Block-based Hybrid DWT-SVD Watermarking Technique

Anitha M P[1], Lijina S S[2]

Student, Computer Science, Malabar Institute of Technology, Kannur, India [1]

Assistant Professor, Computer Science, Malabar Institute of Technology, Kannur, India [2]

Abstract: This paper presents a hybrid image watermarking technique for data hiding over Internet. The idea of the proposed technique is based on fusing multiple watermark images using wavelet fusion algorithm. Then, the resultant fused watermark is embedded in the original image using hybrid DWT - block based SVD watermarking algorithm to produce the watermarked image. The image watermarking technique using the hybrid DWT-block based SVD is more robust than that using the SVD only. By using block based SVD instead of using traditional SVD, the watermarked images that are tampered can also be identified. That is, the extraction of the fused watermark is possible in the presence of severe attacks. Also this watermarking technique improves both the capacity of the embedded information and robustness without affecting the perceptual quality of the original image.

Keywords: Data Hiding, Wavelet Fusion, Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD).

I.   INTRODUCTION

Today, the internet is the most important media for data communication. So important challenge is to protect the data which is transmitted over the internet. Data hiding is used for this purpose. An important method of data hiding is digital watermarking. Watermarking is the process of hiding digital information in a host image. Digital image watermarks may be used to verify the authenticity and integrity the host image or to show the identity of its owners. Several algorithms have been proposed for watermarking, especially for image watermarking to achieve data hiding. A problem arises is that as the capacity of embedded information increases, the quality of the watermarked image and the robustness against attacks are decreased. Therefore, many challenges to to design a robust watermarking algorithm based on robustness, imperceptible, capacity and security.

Hence, there is a need for developing a robust image watermarking algorithm with ability to embed multiple watermarks without affecting the perceptual quality of the original image. In this paper, a hybrid digital image watermarking technique is developed for data hiding taking into account increasing security. In the proposed technique, multiple watermarks images are first fused using wavelet fusion. Then, the resultant fused watermark is embedded in the original image using the block-based hybrid DWT-SVD watermarking algorithm to produce the watermarked image. Robustness geometric against distortion is one of the crucial important issues in watermarking.

A new discrete wavelet transform-singular value decomposition (DWT-SVD) image watermarking algorithm that is robust against affine transformation and ordinary image processing is presented. We use DWT transform to obtain four different frequency sub-bands. Watermarking is embedded in high frequency sub-bands by singular value decomposition. This process does not degrade visual quality of image.

This is unlike traditional view point that assumes watermarking should be embedded in low or middle frequency to have good robustness. By using block based SVD instead of using traditional SVD, the watermarked images that are tampered can also be identified. ie, the extraction of the fused watermark is possible in the presence of severe attacks.

II.   DESIGNING PRINCIPLES OF IMAGE WATERMARKING ALGORITHM

Image watermarking algorithm should have the following characteristics [6]

- **Imperceptibility:** the watermarked image should   not affect the quality of the original image.
- **Robustness:** the watermarked image should not be removed or eliminated by unauthorized person, thus it should resist modifications by attacks.
- **Capacity**: the number of bits that can be embedded in the host signal.
- **Security:** the watermark should only be detected by authorized person.
  All these characteristics are must to produce a robust watermarking algorithm.

III.   DIGITAL WATERMARKING LIFE CYCLE

The watermarking technique consist of three steps[3]

- **Embedding:** an algorithm accepts the host and the data to be embedded, and produces a watermarked signal. Then, the watermarked digital signal is transmitted to another person or stored.
- **Attack:** unauthorized person try to make modifications.
- **Extraction**: is an algorithm which is applied to the attacked signal to attempt to extract the watermark from it. If the signal was unmodified during transmission, then the watermark still is present and it may be extracted.
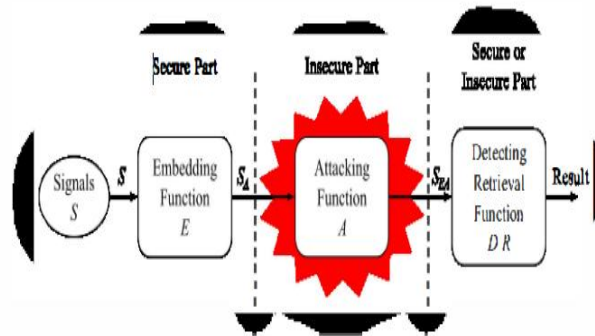

Fig. 1. Watermarking Life Cycle [3]

IV.   PROPOSED SYSTEM AND DESIGN

The hybrid image watermarking technique consists of two phases. In the first phase, the primary watermark is fused with the secondary watermark using wavelet fusion to produce fused watermark. In the second phase, the fused watermark is embedded in the original image using block-based hybrid DWT-SVD watermarking algorithm. The extraction process occurs in two steps: the extraction of fused image and the extraction of both primary and secondary watermarks.
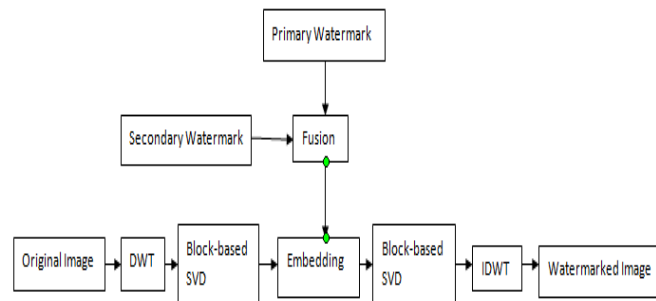

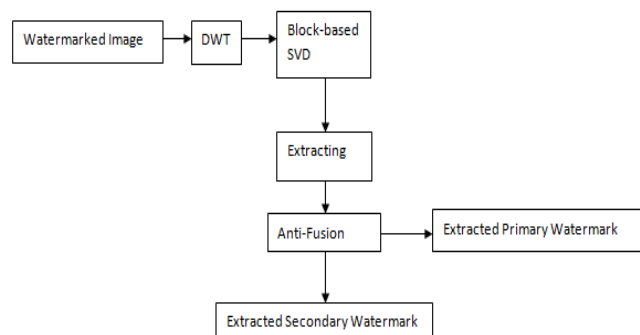Fig. 4. Multiple Watermarking Embedding Strategy

Fig. 5. Multiple Watermarking Extracting Strategy

A. DWT WATERMARKING ALGORITHM

The Discrete Wavelet Transform (DWT) [7] is currently used to in a wide variety of signal processing applications such as image, audio, and video compression and removal of noise in audio. Here one-dimensional DWT separates an image into four bands of data denoted by Lower Level (LL) resolution approximation image, Horizontal Level (HL), Vertical (LH) and Diagonal (HH) detail components.
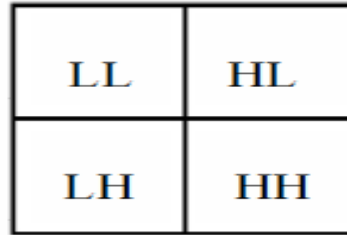
Fig. 2. One-level DWT [7]

B. SVD WATERMARKING ALGORITHM

In [4], The Singular Value Decomposition (SVD) is mathematical technique. The main properties of SVD from view point of image processing are the Singular Values SV's of image which:

- Have a good stability when small perturbation is added to an image, its SVs do not change significantly which robust against different attacks.
- Represent intrinsic algebra properties of image. Using these properties, the watermark can be embedded to SVD matrix without large variation.

The SVD of an image is computed to obtain two orthogonal matrices U, V and a diagonal matrix S . In the approach, the watermark W is added to the matrix S.

C. BLOCK-BASED SVD WATERMARKING ALGORITHM

In block based SVD technique [4], the original image is divided into non-overlapping blocks. The watermark is embedded to the SVs of each block giving new SVs matrices. An SVD is performed on each of these SVs matrices to get the SVs matrices of the watermarked blocks. Then, these SVs matrices are used to build the watermarked blocks. By rearranging these blocks again into one matrix of the same dimensions as the original image, the watermarked image is built in the spatial domain.

D. WAVELET FUSION TECHNIQUE

It has been found that [10] wavelet-based fusion techniques outperform the standard fusion techniques in spatial and spectral quality, especially in minimizing color distortion. Image fusion algorithm based on wavelet transform is proposed to improve the geometric resolution of the images, in which two images to be processed are firstly decomposed into sub-images with the same resolution at the same levels and different resolution among different levels, and then the information fusion is performed using high-frequency sub-images under the "gradient" criterion, and finally these sub-images are reconstructed into the result image with plentiful information. Since the geometric resolution of the image depends on the high-frequency information in it, therefore this image fusion algorithm can acquire good results.
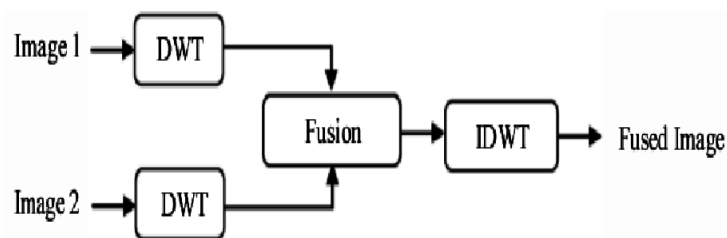

Fig. 3. Wavelet fusion of two images [10]

V.   ALGORITHM DESCRIPTION

A. Watermarking Embedding Algorithm

The watermark embedding algorithm works as follows:

1) The original image is transformed in to four sub-bands using one-level DWT.
2) The block-based SVD is performed on the original image (F matrix). $F=USV^T$
3) The primary and secondary watermarks are fused using wavelet fusion algorithm.
4) The watermark (W matrix) is added to the SVs of the original image (S matrix). $D=S+kW$
5) The SVD is performed on the D matrix. $D=U_wS_w(V_w)^T$
6) The watermarked image (F_w matrix) is obtained using the modified SVs (S_w matrix) $F_w=US_wV^T$
7) The watermarked image is inversed using the one-level IDWT.

B. Watermarking Extracting Algorithm

The watermark extracting algorithm works as follows:

1) The Watermarked image is transformed using one-level DWT.
2) The block-based SVD is performed on the possibly distorted watermarked image (F_w^* matrix).
   $$F_w^* = U^* S_w^* (V^*)^T$$
3) The matrix includes the fused image is calculated.
   $$D^* = U_w S_w^* (V_w)^T$$
4) The possibly fused watermark is obtained.
   $$W^* = (D^* - S)/k$$
5) Anti-fusion of the fused watermark using wavelet fusion to extract primary and secondary watermarks.

VI. CONCLUSION

A hybrid image watermarking technique is proposed. In the proposed technique, two watermark images are first fused then the fused watermark is embedded using the block-based Hybrid DWT -SVD watermarking algorithm. This is suitable for the extraction of the fused watermark even in the presence of attacks. Thus, the proposed image watermarking technique can be used in different applications, depending on the used core watermarking algorithm. This is unlike traditional view point that assumes watermarking should be embedded in low or middle frequency to have good robustness. By using block based SVD instead of using traditional SVD, the watermarked images that are tampered can also be identified. ie, the extraction of the fused watermark is possible in the presence of severe attacks.

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BIOGRAPHY

Anitha M P born at Kannur, Kerala, India. She received the B.Tech degree (2011) in Information Technology from MG University, Kerala, India. She is now pursuing her M.Tech degree in Computer Science and Engineering from Kannur University, Kerala, India.