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Improved Digital Image Watermarking Algorithm Based on Hybrid DWT-FFT and SVD Techniques

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Abstract

In proposed research, a novel and robust digital watermarking method is introduced in which a mixture of DWT (Discrete Wavelet Transform) and FFT (Fast Fourier Transform) along with SVD (Singular Value Decomposition) is applied. Due to the usage of this combination of three techniques in our proposed work, it increases the robustness and imperceptibility of extracted image. At first DWT-FFT-SVD techniques are applied for embedding the watermark then reverse algorithm is applied for extraction. The results are compared with Base Work[1] in which single level DWT-SVD combination is taken for watermarking for copy right protection. It is shown through PSNR (Peak signal-to-noise ratio) that it provided a very high imperceptibility.

Keywords: Discrete Wavelet Transform (DWT), Fast Fourier Transform, Singular Value Decomposition (SVD), Watermarking

1. Introduction

Digital watermarking embeds low level signal into an image which is not always hidden in such a manner that it can not be easily be removed. It may include device control code that prevents illegal recording. An application of watermarking is to provide protection through copyright control, copy right protection, and illicit access to hypermedia data. Watermarking has been considered to be a promising solution to protect the copyright of multimedia data through trans coding, because the embedded message is always included in the data. But in true facts the process of digital watermarking is divided into three stages: first one is the Embedding stage, second is the Distortion / assault Stage and the last one is Detection / Retrieval stage.

In actual fact working of DIW can be separated into different stages: Embedding Stage, Distortion/assault Stage, and Detection/Retrieval Stage. The embedding step is the 1st step where the watermark is inserted into the original data with the aid of utilizing the embedding watermark algorithm and the secret key so that by following some algorithm watermarked picture can be generated. 2nd stage, when the information is passed on the network. At this stage either some attack is carried out or some noise is introduced on to the watermarked Image. At the second phase, the watermark is recovered or extracted with the help of the extraction algorithm from the embedded image by applying some detection mechanism and by way of utilizing secret key. In addition to this, noise is also detected[2].

As per our studies we have seen that Copyright infringement, data embezzlement and misuse results decreasing growth of multimedia data transmission services. That means, as applications in the areas of multimedia communications and multimedia networking increases, the problem of theft and distribution of intellectual property also increases. Thus authentication, security and copyright protection of digital multimedia components becomes an important concern in the digital world and this can be done using watermarking technique. There are two types of watermarking algorithms are available for hiding watermark: spatial domain and transform domain. The basic ideology in

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the transform domain watermarking mechanism is to alter the TC (Transform Coefficients) based on the bits in watermark image. The massiveness of the watermarking schemes based on frequency domain works with DCT, FFT and DWT. However, SVD is the leading numerical analysis technique these days.

The image Watermarking is used to protect content theft in social media website, channels. Image watermarking can be used to market our work.

1.1 Discrete Wavelet Transform

It is normally applied in so many techniques because of its time/frequency characteristics. Right here a picture is handed by way of sequence of different filters like low pass and high pass filters which decompose the picture into sub bands of horizontal element of the multimedia data like image; the backside correct block involves high frequency of usual picture.

This procedure makes use of wavelet filters to convert the picture[3]. Wavelet transforms are very useful due to its extracted features. Wavelet transforms are useful to provide better results in recognition.

Advantages of DWT: It provides information regarding frequency and time of the signal, Transform of a non-stationary signal is efficiently obtained, without loss of much resolution, decreases the size of image, and also decreases the redundancy along with computational time.

Real life application of DWT is noise suppression, Non-stationary signal analysis (seismic signal analysis, bio-medical signals like ECG).

Figure 1. Four band of image after applying DWT.

1.2 Fast Fourier Transform

To obtain FFT Coefficient, it is processed out on spatial domain image. Magnitude value, phase angle, real and imaginary part are the features retrieved by FFT coefficients[4–6]. When compared with Discrete Fourier Transform (DFT), FFT computation is much faster, only (N/2) [log2N] in FFT is against W while to compute N-point DFT, the required no of multiplication is the reason behind its slow process. To extract the features of DWT approximation band is required while Magnitude values are required for the features of FFT. To design the proposed algorithm, firstly we have introduced a Hybrid 3-Level DWT-FFT technique on both cover as well as watermark image. Further, we compute the singular values of LL sub band of both images then embedded these two images to obtain watermarked image. Later on, inverse scheme is applied to obtain extracted watermark image.

1.3. Singular Value Decomposition

The third technique introduced to generate the proposed algorithm is SVD is the tool in linear algebra available to analyze image in matrices form. In this technique, image is decomposed in three same size matrices. Presume that image is denoted as matrix A. Let A be a p x q matrix with p = q. The structure of SVD of A is:

$A = U^* S^* V^T$

In this formula, U and V are matrices of type orthogonal and S is square diagonal matrices. SVD method can be applied to transform matrix i.e. A into product U,S,V^T, which helps us to re-factor digital image in three matrices. The exploitation of singular values for such refactoring helps us to represent image with less significant set of values, which is capable of preserving useful and functional features of the original image, also require less storage space in the memory, and in this way reach the image compression ratio[7].

2. Related works

Lots of work towards the area of digital watermarking have been done in past. This section presents a brief survey of existing approaches to embed the watermark and extract the cover image successfully with their advantages and limitations.

Work done by Nikita Kashyap et al.[8] puts forward a technique for image watermarking that is based on a 2 level DWT. On this method the invisible watermark can also be embedded into salient points of the picture using alpha blending manner. This process distinguishes

between the higher values of PSNR using second level DWT compared with single level DWT and indicates that 2-level DWT furnish higher performance than 1-stage DWT.

The mechanism proposed by researchers[9] in which both robustness and imperceptibility requirements are achieved at satisfactory level. To achieve the target, authors proposed a DIW scheme based on hybrid DWT and SVD. The proposed approach is not implanted watermark straight on the wavelet coefficients however alternatively than on the elements of singular values of the hidden pictures.

A novel technique for DIW by 2 levels DWT with SVD has been proposed in[10]. First of all, second level DWT is calculated on HL sub-band of image and then SVD is applied to embed the watermark. Experimental results of the proposed procedure have proven the tremendous growth within the robustness underneath attacks. This process is robust for various attacks but some measures can be taken in future to increase the imperceptibility of the image.

A new robust watermarking technique, where in first of all, main image is converted by using the DWT as much as the three-layers, means observe three times, so that picture is divide into four the sub bands like (LL, LH, and HL, HH) and watermarked image is embedded into the intermediate frequency sub band. This procedure has been proposed by the aid of Qing Liu et al.[11]. Spread spectrum science can also be taken for this procedure and sightless watermarking procedure is applied to extract the watermark. Technology used in Spread spectrum used to provides secure communications because signal is "hidden" like noise but the downside of this is, it increases bandwidth of signal and increases the complexity.

Malika Narang and Sharda Vashisth[12] proposed a digital watermarking technique in which paper watermarking is done by dwt which is Multi resolution technique. This gives moderate PSNR value.

A new digital watermarking process established on DET and SVD proposed in[13]. In this system watermark is implanted in excessive-frequency band by SVD. The outcome shows that the method is able to with stand variety of attacks including common geometric attacks but the downside of this algorithm is its average Imperceptibility.

A new watermarking method founded on the DWT has been proposed by Xia and Boncelet et al.[14]. The authors introduce the decoding procedure of a probably marked image and are using DWT to do so. If the value of cross-correlation is used as a threshold, then the watermark image will be discovered. Otherwise, the picture was decomposed into finer and finer bands except the entire, extracted watermark was correlated with the whole, customary watermark. This technique proved to be more robust than the DCT method.

A hybrid plan founded on DWT and SVD presented in[15]. After decomposing the hidden picture into 4 bands, SVD is applied to each and every band, after which identical watermark information is embedded by means of editing the singular values. Due to the change in all frequencies, makes it possible for the progress of a watermarking proposal that's robust against different attacks.

Authors in[15] have compared watermarking different watermarking methods. Performance analysis is measures on the basis of PSNR and Similarity factor of watermark and recovered watermark. The result of this technique shows that the hybrid method is the best technique for watermarking.

It has been found that, research has been carried out with many Watermarking algorithms (spatial and transform domain) for embedding the watermark image in the cover image in image processing. The foremost focus of each algorithm is to increase the imperceptibility and robustness of the watermarked Image. Each Algorithm is giving a different result with the same parameters like PSNR, MSE etc.

3. Proposed work

From literature review it has been observed that most of the approaches introduced in past having problems like Low Imperceptibility, Data embedding capacity is less, Quality and More conceptual complexity. These problems have been removed in proposed work.

A new digital watermarking approach based on hybrid 3-level DWT_FFT and SVD have been proposed in this work. The proposed algorithm is developed based on three stages. Firstly, three level DWT is applied on the host image to calculate the four sub-bands of original gray scale image. After that FFT is applied on to the LL sub band of host image. Later on SVD is calculated on LL sub band. To manage as well as to develop the force of the watermark, we have taken a scale factor. At second stage watermarked image is retrieved by embedding singular value of LL sub-band of both original gray scale

image and watermark image. At the final stage of the algorithm exactly reverse practice is involved to remove watermark image from the watermarked image. The performance of this scheme was estimated with respect to the imperceptibility. It can be seen from the results that the PSNR value of our proposed algorithm is higher. The proposed system provided good imperceptibility and the robustness.

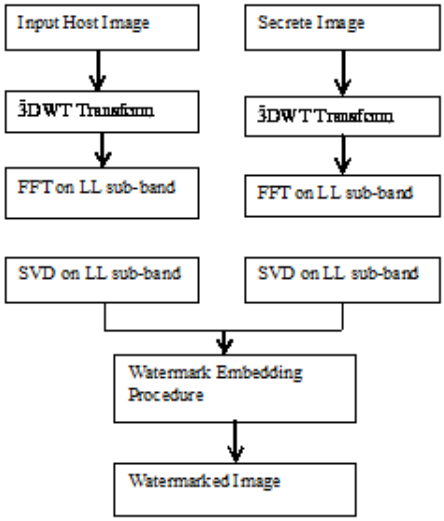


Figure 2. Watermark embedding procedure.

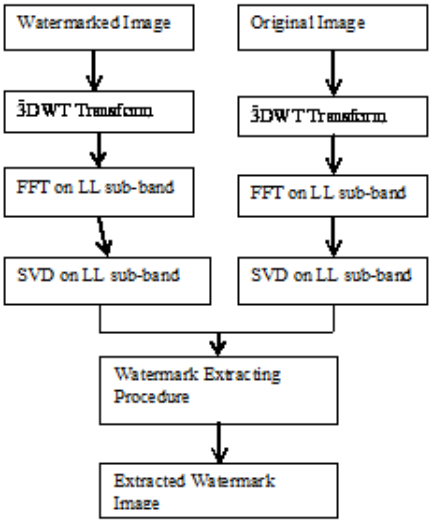


Figure 3. Watermark extracting procedure.

3.1. Enhanced or Proposed Algorithm

The general steps followed in the proposed technique are as follows

3.1.1 Watermark Insertion

Step 1 Input the original image (a) and convert it into gray scale image using function-

I=rgb2gray (a)

Step 2 Now apply three level DWT to "I" and decompose it into 4 sub bands LL_3, LH_3, HL_3 and HH_3.

Step 3 Apply FFT onto the LL sub band of I.

F=fft2 (LL_3)

Step 4 Calculate SVD of the LL sub band of cover image i.e.

$ILL = UI\ SI\ VI^T$

Step 5 Now take the watermark image and apply three levels DWT to generate decompose image into four sub bands i.e. LL_3, LH_3, HL_3 and HH_3.

Step 6 Apply FFT onto the LL sub band of I.

F=fft2 (LL_3)

Step 7 Apply SVD to the LL sub band of watermark i.e.

$WLL = UW\ SW\ VW^T$

Step 8 Adjust the singular values (**I_s**) of Ie with the singular values (**W_s**) of watermark i.e.

$S\_n = I\_s + \alpha * W\_s$

Here α stands for scale factor.

Step 9 Now obtain modified DWT coefficient i.e.

$IeLL' = U * S\_n * V^T$

Step 10 At last, the watermarked image "**W***" is obtained by applying inverse three level DWT.

3.1.2 Watermark Extraction

Step 1 Take the watermarked image and apply the same process to calculate the singular values of watermarked image.

Step 2 Subtract the SVr values of watermarked image i.e. (Wm_s) from SV values of original image i.e. (I_s) to get the singular values of watermark image i.e.

$S\_w = (I\_s - Wm\_s)/\alpha$

Step 3 Obtain modified DWT coefficient i.e.

$W*LL' = U\_w * S\_w * V\_w^T$

Step 4 Get the watermark image by applying inverse hybrid three levels DWT_FFT process.

4. Results Analysis

The proposed technique develops a hybrid technique DWT_FFT along with SVD for embedding the

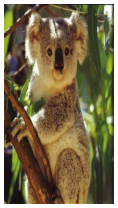
watermark on the input cover Image. The focal point of digital watermarking in transform domain is to insert the max possible watermark signal into multimedia data without affecting image quality. By using that hybrid technique various issue such as visual quality of the image and robustness can be resolved, a single transform based watermarking is not able to satisfy diverse criteria desired for watermarking contradict each other. In order to increase the robustness, the payload should be increased but it decreases the imperceptibility of the image. The incorporation of imperceptibility and robustness simultaneously in watermarking system design is an issue that needs to be addressed. DWT reduces the image data and then watermark is embedded in high frequency sub bands. This will have filtered out the unwanted information from the image. Thus at the same time to maintain the robustness and imperceptibility of the watermarked image.

Figure 4. (a) Original Cover Image, (b) DWT Transform of Cover Image (c) Watermark Image (d) DWT Transform of Watermark Image (e)Watermarked Image (f) Extracted Watermark Image.

In Figure 4, we have shown that (a) is the gray scale host image, (b) shows the image retrieved after applying DWT transform of host image. Then after applying FFT, singular value of host Image is calculated. Than (c) shows the watermark image, (d) is the DWT transform of watermark image. After that same process is applied to calculate the singular values of watermark image. Than embedded the host and the watermark image using their singular values and scale factor Alfa i.e. (e). Than repeat the inverse of the process to extract the watermark image i.e. (f) Table1 Shows the PSNR value of extracted watermark image. PSNR is a ratio most likely applied as the great measurement between the original and the compressed picture. The more PSNR, the better class of image is reconstructed or compressed image. The results of proposed algorithm give the more PSNR values so the better quality of image.

As shown through table (1) for the different values of Alfa the PSNR of base does not vary or remains same for all the values of Alfa which means there is no effect of scale factor while the PSNR of proposed method vary or increasing as the value of scale factor is increasing. The value of PSNR of proposed method is varying due to the use of FFT.

Table 1. Shows comparative results of base and propose method based on PSNR value

Original Image	Watermark Image	Alfa	Base PSNR	Proposed PSNR
		.1	31.3614	38.7831
		.2	31.3614	45.1320
		.3	31.3614	48.3381
		.4	31.3614	48.3410
		.5	31.3614	48.3819
		.6	31.3614	48.8867
		.7	31.3614	54.2766
		.1	29.7752	38.7919
		.2	29.7752	45.3399
		.3	29.7752	48.3343
		.4	29.7752	48.3604
		.5	29.7752	48.4642
		.6	29.7752	48.9342
		.7	29.7752	54.4023
		.1	23.8511	38.7783
		.2	23.8511	43.4338
		.3	23.8511	48.3164
		.4	23.8511	48.3497
		.5	23.8511	48.5467
		.6	23.8511	49.2060
		.7	23.8511	51.1966
		.1	29.5075	38.7688
		.2	29.5075	42.5734
		.3	29.5075	48.3168
		.4	29.5075	48.3473
		.5	29.5075	48.3928
		.6	29.5075	48.5657
		.7	29.5075	49.4351
		.1	28.2185	38.9947
		.2	28.2185	47.7676
		.3	28.2185	48.3364
		.4	28.2185	48.3451
		.5	28.2185	48.4145
		.6	28.2185	49.4773
		.7	28.2185	59.5175

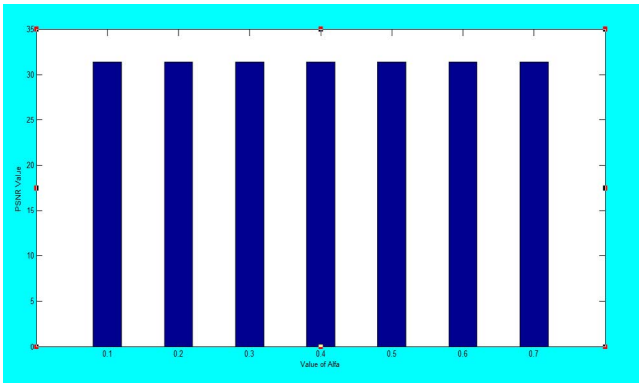


Figure 5. Display the PSNR values of base method.

Figure 5 is the graph representation of PSNR values generated by Base Method applied on the first set of original and watermark images taken from Table 1.

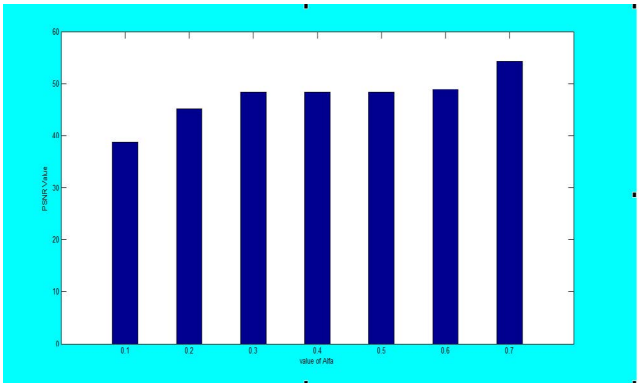


Figure 6. Display the PSNR values of proposed method.

Figure 6 is the graph representation of PSNR values generated by Proposed Algorithm applied on the first set of original and watermark images taken from table 1.

5. Conclusion

The proposed solution uses the hybrid 3 level DWT-FFT technique along with SVD technique for appending the watermark on the Cover Image and follows the reverse scheme to extract the watermark image from watermarked image. The proposed work is able to achieve moderate robustness, high imperceptibility with reduced amount of data to be processed. A no of experiments has been taken and Analysis is done based on experimental results which shows better performance of the proposed method when compared with the single level DWT-SVD based watermarking introduced in Base method. PSNR value generated from proposed algorithm is much higher than base algorithm which assures the better quality of images. The combination of three techniques hybrid DWT-FFT along with SVD, introduced in proposed method is the reason behind the better performance, good imperceptibility and enhanced quality of image.

6. Future Work

In further course of work, we would like to work on cropping attack with the existing method since it is not robust against cropping attack. In this work different images with variable frequency (low frequency image, middle-low frequency image, and high frequency image) are not consider. So, in future, unique watermarks can also be embedded in different frequency level. Therefore, the future research direction includes, applying the proposed method to the other three frequency images and then extract the watermark after applying some extra changes into it.

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