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RESEARCH ARTICLE

Hybridization of DWT, CZT and Modified SVD for Digital Image Watermarking

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Abstract—The main goal with this paper is to offer an improved evaluation of some well-known Digital image watermarking techniques. The standard Watermarking methods contain DCT, DWT and Typical SVD which are accustomed to modify a Digital Image. This paper aims at the collaboration of DWT, CZT and modified SVD to generate better results. It helps to meet the robustness and imperceptibility traits of a watermarking algorithm. Hence, only aim of this paper is to enhance the visual quality of the watermarked image against common signal processing operations and attacks. Correct analysis of earlier work done on digital images has also been considered in order to obtain satisfactory results. The key target of this paper is to enhance watermarking techniques applying chirp z-transformation and modified SVD.

Keywords: Watermarking, DCT, CZT, WT, SVD, Arnold Transform.

I. INTRODUCTION

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. RELATED WORK

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 basic requirements is evaluated for a watermarking scheme to be effective. These requirements could be categorized as imperceptibility, robustness, capacity etc.

Discrete Cosine Transform (DCT) transforms real data into real spectrum and therefore avoids the problem of redundancy. The two-dimensional DCT is generally utilized in digital image processing. 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] SVD is a powerful numerical analysis tool for matrices which give minimum least truncation error. 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; they represent intrinsic algebraic image properties[7].

III. PROBLEM EVALUATION

The problem can be evaluated in two major parts by specifying the existing problems and providing appropriate solutions of those problems.

A. Existing Problems

1) The effect of the multiple attacks on a given watermarked image has been neglected by the most of the existing researchers.
2) Most of the researchers have used Standard SVD, the use of improved or modified SVD has been ignored in the most of existing research.
3) The use of the other watermark scrambling has also been neglected in the majority of the existing research. Moreover, the Standard Watermark Scrambling needs to be modified.

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 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 attacks is likely to be considered to evaluate the effectiveness of the proposed technique.

IV. PROPOSED ALGORITHM

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

A. Watermark Embedding Algorithm

1) Resize the Cover image and split it into red, green and blue channels.
2) Apply DCT on Blue Channel of Colored Cover image and 2-Level DWT for its conversion into Blocks.
3) After application of DWT the Cover will be divided into four bands LL, LH, HL and HH.
4) Further CZT and modified SVD (using Arnold Transform) will be applied on high frequency Subband HH to obtain USV matrix.
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.

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

AA is the Arnold Matrix

7) Apply modified SVD on watermark; 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 5.
   $s' = s + \alpha\, s_w$
   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

1) Apply DCT and DWT to original Cover image such that the resultant is four subbands LL, LH, HL, LL.
2) Compute CZT on high frequency subband HH of Cover and Decomposed 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
   $s'' = (s'-s)/\alpha$
6) Combine orthogonal matrixes of Watermark with the resultant of Step 5 to obtain extracted Watermark image and apply inverse Arnold to obtain output.

V. EXPERIMENTAL SETUP

In order to implement the proposed algorithm MATLAB has been used. The proposed technique has been compared with existing technique which is hybridization of DWT, CZT and modified SVD using the tools available in the MATLAB.

TABLE I: INFORMATION OF IMAGES

Set	COVER	WATERMARK	Format of Images	Size of Cover	Size of Watermark
1	MOON	FB	JPEG	45kb	07.77kb
2	POT	RUPEE	JPEG	38kb	05.03kb
3	BACKYARD	ARROWS	JPEG	48kb	40.60kb
4	TIGER	HAND	JPEG	204kb	23.60kb
5	FRUITS	MUSIC	JPEG	101kb	43.50kb
6	FROG	PAINT	JPEG	44kb	07.00kb
7	CAR	LOGO	JPEG	179kb	49.00kb
8	COLORS	GOOGLE	JPEG	175kb	64.80kb
9	COLLAGE	DESIGN	JPEG	166kb	29.30kb
10	TURTLE	WORD	JPEG	47kb	15.80kb

The above table shows the set of ten images taken in JPEG format as Cover and Watermark together.

VI. RESULTS

The original image is "Pot" in which we want to insert a watermark "Rupee" and protect it from attacks in our proposed work. This is done by manipulating the singular value s of Cover Image with the singular value s′ of Watermark and scaling factor α.

TABLE II: EXTRACTED WATERMARK

Watermarks / Attacks	Extracted Watermark in Proposed System	Extracted Watermark in Existing System
Gaussian Attack		
Contrast Enhancement		
Gammma Correction		
Without Attack		

The Tables II depict that the extracted watermark in the PROPOSED System is hardly affected by attacks like Gaussian Filter Attack, contrast enhancement, gamma correction and without attack on the Watermarked Image.

VII. PERFORMANCE EVALUATION

The performance of proposed algorithm has been evaluated on the basis of BER, MSE and RMSE values by drawing appropriate tables and bar charts. The Bar Chart indicates the Input images 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.

A. *Mean Square Error:* It is average of square of error, which has to be minimized, so our goal is to reduce the MSE as much as possible.

$$MSE = \frac{1}{MN}\sum_{X=1}^{M}\sum_{Y=1}^{N}(I_{X,Y} - O_{X,Y})^2$$

TABLE VI: MSE VALUES

S.NO.	EXISTING	PROPOSED
1	9.53	.51
2	6.03	.04
3	20.97	.71
4	11.32	.12
5	21.63	.83
6	19.11	.37
7	16.41	.41
8	20.47	.83
9	21.75	.72
10	11.26	.51

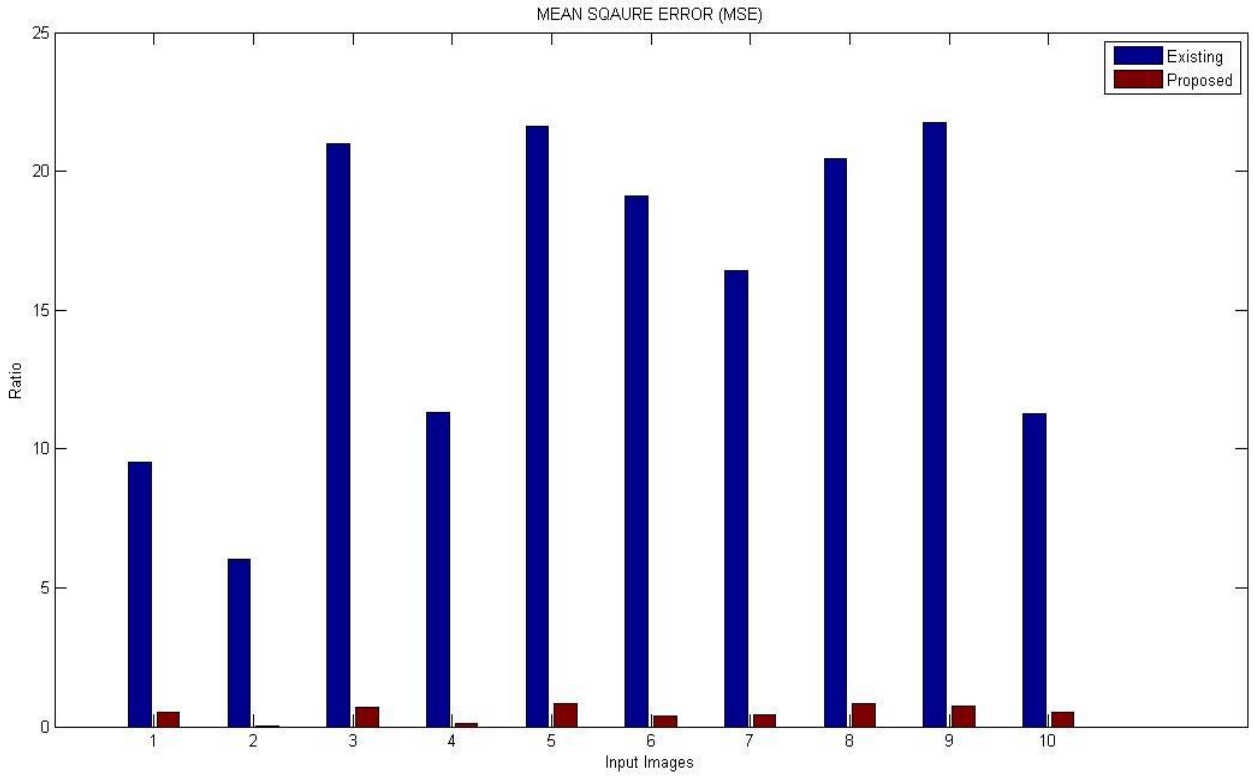

Figure 3. MSE Analysis

The collaboration of CZT, DWT and SVD has reduced the mean square error to a greater extent as shown above.

B. *Bit Error Rate*: It is the number of error bits over the total number of bits transferred, as BER need to be minimized, so our goal is to reduce them as much as possible.

$$\text{BER} = \frac{1}{10\log_{10}\frac{255^2}{\text{MSE}}}$$

TABLE V: BER VALUES

S.NO.	EXIXTING	PROPOSED
1	.026	.019
2	.025	.016
3	.029	.020
4	.027	.018
5	.029	.020
6	.028	.019
7	.028	.019
8	.029	.020
9	.029	.020
10	.027	.018

The above table indicates the calculated BER values of existing algorithm with respect to the proposed algorithm. The BER values are greater than the existing work.

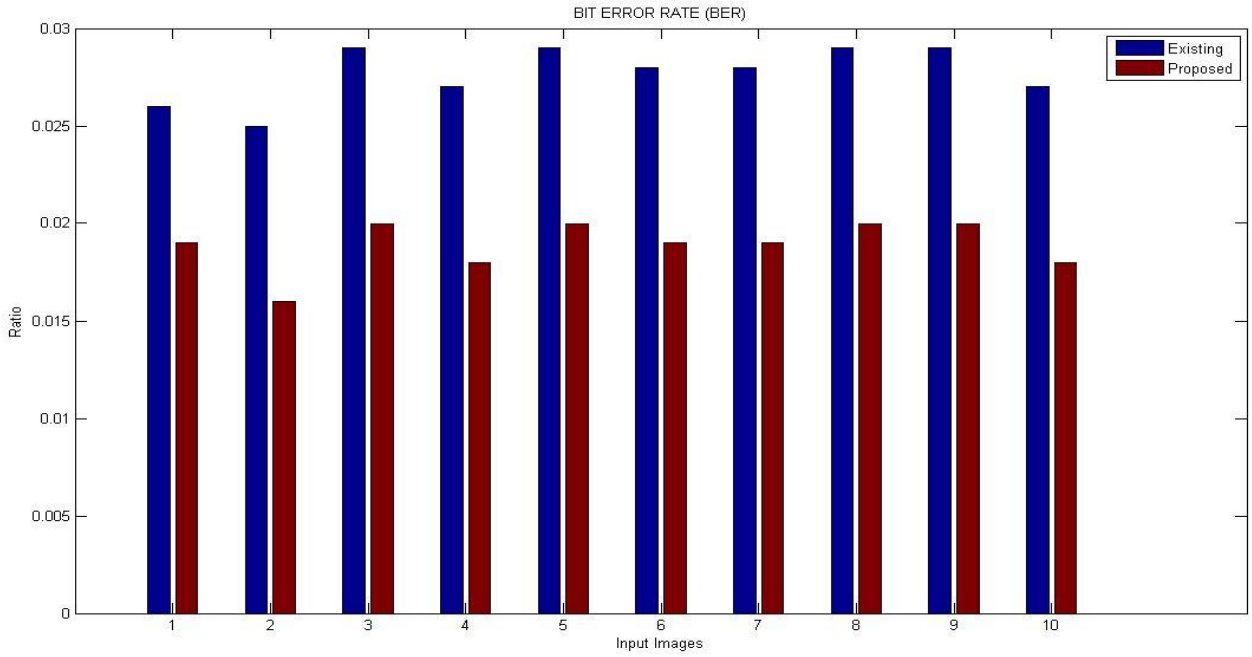

Figure 2. BER Analysis

This figure denotes the bar chart of PSNR values. The Red bar is of proposed algorithm whereas the blue bar denotes the existing algorithm. Bit error rate is the number of error bits over the total number of bits transferred, as BER need to be minimized, so our goal is to reduce BER as much as possible. Table 6.3 and Figure 6.3 has clearly shown that the BER is less in our case therefore proposed algorithm is providing better results.

C. Root Mean Square Error: It is the square root of mean square error , as RMSE need to be minimized, so our goal is to get low RMSE The reduced RMSE value of proposed algorithm with respect to the existing one denotes that the proposed algorithm gives better results.

$$RMSE = \sqrt{\frac{1}{MN}\sum_{X=1}^{M}\sum_{Y=1}^{N}(I_{X,Y} - O_{X,Y})^2}$$

TABLE V: RMSE VALUES

SET	EXIXTING	PROPOSED
1	3.09	.72
2	2.45	.19
3	4.58	.84
4	3.37	.35
5	4.65	.91
6	4.37	.61
7	4.05	.64
8	4.52	.83
9	4.66	.72
10	3.36	.51

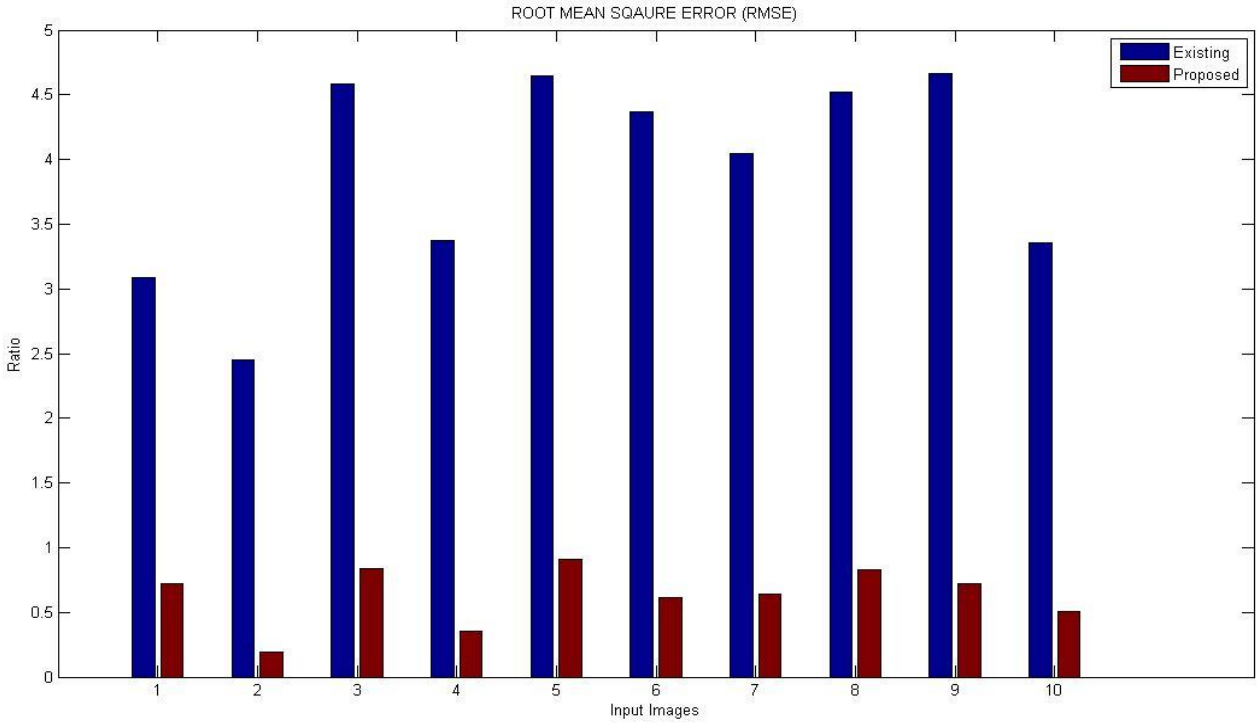

Figure 3. RMSE Analysis

This figure denotes the bar chart of RMSE 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. Thus, proposed algorithm is better than the existing one as indicated by the reduced values of RMSE.

VIII. CONCLUSIONS

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 will help 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 is likewise used to safeguard watermark further. Arnold transform has changed the watermark in such a way so it becomes meaningless for the hackers or crackers. The results can further be improved by using conturlet transformation instead of using the Standard techniques like DCT and DWT. Various sort of multiple attacks can be introduced to check the effectiveness of the proposed technique.

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