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Fast Fourier Transform based Hybrid Image Watermarking using Arnold Scrambling

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Abstract: Aiming at the problem of poor robustness of existing digital watermarking algorithms to signal processing and geometric attacks, this paper provides modification in SVD, which is neglected by many researchers. This research work proposes a new integrated watermarking technique which will integrate DCT, DWT, FFT and modified SVD. The SVD will be modified by Arnold transform. Proposed algorithm will combine the advantages of the well-known watermarking techniques FFT, DCT, DWT and modified SVD. DCT will be applied to the input cover image. Then FFT will come in action, and followed by DWT to form sub-bands. To accomplish inaudibility HH wave band will be selected for additional wave level decomposition. Modified-SVD will be then applied to HH and values will be adapted with the values of the image going to be watermarked. Thus the proposed technique has better results because the insertion is more secure as followed by several well-known techniques. Thus the results are more efficient even in case of some well-known techniques.
Index Term: DCT, FFT, DWT, SVD, WATERMARKING, ARNOLD TRANSFORM.

I. INTRODUCTION

The spreading of digital multimedia nowadays has made copyright protection a necessity. Authentication and information hiding have also become important issues. To achieve these issues watermarking technology is used. Several researchers have worked in the field of watermarking for its importance. The work in this field has led to several watermarking techniques such as correlation-based techniques, frequency domain techniques, DFT based techniques and DWT based techniques **[Saini et al., 2014]**. Watermarking means embedding a piece of information into multimedia content, such as video, audio or images in such a way that it is imperceptible to a human observer, but easily detected by a computer or detector.Before the emergence of digital image watermarking it was difficult to achieve copyright protection, authentication and data hiding but now it is easy to achieve these goals using watermarking techniques.Every watermarking algorithm consists of an embedding algorithm and a detection algorithm.

Owing to the widespread use of multimedia products, the watermarking technology is used in various applications. These include prevention of unauthorised distribution, broadcast monitoring, multimedia authentication, inserting meta-data for error correcting or improving coding efficiency and adding archived data to multimedia products are some applications of digital watermarking. In the watermarking design process, there is a trade-off between the three parameters of: robustness, imperceptibility and data payload. Robustness is the ability of watermark restoration after attacks. Imperceptibility addresses the quality degradation of watermarked image. Finally, after determining the acceptable requirements for robustness and imperceptibility; data-payload or storage capacity is defined as the number of bits that can be inserted into certain parts of the digital product. Depending on considered application of watermarking, a reasonable compromise among the above parameters should be maintained.

FFT is a method to compute DFT and also we can find DFT's inverse. Now days, science introduce many FFT algorithms for computing DFT. It is also very effective. It is used for same purpose as FFT But it is slow related to FFT.We are considering only frequency coefficients of an signal. DFT and FFT are techniques which can convert samples into its equivalent frequency coefficients. The DFT is obtained by decomposing the sequence of values into modules of frequencies. Computing the DFT of N point takes O(N2) arithmetical operation, where as a FFT can takes only O(N log N) operation.The best-known FFT algorithms depend upon the factorization of N, but there are FFTs with O(N log N) complexity for all N, even for prime N. Many FFT algorithms only depend on the fact that is an N-th primitive root of unity, and thus can be applied to analogous transforms over any finite field, such as number-theoretic transforms.

The FFT is applied on spatial domain image to obtain FFT coefficients . The features that are extracted from FFT coefficients are real part, imaginary part, magnitude value and phase angle. The FFT computation is fast compared to Discrete Fourier Transform (DFT), since the number of multiplications required to compute N-point DFT are less i.e., only (N/2)[log2N] in FFT as against N2 in DFT. The features of DWT are obtained from approximation band only. The features of FFT are computed using the magnitude values.

II. IMAGE WATERMARKING ARCHITECTURE

Digital watermarking hides the copyright information into the digital data through certain algorithm. To trace illegal copies, a unique watermark is required based on the location or identity of the recipient in the multimedia network. The sort of information hidden in the item when using watermarking is usually a signature to signify origin or ownership for the purpose of copyright protection. The major application of watermarking is copyright control, in which an image owner seeks to avoid illegal copying of the image. Robust watermarks are well matched for copyright protection, because they reside intact with the image under various manipulations. A digital watermark can be visible or invisible. A visible watermark typically consists of a conspicuously visible message or a company logo indicating the ownership of the image. On the other hand, an invisibly watermarked image appears very similar to the original. The existence of an invisible watermark can only be determined using an appropriate watermark extraction or detection algorithm. In this report we restrict our attention to invisible watermarks. A watermarking system is divided into three distinct steps, embedding, attack and detection **[Zhu et al., 2013]**. In embedding an algorithm accepts the host and the data to be embedded, and produces a watermarked signal.The watermark insertion step is represented as: X0 = EK(X; W)
where X is the original image, W is the watermark information being embedded, K is the user's insertion key, and E represents the watermark insertion function and the watermarked variant is represented as X0.
Depending on the way the watermark is inserted, and depending on the nature of the watermarking algorithm, the detection or extraction method can take on very distinct approaches. Watermark extraction works as follows:
ˆW= DK0(ˆX 0)
where ˆX 0 is a possibly corrupted watermarked image, K0 is the extraction key, D represents the watermark extraction/detection function, and ˆW is the extracted watermark information.

III. WATERMARKING TECHNIQUES

Many watermarking techniques are available. But, the following techniques are mostly used in image watermarking.

A. Discrete Cosine Transform

The DCT transforms or converts a signal from spatial domain into a frequency domain. DCT is real-valued and provides a better approximation of a signal with few coefficients. This approach reduces the size of the normal equations by discarding higher frequency DCT coefficients [Divecha and Jani, 2013]. Important structural information is present in the low frequency DCT coefficients. Hence, separating the high-frequency DCT coefficient and applying the illumination enhancement in the low–frequency DCT coefficient, it will collect and cover the edge information from satellite images. The enhanced image is reconstructed by using inverse DCT and it will be sharper with good contrast.DCT is popularily used in data compression techniques such as JPEG and MPEG. The major benefits of DCT include its high energy compaction properties and availability of fast algorithms for the computation of transform. The energy compaction property of the DCT results in transform coefficients with only few coefficients having values, thus making it well suited for watermarking.
Two-dimensional discrete cosine transformation and its inverse transform are defined as:

C(u,v)=α(u)α(v)
f(x,y)=
where, u,v = 0,1,2……… N-1
x,y = 0,1,2………N-1
α(u) is defined as follows:
α(u) = √1/N u=0;
α(u) =√2/N u=1,2......N-1

B. Fast Fourier Transform

The Fourier Transform is an important image processing tool which decomposes an image into sine and cosine terms. The transformation output represents the image in the frequency or *Fourier*, where the input image is in spatial domain. In the Fourier domain image, each pixel represents a particular frequency contained in the spatial domain image [Makwana and parmar, 2013].The Fourier Transform is used in wide range of applications, as image filtering image analysis, image reconstruction, image compression and image watermarking.

C. Discrete Wavelet Transform

The DWT is nothing but a system of filters. There are two filters involved, one is the “wavelet filter”, and the other is the “scaling filter”. The wavelet filter is a high pass filter, while the scaling filter is a low pass filter. After applying a 1-level DWT on an image, we get the approximation subband LL, the horizontal subband HL, the vertical subband LH, and the diagonal subband HH. Moreover, if we want to apply a 2-level DWT on the image, we just simply apply another 1-level DWT on the approximation subband LL. After applying a 2- level DWT, we also get the approximation subband LL2, the horizontal subband HL2, the vertical subband LH2, and the diagonal subband HH2 of the approximation subband LL other than subbands LH, HL, HH. An advantage of DWT over other transforms is it allows good localization both in time and spatial frequency domain. Because of their inherent multi-resolution nature, wavelet coding schemes are especially suitable for applications where scalability and tolerable degradation are important. DWT is preferred, because it provides both a simultaneous spatial localization and a frequency spread of the watermark within the host image [Saini et al., 2014].

D. Singular Value Decomposition

SVD is an effective numerical analysis tool used to analyze matrices. The Singular Value Decomposition of image I of size m x n is obtained by the operation

I= USV

where U is column-orthogonal matrix of size m x m , S is the diagonal matrix with positive elements of size m x n and transpose of n x n orthogonal matrix V. The diagonal entries of matrix S are known as the singular values of I. The columns of U matrix are known as left singular vector and the columns of the matrix V are known as the right singular vector of I **[Zhao and Xu, 2013]**. Thus, each singular value represents the luminance of image layer and the corresponding pair of singular vector represents the geometry of the image layer. In SVD based image watermarking, several approaches are possible. A common method is to apply SVD to the entire cover image and modify all the singular values to embed the watermark. The important property of SVD based watermarking is that the large of the modified singular values of image will change by very small values for different types of attacks.

E. Arnold Transformation

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 purpose of security. If the transformation rules and keys were not given, the original image cannot be reconstructed. Common ways of scrambling include Arnold transform, Magic transformation, Fractal Hilbert curve, Conway game and Graycode transformation etc [Divecha and Jani, 2013]. Arnold transform is used to scramble watermarking image. This is a transformation proposed by Arnold in his ergodic theory called cat-face transformation. Assume image pixel coordinates are x and y, x, y E {0,1,… N-1} (N is the order of image array), Arnold transform is

IV. ATTACKS APPLIED

A. Gaussian Noise Attack

Gaussian noise is statistical noise having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed.In digital image processing Gaussian noise can be reduced using a spatial filter, though when smoothing an image, an undesirable outcome may result in the blurring of fine-scaled image edges and details because they also correspond to blocked high frequencies. Conventional spatial filtering techniques for noise removal include: mean (convolution) filtering, median filtering and Gaussian smoothing.

B. Median Filter Attack

Mean and median filters are simple burring functions of image processing software. The resistance of a watermarked algorithm against mean and median filter depends largely on where the watermark information is embedded. High frequency edge embedding will likely suffer from mean and median filters while low frequency intensity embedding will remain relatively resistant to such filter attacks. Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. Mean filtering is a method of ‘smoothing’ images by reducing the amount of intensity variation between neighbouring pixels. The mean and median filter works by moving through the image pixel by pixel, replacing each value with the average value of neighbouring pixels, including itself.

C. Histogram Attack

Histogram equalization often produces unrealistic effects in photographs. It produces undesirable effects (like visible image gradient) when applied to images with low color depth. For example, if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number of unique shades of gray) of the image.The histogram attack estimates a watermark by using only histogram of an image. An operation called flattering may be applied to images to enhance the histogram attack. A disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise, while decreasing the usable signal. it can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image.

V. RELATED WORK

In this we make a short overview of most popular watermarking methods. But we mainly focus on the functional aspects of the methods.

[Jain and Jain, 2015] has proposed digital image watermarking using hybrid 3-level DWT-FFT technique via image compression for better results as compared to previous techniques of information hiding.[Kumar et.al, 2015] provides Digital Image Watermarking based on Hybrid DWT-FFT with different malicious attacks (JPEG compression, Salt & Peppers Noise, Gaussian Noise, Blurring and Blurring & Noise). Signal to Noise Ratio (SNR) is computed to measure image quality for proposed technique for better results as compared to previous techniques of information hiding. [Neelima and Saravanan, 2015] Digital watermarking is the powerful solution to copyright protection of digital media. Digital watermarking is having some other applications as copyright protection, fingerprinting, owner identification etc. The main requirements of digital watermarks are integrity, robustness and complexity. The author has introduced the measure of recovered image quality in terms of signal to noise ratio and similarity ratio by using two dimensional discrete cosines transform (DCT2) watermarking and two dimensional fast Fourier transform (FFT2) watermarking methods. [Saini et al., 2014] has introduced a hybrid watermark embedding and extracting technique. SVD and DWT methods are used for watermark embedding because DWT method is more flexible and provides a wide range of functionalities for still image processing. [Sharma and Oberoi, 2014] has described an image hiding method using Fast Fourier Transform (FFT) algorithm which calculates the Peak Signal to Noise Ratio (PSNR) values and compare them with Gray Scale and Discrete Cosine Transform (DCT). The experimental results show that the quality and embedding capacity of watermarked image for this scheme is higher as compared to other existing watermarking schemes. [Zhao and Xu, 2013] has presented a new semi-blind watermarking scheme based on discrete wavelet transform (DWT) and subsamping. For watermark embeddng, the host image is decomposed into subimages by sub samping and after transforming these subimages via DWT, the embedding subgraph is obtained. Then its detail coefficients are transformed by singular value decomposition (SVD). [Divecha and Jani, 2013] has presented digital image watermarking is a technology that has been developed to secure digital content from illegal use. Author proposed the implementation and performance analysis of two different watermarking schemes based on DCT-DWT-SVD. [Sreelekha et.al 2013] has proposed watermarking technique using combination of various transforms such as Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD), Discrete Sine Transform (DST), Fast Fourier Transform(FFT) and edge detection technique. Pixel values of the blocks are modified based on the threshold value determined from edge detection. [Makwana1 and Parmar, 2013] In this paper author has described that FFT is a transformation technique. It is used to transform an audio signal from time domain to frequency domain. It can also be applied with Watermarking and Encryption techniques. Watermarking is a technique to hide any kind of data in another file where as Encryption is a technique to change the data in unreadable form. After applying FFT we get the effective output. [Yang Qianli et al., 2012] has introduced a digital watermarking algorithm with gray image based on two dimensions which are discrete wavelet and cosine transform for protecting digital media copyright efficiently. In which, the image is transformed into discrete wavelet domain three times, then split the image into sub-blocks, which is lower in horizontal direction and high in vertical direction, and then transform every block into discrete cosine domain, and are embedded into cover image. [Shi et al., 2012] has described an RST invariant watermarking scheme using DWT-SVD and logistic map in which the watermark is a visually meaningful grayscale logo. In which, the embedding is done by modifying the singular values of the approximation subband of the host image with logistic map encrypted watermark, and then the watermark image is reconstituted. [Al-Gindy et al., 2011] has introduced a new copyright protection technique using colour watermarks. In which, the watermark is a RGB colour image where each pixel is represented by 24 bits. Then, the RGB colour watermark is preprocessed by converting it into binary sequence. The preprocessed colour watermark is embedded multi-times into the green channel of the RGB host image by modifying the low frequency coefficients of the DCT transformation.

VI. STEPS OF PROPOSED APPROACH

This section will explain the working of the proposed algorithm.

A. Watermark Embedding Process

The detailed insertion process for the proposed approach is given below:

Step1: Consider the Cover Image of size N*N and let it be C1. If it is a color image select the color channel.

Step2: Apply DCT to cover image C1 and name it C2. Discrete Cosine Transformation (DCT) transforms a signal from the spatial into the frequency domain by using the cosine waveform. It divides the information energy in the bands with low frequency.

Step 3: Apply FFT on DCT signal.

Step 4: Apply DWT to FFT based C2 to decompose it into four N/2 x N/2 sub-bands LL1, LH1, HL1 and HH1.Applying DWT in 2D images corresponds to 2D filter image processing in each dimension. The input image is divided into 4 non-overlapping multi-resolution sub-bands by the filters, namely LL1 (Approximation coefficients), LH1 (vertical details), HL1 (horizontal details) and HH1 (diagonal details).

Step 5: Evaluate HH1 band and then DWT will come in action to decompose DWT coefficients into four N/4 * N/4 sub bands LL, LH, HL and HH. The sub-band (HH1) is processed further to obtain the next coarser scale of wavelet coefficients.

Step 6: Apply SVD to HH, block by block and for each block calculate HH=U1*S1*V1, and acquire U1, S1 and V1.

Step 7: Modify Singular values of SVD ie S1 by standard values of Arnold Transformation such as S2=S1*

Arnold Transformation is an image scrambling method to secure the image data by scrambling the image into an unintelligible format. To be specific to the digital image, the transformation of point (x, y) to another point (X ', Y ') is:

1 1

1 2

Where, are standard values.

Step 8: Let W of size N/16 x N/16 to represent watermark.

Step 9: Now, modify S2 with watermark such that S=S2 + a* W.

Step 10: Obtain HH* using HH*= U*S*VT.

Step 11: Apply inverse DWT to LL, HL, LH and HH* to get matrix HH1*.

Step 12: Apply inverse DWT to LL1, HL1, LH1 and HH1* to get cover image C2.

Step 13: Apply inverse DCT to C2 to produce C1 and set it to selected color channel to get watermarked image WI.

B. Watermark Detection Process

The Mining process has been alienated into subsequent steps and is momentarily designated as given below:

Step 1: Select color channel and apply DCT to WI to get C2.

Step 2: Apply FFT to C2 to get FFT based C2.

Step 3: Apply DWT to C2 to get LL1, HL1, LH1 and HH1*

Step 4: Select HH1* band and apply DWT to it to get LL, HL, LH and HH*.

Step 5: Apply SVD to HH*, block by block and for each block calculate HH*=WU1*WS1*WV1, and acquire WU1, WS1 and WV1.

Step 6: Obtain W=(S-WS1)/a.

VII. RESULTS AND DISCUSSIONS

In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. The developed approach is compared against some well-known image watermarking techniques available in literature. In order to do cross validation we have also implemented a new semi-blind watermarking scheme based on discrete wavelet transform (DWT) and subsampling. After these comparisons, we are comparing proposed approach against Gaussian Noise, Median Filtering and Histogram Attack using some performance metrics. Result shows that our proposed approach gives better results than the existing techniques. Table 1 is showing the various images which are used in this research work. Images are given along with their formats. All the images are of same kind and passed to proposed algorithm.

Table 1 Images taken for experimental analysis

Image name	Extension	Watermark	Extension
Hydrangeas	.jpg	1	.jpg
Strawberries	.jpg	Logo1	.png
Cake	.jpg	Logo2	.png
Pomegranate	.jpg	Adesh	.jpg
Chrysanthemum	.jpg	Punjabi	.jpg
Baby	.jpg	Arrows	.jpg
Sunset	.jpg	Water	.jpg
Sea	.jpg	Dds	.jpg
Warning	.jpg	Hello	.jpg
Sparrow	.jpg	Star	.jpg

A. Experimental Results

Fig 11: Watermarked Image of Proposed Technique

Figure 11 has shown the watermarked image of proposed technique. Comparing the watermarked image with the original cover image does not feel the presence of the watermark. So the algorithm achieves visual invisibility.

Fig 12: Extracted watermark of proposed technique without any attack

Figure 12 has shown the extracted watermark of proposed technique. The extracted watermark as compared to the original watermark does not show any difference. The proposed method also removes the standard SVD line in watermark, hence improves the quality.

Fig 13: Extracted watermark of proposed technique after Gaussian noise attack

Figure 13 has shown the extracted watermark of proposed technique after Gaussian noise attack. The extracted watermark does not show any noise as compared to extracted watermark of existing technique.

Fig 14: Extracted watermark of proposed technique after Median Filter attack

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Figure 14 has shown the extracted watermark of proposed technique after median filter attack. The extracted watermark removes the standard SVD line in watermark.

Fig 15: Extracted watermark of proposed technique after Histogram attack

Figure 15 has shown the extracted watermark of proposed technique after histogram attack. The extracted watermark removes the standard SVD line in watermark.

B. Results And Analysis

The proposed algorithm is tested on various images. The algorithm is applied using various performance indices Mean Squared Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalized Cross-Correlation (NCC), Bit Error Rate (BER), and Root Mean Square Error (RMSE). In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. In order to do cross validation we have also implemented semi blind watermarking scheme using DWT-sub sampling. The developed approach is compared against some well-known watermarking techniques available in literature. After these comparisons, we are comparing proposed approach against Gaussian Noise Attack, Median Filter Attack and Histogram Attack using some performance metrics. Result shows that our proposed approach gives better results than the existing techniques.

C. Performance Analysis

This section contains the cross validation between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the existing methods.

Table 1: PSNR analysis

Images	Existing Technique	Proposed Technique(FFT)
Hydrangeas	37.7691	39.3362
Strawberries	37.2062	38.7498
Cake	40.3370	40.7454
Pomegranate	37.6342	38.2655
Chrysanthemum	37.6578	38.9121
Baby	39.1233	39.3045
Sunset	37.4936	40.6621
Sea	44.4616	39.3413
Warning	38.6684	39.3658
Sparrow	37.9151	39.1057

Table 1 has clearly shown that the proposed technique outperforms over the available techniques in terms of PSNR. Thus it has lesser effect on the cover image during watermark injection process.

Table2: MSE Analysis

Images	Existing Technique	Proposed Technique
Hydrangeas	0.7929	0.6637
Strawberries	0.9385	0.7535
Cake	0.3674	0.3287
Pomegranate	0.8256	0.6953
Chrysanthemum	0.8198	0.6535
Baby	0.5285	0.3515
Sunset	0.8611	0.6853
Sea	0.1068	0.0392
Warning	0.6056	0.5697
Sparrow	0.7590	0.7465

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Table 2 has clearly shown that the proposed technique outperforms over the available techniques in terms of MSE. Thus it has more effect on the cover image during watermark injection process.

Table3: RMSE Analysis

Images	Existing Technique	Proposed Technique(FFT)
Hydrangeas	0.8904	0.2888
Strawberries	0.9688	0.3195
Cake	0.6061	0.2265
Pomegranate	0.9086	0.3473
Chrysanthemum	0.9054	0.3107
Baby	0.7270	0.2903
Sunset	0.9280	0.2297
Sea	0.3268	0.2885
Warning	0.7782	0.2873
Sparrow	0.8712	0.3005

Table 3 has clearly shown that the proposed technique outperforms over the available techniques in terms of RMSE. Thus it has lesser effect on the cover image during watermark injection process.

Table4: BER Analysis

Images	Existing Technique	Proposed Technique(FFT)
Hydrangeas	0.0265	0.0254
Strawberries	0.0269	0.0258
Cake	0.0248	0.0248
Pomegranate	0.0266	0.0261
Chrysanthemum	0.0266	0.0257
Baby	0.0256	0.0254
Sunset	0.0267	0.0246
Sea	0.0225	0.0254
Warning	0.0259	0.0254
Sparrow	0.0264	0.0256

Table 4 has clearly shown that the proposed technique outperforms over the available techniques in terms of BER. Thus it has more effect on the cover image during watermark injection process.

D. Correlation Analysis

Table5: Gaussian Noise Attack

Images	Existing Technique	Proposed technique(FFT)
Hydrangea	0.9205	0.9907
Strawberries	0.7371	0.9728
Cake	0.7908	0.9919
Pomegranate	0.9007	0.9656
Chrysanthemum	0.4307	0.9885
Baby	0.6901	0.9405
Sunset	0.5860	0.9803
Sea	0.4736	0.8436
Warning	0.5935	0.9871
Sparrow	0.8830	0.9734

Table 5 has clearly shown that the proposed technique outperforms over the available techniques in terms of Gaussian Noise Attack. Thus it has similar effect on the cover image during watermark injection process.

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Table6: Median Filter

Images	Existing Technique	Proposed Technique(FFT)
Hydrangeas	0.9699	0.9854
Strawberries	0.9728	0.9860
Cake	0.9708	0.9854
Pomegranate	0.9718	0.9858
Chrysanthemum	0.9718	0.9745
Baby	0.9728	0.9818
Sunset	0.9708	0.9411
Sea	0.9718	0.9801
Warning	0.9708	0.9742
Sparrow	0.9718	0.9839

Table 6 has clearly shown that the proposed technique outperforms over the available techniques in terms of Median Filter Attack. Thus it has similar effect on the cover image during watermark injection process.

Table7: Histogram Attack

Images	Existing Technique	Proposed Technique(FFT)
Hydrangeas	0.9395	0.9895
Strawberries	0.9388	0.9822
Cake	0.3411	0.9900
Pomegranate	0.9471	0.9870
Chrysanthemum	0.8567	0.9882
Baby	0.9547	0.9850
Sunset	0.9491	0.9865
Sea	0.9470	0.9674
Warning	0.9488	0.9850
Sparrow	0.9506	0.9890

Table 7 has clearly shown that the proposed technique outperforms over the available techniques in terms of Histogram Attack. Thus it has similar effect on the cover image during watermark injection process.

VIII. CONCLUSION AND FUTURE SCOPE

The image watermarking methods using DWT, FFT, DCT and SVD are considered to be more appropriate and secure in real-time systems. But it is found that most of the existing researchers have neglected modification in SVD to improve the robustness further. So to overcome these problems a new algorithm is proposed in this research. The proposed work integrates DCT,DWT, FFT and modified SVD by block by block method with modified S values to give better results than the older techniques. Moreover, the use of standard SVD is easily crack-able by the hacker or cracker. The integrated technique has successfully reduced the limitations of the existing watermarking technique. Comparative analysis has shown the significant improvement of the proposed algorithm over the available algorithms.

This research work has not considered any evolutionary technique to modify SVD in more secure manner. So in future we will propose a new Ant Colony Optimization based improved SVD to enhance the results further.

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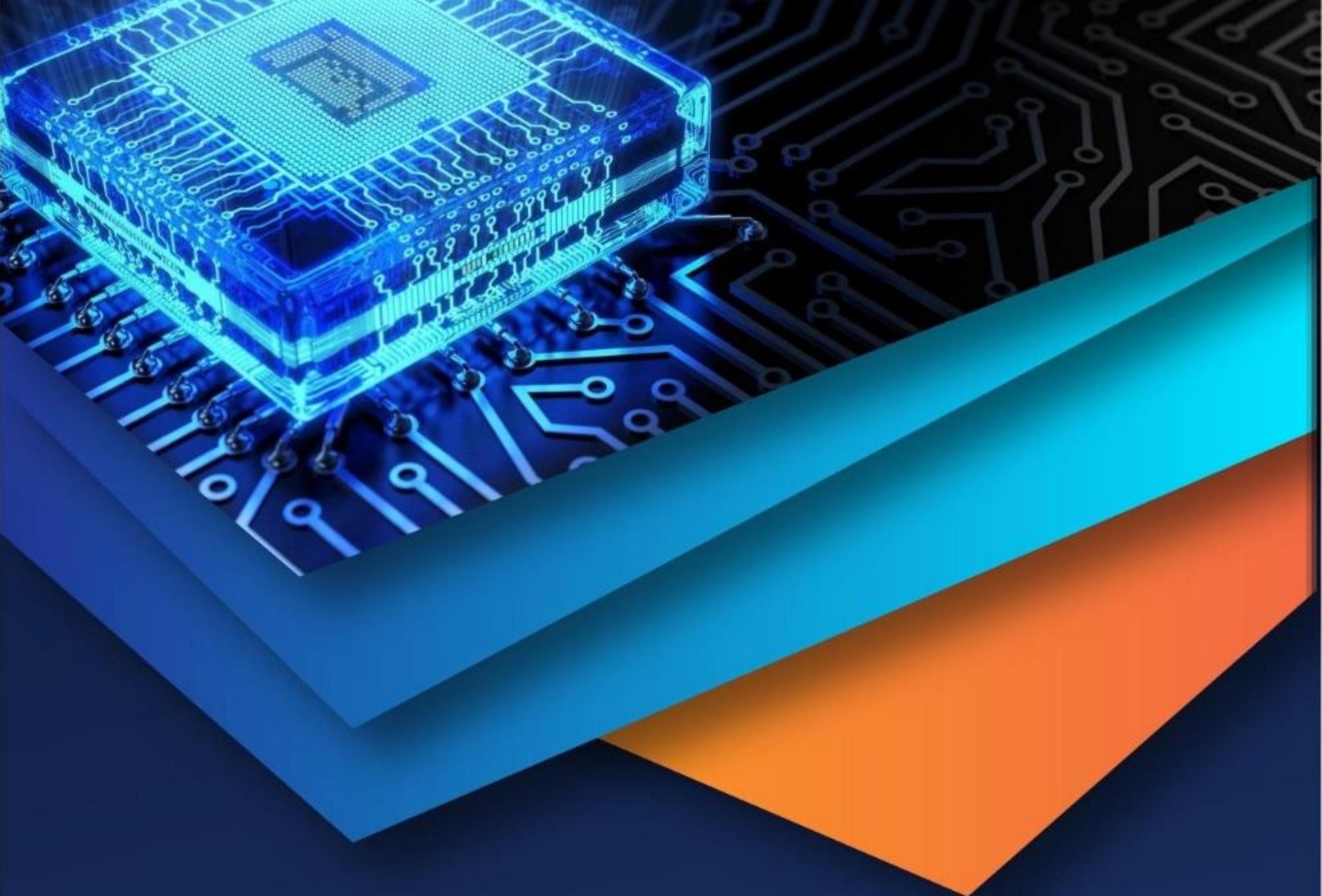

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