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Review on Image Watermarking using Bidimensional Empirical Mode Decomposition

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Abstract— ***As digital image watermarking has become an important tool for copyright protection, various watermarking schemes have been proposed in literature. Among them image watermarking using bidimensional empirical mode decomposition (EMD) is a newly developed method. In this review paper a comparison of EMD based methods of image watermarking is done. The use of Bidimensional Empirical Mode Decomposition(BEMD) in watermarking is motivated by the fact that it has better quality than Fourier, Wavelet and other decomposition techniques in extracting intrinsic components because of its fully data driven property. This decomposition is also proven as a very powerful tool for multi-scale analysis of non-stationary and nonlinear signals and also by the characteristics of the IMF. The watermarking is done on the IMFs obtained by performing BEMD. This watermarking technique is more robust against various signal processing operation and attacks.***

Index Terms**—Bidimensional Empirical Mode Decomposition, Blind Watermarking, Public Watermarking, Robustness, Watermarking Schemes,**

I. INTRODUCTION

The growth in the distribution of media files over the internet has caused serious concerns regarding piracy and unauthorized distribution. Digital image watermarking has received a great deal of attention in the literature to provide efficient solutions for copyright protection of digital media by embedding a watermark in the original image. A watermarking scheme can be private (not blind) or public (blind), depending on the need. The process of watermarking involves the modification of original information data to embed watermark information. In order to prove ownership the embedded watermark is recovered back using an appropriate watermark extraction algorithm. [6]. Block diagram of watermark embedding in the original image is shown in Fig. 1. Block diagram of watermark extraction is shown in Fig. 2.

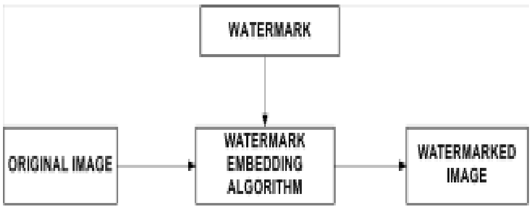

Fig 1. Block diagram of watermark embedding

Fig 2. Block diagram of watermark extraction

Various watermarking techniques have been developed. However, these techniques can be grouped into two classes: spatial domain and frequency domain. The spatial domain methods are to embed the watermark by directly modifying the pixel values of the original image. It has the advantages of low complexity and easy implementation, but they are generally fragile to image processing operations or other attacks. On the other hand, the transform domain techniques embed the watermark by modulating the magnitude of coefficients in a transform domain, such as discrete cosine transform, discrete wavelet transform (DWT), and singular value decomposition (SVD). Transform domain methods can embed more information and yields more robustness against many common attacks, but the computational cost is higher than spatial domain watermarking methods [1]. The main specifications of a watermarking system are: robustness, Imperceptibility, and Capacity. The watermark is a signal embedded into the host media to be protected, such as an image or audio or video. It contains useful certifiable information for the owner of the host media, such as producer's name, company logo, etc.; the watermark can be detected or extracted later to make an assertion about the host media. There are two important properties for a watermark; the first is that the watermark embedding should not alter the quality and visually of the host image and it should be perceptually invisible. The second property is robustness with respect to image distortions. This means that the watermark is difficult for an attacker to remove and it should be also robust to common image processing and geometric operations, such as filtering, resizing, cropping and image compression. Empirical mode decomposition (EMD) is an adaptive decomposition of data, introduced by Huang for one dimensional signal and extended to image after that. Researches proves that the EMD is as better quality than Fourier, wavelet and other decomposition techniques in extracting intrinsic components of textures and image compression because of its fully data driven property. This decomposition is also proven as a very powerful tool for multi-scale analysis of non-stationary and non-linear signals [3]. The bidimensional empirical mode decomposition (BEMD) is a highly adaptive decomposition. It is based on the characterization of the image through its decomposition in

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intrinsic mode function (IMF) where the image can be decomposed into a redundant set of signals denoted IMF and a residue, adding all the IMFs together with the residue reconstructs the original image without information loss or distortion. The rest of the paper is organized as follows. In Section II, we present the current state of the art related to image watermarking for copyright protection. In Section III, we discuss the various methods of image watermarking. In Section IV we propose the work that is intended as the first authors M. Tech. project and in Section V we discuss its applications. Finally Section VI summarizes this paper with some concluding remarks.

II. CURRENT STATE OF THE ART

Watermarking is a protection tool for data encoding and copyright protection. Digital watermarking method are mainly of two types based on processing method, spatial domain, like LSB and transform domain, like DCT, DWT methods. In the spatial domain method the watermark is embedded in the lower order bit planes. It is an easy implementation method and has low complexity but is not robust against the common attacks. Transform domain method produce high quality watermarked image by first transforming the original image into the frequency domain by the use of Fourier Transform, Discrete Cosine Transform or Discrete Wavelet transforms and modifying the transform coefficients to embed the watermark data. It is observed that Transform based watermarking is much better than the spatial Domain watermarking [1]. In a robust watermarking technique based on the BEMD where an additive watermarking scheme is applied to each IMFs obtained by the BEMD and the watermark is a binary matrix differently ponderated for each one of the four first IMFs. In another works where the watermark bits are embedded directly on the wavelet coefficients, the proposed scheme suggests rather the embedding of the wavelet coefficients of the mean trend results by performing the BEMD on the host image, using Singular Value Decomposition (SVD) [1]. The watermarked image has a very good perceptual transparency. The extraction algorithm is a non blind process, which uses the original image as a reference for retrieving the watermark. The proposed algorithm is robust against rotation, translation, compression and noise addition. It has also a superior Peak Signal to Noise Ratio (PSNR) for the watermarked image. In another blind image watermarking algorithm based on the multiband wavelet transformation and the EMD. Unlike the watermark algorithms based on the traditional two-band wavelet transform, where the watermark bits are embedded directly on the wavelet coefficients, in the proposed scheme, we embed the watermark bits in the mean trend of some middle-frequency sub images in the wavelet domain. We further select appropriate dilation factor and filters in the multiband wavelet transform to achieve better performance in terms of perceptually invisibility and the robustness of the watermark.

III. METHODS OF IMAGE WATERMARKING

A. Bidimensional empirical mode decomposition based techniques

The BEMD is a 2D extension of EMD. As a first application of image watermarking using the IMF after decomposition by BEMD, it will use the Patchwork algorithm; proposed by Bender and Al. This method will apply the additive watermarking scheme to each IMF obtained by the BEMD where the watermark is a binary matrix in (-1; 1) differently ponderated for each one of the four first IMF modes. The watermark detection is done by operation dual of the one used in image watermarking process. During this process decompose the watermarked image to the fourth first modes and residue. Then perform the inverse operation of that done during embedding. The block diagram of image watermarking using BEMD is shown in Fig. 3. Various robustness tests are performed on the watermarked image. This method presents an excellent behavior against noise and JPEG compressions attacks and thus it is very promising images watermarking method [1].

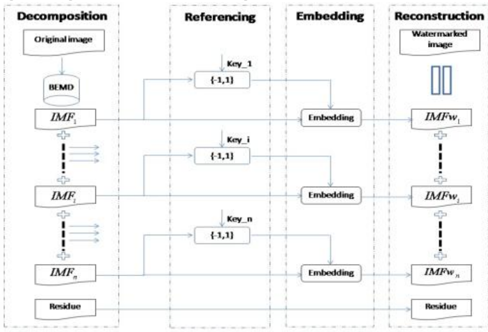

Fig 3. Diagram of the image watermarking method using BEMD

B. DWT and BEMD based technique

In this proposed scheme the embedding of the wavelet coefficients of the mean trend results by performing the BEMD on the host image, using Singular Value Decomposition (SVD). Initially, the BEMD is performed on the cover image. Three levels of decomposition are required leading to 3 IMF functions and a residue of order 3. Then, one level DWT is applied on the obtained residue of image I and on the watermark image W to generate the necessary four sub-bands LL, LH, HL and HL [6]. In the proposed algorithm, only the HL band has been used. Finally, the SVD decomposition is applied on the two obtained HL sub-bands. The singular values of watermark are added to those of the cover image residue. The watermarked image has a very good perceptual transparency. The extraction algorithm is a non blind process, which uses the original image as a reference for retrieving the watermark. The proposed algorithm is robust against rotation, translation, compression and noise addition. It has also a superior Peak Signal to Noise Ratio (PSNR) for the watermarked image. The obtained results, tested on different images by various attacks, are satisfactory in terms of imperceptibility and robustness.

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C. Multiband Wavelets and BEMD based techniques

Here a blind image watermarking algorithm based on the multiband wavelet transformation and the EMD. Unlike the watermark algorithms based on the traditional two-band wavelet transform, where the watermark bits are embedded directly on the wavelet coefficients, in the proposed scheme, embed the watermark bits in the mean trend of some middle-frequency sub images in the wavelet domain. We further select appropriate dilation factor and filters in the multiband wavelet transform to achieve better performance in terms of perceptually invisibility and the robustness of the watermark [2]. The experimental results show that the proposed blind watermarking scheme is robust against JPEG compression, Gaussian noise, salt and pepper noise, median filtering, and Conv-Filter attacks. The comparison analysis demonstrates that this scheme has better performance than the watermarking schemes reported recently.

D. BEMD and bit plane decomposition based technique

In order to get a better robustness and invisibility of the Watermarking, a new color image watermarking embedding Algorithm, which was based on BEMD and bit plane decomposition, is proposed. With the features of human visual system (HVS) and Arnold shuffling transform, it embedded the watermarking information decomposed by the bit plane into one of intrinsic mode functions (IMF) form the host image to finish the effective embedding algorithm. The experimental results show that the algorithm has the better robustness and imperceptibility, so it can be effective against a variety of malicious attacks such as JPEG compression, median filtering, rotating, salt and pepper noise and Gauss noise.

E. Computationally efficient BEMD

This method presents two different approaches in colour image decomposition domain BEMD. The first approach applies the BEMD on each channel separately and the second is based on interpolation of each channel in the sifting process. The comparison of two approaches shows the same performance of each approach in terms of visual quality, but they do not provide the same results in execution time which presents the most important criterion in real time applications. It was shown that the second BEMD approach based on interpolation of each channel in the sifting process, gives a gain in the point of view the execution time. After performing BEMD the watermarking is done by using DWT. This method is more robust against filtering, cropping and compression.

IV. WATERMARKING ALGORITHM

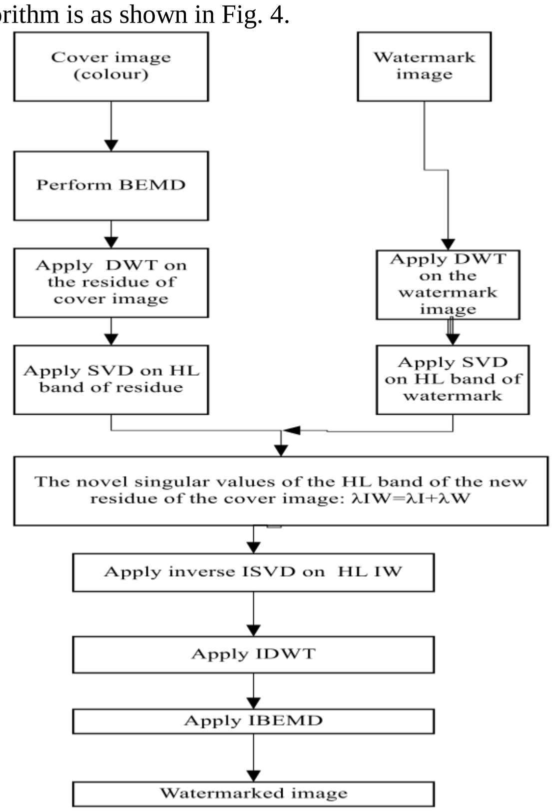
In the proposed scheme of this work, the watermarking is done on colour image. The watermark is inserted by use of the obtained residue from BEMD of the image. Because the mean trend (residue) of the signal is highly robust against noise attack and JPEG compression, the DWT is applied on it and the obtained middle sub bands are used to embed the watermark in the image by means of SVD tool.

A. Watermark Embedding

The watermarking is done by using BEMD on a cover image. In this paper the watermarking is done on a colour image. The BEMD is a powerful tool for the decomposition of non-stationary and non-linear signals. BEMD is an adaptive decomposition technique. The BEMD is performed on the cover image. Here the decomposition is performed in 3 iterations. The three iterations of decomposition performed will result in three IMFs and a residue. The first IMF contains highest spatial frequency component. The spatial frequency decreases when going to the next mode. The residue contains lowest spatial frequency component. The watermarking can be done either on the IMFs or on the residue. In this paper watermarking is done on the residue. Then one level decomposition is applied on the residue and the watermark image to generate the necessary four sub-bands LL, LH, HL and HL. In the proposed algorithm, only the HL band has been used. Finally, the SVD decomposition is applied on the two obtained HL sub-bands. The singular values of watermark are added to those of the cover image residue.

$$\lambda_{iw} = \lambda_i + \lambda_w$$

Where λ_i and λ_w represents the singular values of the residue and watermark. λ_{iw} represents the singular value of the watermarked image. On the modified sub-band, the inverse DWT is applied to achieve the embedded residue. Then the modified residue is summed with the three IMFs to achieve the watermarked image. The watermark embedding algorithm is as shown in Fig. 4.



B. Watermark Extraction

The extraction algorithm is a non-blind scheme. The extraction algorithm uses the cover and the original

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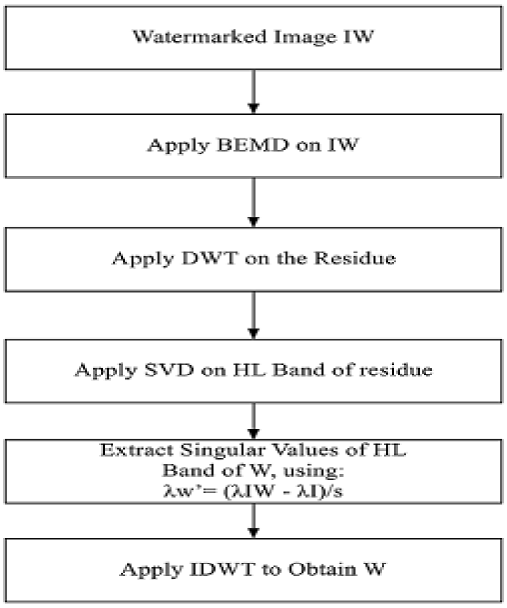
watermark images to extract the watermark [6]. On the residue RIW of the watermarked image, the one level DWT is applied to generate the four sub-bands. The SVD decomposition is applied on the sub-band HL. The singular values of watermark are extracted from the singular values of the DWT transformed residue of the watermarked image. The Extracted singular values formed the S matrix [7]. This latter is combined with other matrices U and V to generate the Watermark image W as illustrated in Fig. 5.



V. SIMULATION RESULTS

The proposed system is implemented in MATLAB 8.1.0.197613. The cover image is decomposed adaptively by using BEMD process. The results of BEMD process is shown in Fig. 6. The watermark is embedded into the residue obtained by performing BEMD on the cover image. The result of watermarking process is shown in Fig. 7. The PSNR value of watermarked image is calculated and the obtained PSNR value is 72.06 dB.

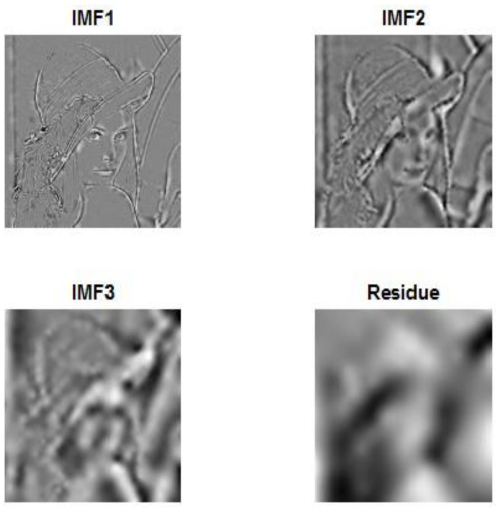


Fig 6. The results obtained by the BEMD process

VI. APPLICATIONS

Various applications of image watermarking are:
1. Copyright Protection: Visible watermarking can be used for enhanced copyright protection. In such situations, where images are made available through Internet and the content owner is concerned that the images will be used commercially without payment of royalties. Here the content owner desires an ownership mark, that is visually apparent, but which does not prevent image being used for other purposes.
2. Data Hiding: It tries to invisibly embed the maximum amount of data into a host signal. This allows communication using enciphered messages without attracting the attention of a third party. In this robustness is not important while invisibility and capacity are required.
3. Fingerprinting: Watermarking is used in fingerprinting to trace the source of illegal copies. In this different watermarks are embedded by the owner in the copies of the data that are supplied to different customers.
4. Image Authentication and Data Integrity: An interesting Application for digital watermarking is image authentication. With the help of advanced image editing softwares, digital images can be manipulated maliciously. Thus, it is essential to be able to detect unauthorized image manipulations. In image authentication, a specific watermark is inserted into image, so that all attempts to manipulate the content of the image will alter the watermark also.

VII. CONCLUSION

We have discussed different digital image watermarking using BEMD algorithm. The BEMD is a powerful decomposition technique used for the adaptive decomposition of signals. The watermarking can be done using and different watermarking techniques using BEMD is discussed. The different watermarking techniques involves using DWT along with BEMD, Multiband Wavelets and BEMD, and another method involves performing BEMD on cover image and then

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DWT is applied on it and the obtained middle sub bands are Used to embed the watermark in the image by means of SVD Tool. There exist several computationally efficient methods for performing BEMD and thus the overall time consumed by the watermarking process gets reduced. In this work, a BEMD-DWT-SVD based non-blind watermarking scheme is Presented and tested. The watermark is inserted in the mean trend by means of the SVD tool. The experimental results shows that the various watermarking scheme using BEMD is robust against various signal processing operations and attacks such as JPEG compression, Gaussian noise, salt and pepper noise, median filtering, and ConvFilter attacks.

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