar chart of PSNR values. The Red bar is of proposed algorithm whereas the blue bar denotes the existing algorithm. This figure shows the improved values obtained from proposed algorithm as compared to existing one.

TABLE V: MSE VALUES

S.NO.	COVER IMAGE	WATERMARK	EXISTING	PROPOSED
1	LION	DOG	0.5396	0.4209
2	BIRD	SNOW	0.7590	0.7465
3	DUCK	BEACH	0.8333	0.7782
4	PLANE	WATERFALL	0.1108	0.0220
5	SUNSET	COFFEE	0.8611	0.6853
6	SEA	TENNIS	0.1068	0.0392
7	WHALE	HOUSE	0.8672	0.7465
8	BERRIES	MOON	0.9385	0.7535
9	TIGER	CAR	0.2413	0.1227
10	BIKE	HORSE	0.7597	0.7523

The reduced MSE value of proposed algorithm with respect to the existing one denotes that the proposed algorithm gives better results.

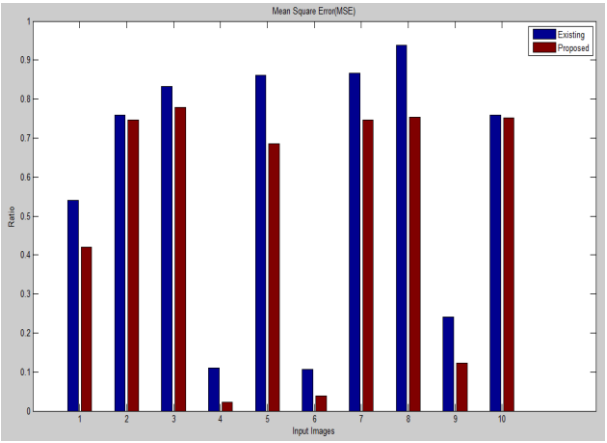


Figure 6. MSE Analysis

This figure denotes the bar chart of MSE values. The Red bar is of proposed algorithm whereas the blue bar represents the existing algorithm. This figure shows the improved MSE values obtained as compared to existing one. Thus, proposed algorithm is better than the existing one as indicated by the reduced values of MSE.

IX. CONCLUSION AND FUTURE SCOPE

A new watermarking technique on the basis of the DWT in conjunction with the CZT and modified SVD is proposed. This algorithm combines the advantages of the three transforms, therefore have significantly produced more robust results. The algorithm has helped to satisfy the imperceptibility characteristics of a good watermarking algorithm by greatly improving the visual quality of the watermarked image and being robust against common signal processing operations and attacks. Also the watermark scrambling using the Arnold transform has safeguarded the watermark further. Arnold transform has changed the watermark in such a way that it becomes meaningless for the hackers or crackers.

The future scope of this paper is that the results can further be improved by using conturlet transformation instead of using the Standard Frequency Domain techniques like DCT and DWT. Various sort of multiple attacks like

cropping, rotation etc. can be introduced to check the effectiveness of the proposed technique. Some other scrambling Transformation can be used instead of Arnold.

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