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Robust Watermarking of Digital Media

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ABSTRACT

Watermarking is a very important technique for copyrights of various electronic documents and media. The images are widely available on the Internet, so it may sometimes desirable to use watermarks. Digital watermarking is the processing of combined information into a digital signal. A watermark is a secondary image, which is overlaid on the host image, and provides a means of protecting the image. Watermark must be robust and recoverable even if a part of content is altered by one or more attacks like compression, geometric distortions, filtering, , resizing etc. In this paper, we propose a blind watermarking scheme based on the discrete wavelet transform (DWT) and singular value decomposition (SVD). Singular values (SV's) of high frequency (HH) band are used to optimize perceptual transparency and robustness constraints. Although most of the SVD-based schemes prove to be robust, little attention has been paid to their security aspect. Therefore, we introduce a signature based authentication mechanism at the decoder to improve security. The main objective is to develop an algorithm for invisible watermarking of Digital Media, to maintain the data security and confidentiality of particular digital media without compromising the quality of that object.

Keywords - Copyright protection, Decomposition, Digital watermarking, Signature, Singular Values

I. Introduction

Over the internet due to the lack of security, the images can be easily duplicated and distributed without the owner's permission. Fast development of digital technologies has improved the ways to access information. However, digitization also brings in disadvantages like illegal reproduction and distribution of digital content. Internet plays a very crucial role in circulation of illegal and unauthorized digital content. One way to protect digital content against illegal reproduction and distribution is to embed some extra information called watermark into it. Original image depicts the carrier which needs protection. The watermark encoder embeds the watermark in to the cover image. The optional key is used to enhance the security of the system. Decoder extracts the watermark from the received image with the help of key and original image if required.

Watermarking techniques can be classified based on the presence or absence of original content at the time of watermark detection. One is Non-blind scheme. It requires presence of original content during watermark detection. Other is Blind scheme. It does not require the presence of original content while decoding the watermark.

In the early days non-blind watermarking schemes were popular as they were more robust than blind schemes. It is due to the fact that in watermarking model, original content is treated as a noise source to watermark, which is the signal of interest. Presence of original content at the receiver nullifies the effect of this noise. However, non-blind schemes suffer from two distinct disadvantages. First disadvantage is Security compromise in which Nonblind detection does not guarantee unequivocal claims of ownership by the content creator. Attacker can easily fool the system and even worst, may claim the ownership by inserting another watermark in the content. Second disadvantage is Practical application constraints in which it is not possible to ensure presence of original content during detection for every watermarking application. For e.g., copy protection in DVD [8].

In this paper, we propose a blind, secure and robust watermarking scheme based on SVD and DWT. The paper is organized in different sections; section 2 presents the previous work done on watermarking. In section 3, we propose a DWT–SVD based watermarking technique. Section 4 provides the experimental details performed with sample images; finally conclusions are drawn in section 5.

II. Literature Review

So far many watermarking schemes have been proposed with the intentions of improving robustness. Many watermarking schemes which are robust against compression have been developed using these transforms. Kasmani & Naghsh-Nilchi [1] proposed a combination of DWT and DCT to embed the binary watermark. They have performed 3-level DWT decomposition and then applied DCT to embed the watermark. Results showed a good watermark recovery against many attacks but this scheme suffers from high time complexity. Moreover, they had used a non-blind detection. The hybrid image watermarking algorithm proposed in [2] which satisfy both imperceptibility and robustness requirements. They have used singular values of Wavelet Transformation's LH and HL sub bands to embed watermark. To increase and control the strength of the watermark, they used a scale factor. An optimal watermark embedding method is developed to achieve minimum watermarking distortion. A secret embedding key is designed to securely embed the fragile watermarks so that the new method is robust to counterfeiting, even when the malicious attackers are fully aware of the watermark embedding algorithm. B.Chandra Mohan, S. Srinivas Kumar [3], have proposed a robust watermarking scheme based on SVD. The watermark image is embedded in both D and U matrices. Since, the same watermark is embedded twice in the same image. Robustness is achieved by using the Dither quantization for D matrix and altering coefficients of U matrix. The quality of the watermarked image is good in terms of perceptibility and PSNR (43.11dB). Sneha Jose, Rajesh Cherian Roy, Sreenesh Shashidharan [4], proposed a novel hybrid watermarking scheme based on DCT-DWT-SVD. In this method, the watermark is embedded very deep into the cover image since three transform (DCT, DWT, SVD) are taken before embedding the watermark which help in resilience the attacks. This method can be used for copyright protection, fingerprinting, tamper detection, authentication and secure communication. Sangeeta Jadhav, For extracting the color image watermark a new method has been proposed in [5]. Authors stated that it is not convenient to carry the original image all the time in order to detect the owner's signature from the watermarked image. Moreover, for those applications that require different watermarks for different copies. it is preferred to utilize some kind of watermarkindependent algorithm for extraction process i.e. dewaters marking. Authors used Blind Source Separation (BSS) technique for watermark extraction. Single level Discrete Wavelet Transform (DWT) is used for embedding.

Ghazy *et al* [6] divided the image into nonoverlapping blocks and then applied SVD to these blocks. Singular values from these blocks were used to embed the watermark. The scheme has givin good results against compression, filtering, noise addition but failed against cropping and geometric attacks. With an aim to increase the robustness of watermarking scheme Bhandari *et al* [7] used spread spectrum (SS) along with SVD. They used two watermarks during embedding; one was inserted using spread spectrum technique and other by pure SVD. SS techniques provided robustness against rotation, filtering, compression scaling, print and scan attack, while, SVD offered good robustness against noise addition and histogram equalization. Hence, these two complementary techniques covered wide range of attacks however, scheme was non-blind in nature.

III. Proposed Methodology

We propose a basic watermarking which is based on cascading of DWT with SVD. DWT decomposes the image into four frequency bands: LL, LH, HL, and HH band. HL and LH represent middle frequency and HH represents high frequency band and LL band represents low frequency. HL band gives horizontal details, LH provides vertical details and HH band highlights diagonal details of the image and LL band represents approximate details. In this proposal, we select HH band to embed the watermark because it contains the finer details and contributes insignificantly to the image energy. Hence watermark embedding will not affect the perceptual fidelity of cover image. Moreover, high energy LL band coefficient cannot be tweaked beyond certain point as it will severely impact perceptual quality. The proposed scheme is based on the idea of replacing singular values of the HH band with the singular values of the watermark. We used a signature based authentication mechanism at the decoder to improve security. Signature should remain robust against wide range of attacks hence one set of signature bits are embedded into LL4 and another set is embedded into HH4 band to ensure recovery from at least one of the band. Fig 1 shows the typical watermark embedding system.



Fig.1 A Typical Watermarking System

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- 3.1 Watermark embedding algorithm
- 3.1.1 Apply DWT decomposition and decompose cover image into four sub-bands: LL, HL, LH, and HH.
- 3.1.2 Apply SVD to HH band.

 $\mathbf{H} = \mathbf{U}_{\mathrm{H}} \times \mathbf{S}_{\mathrm{H}} \times \mathbf{V}_{\mathrm{w}}^{\mathrm{T}}$

3.1.3 Watermark W is decomposed using SVD

 $\mathbf{W} = \mathbf{U}\mathbf{w}\times\mathbf{S}\mathbf{w}\times\mathbf{V}\mathbf{w}T$

- 3.1.4 Replace the singular values of the HH band with the singular values of the watermark.
- 3.1.5 Apply inverse SVD to obtain the modified HH band.

 $H' = UH \times SW \times VHT$

- 3.1.6 Apply inverse DWT to produce the watermarked cover image.
- 3.2 Watermark extraction algorithm
- 3.2.1 Apply DWT decomposition and decompose the watermarked image into four sub-bands: LL, HL, LH, and HH.
- 3.2.2 Apply SVD to HH band.

 $H = UH \times SH \times VHT$

- 3.2.3 Extract the singular values from HH band.
- 3.2.4 Construct the watermark using singular values and orthogonal matrices Uw and Vw obtained using SVD of original watermark.

$$W_E = U_w \times S_H \times V_w^T$$

- 3.3 Signature embedding
- 3.3.1 Generate the signature of N bits for the U and V matrices of watermark.
- 3.3.2 Using DWT decomposition, decompose the cover image into 4 sub-bands: LL, HL, LH, and HH. Further decompose LL band to the 4th level.
- 3.3.3 Modify LL4 and HH4 band coefficients with the bits of signature.
- 3.4 Signature extraction

- 3.4.1 Using DWT decomposition, decompose the watermarked image into 4 sub-bands: LL, HL, LH, and HH with help of DWT decomposition, decompose LL band to the 4th level.
- 3.4.2 Extract the signature from LL4 and HH4 band.
- 3.4.3 Generate signature using U and V matrices of the original watermark at the receiver and compare it with extracted signature. If they match, authenticate U and V matrices and use them in watermark estimation.

IV. Experimental Results

In our experiments 512×512 gray scale test images namely 'Passion' as a cover image and 'BMW logo' as a embedding image were used.



Fig. 2 Passion



Fig. 3 BMW logo

After embedding the watermark logo, we get the watermarked image as shown in Fig. 3 Watermarked Image. The Fig. 5 shows the extracted watermark.



Fig. 4 Watermarked Image



Fig. 5 Extracted logo

V. Conclusion

Many of the existing DWT and SVD based approaches do not handle the issue of authentication and security. The proposed method covers this flaw by incorporating signature-based authentication mechanism.

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