Image Watermarking Algorithm in Frequency Domain: A Review of Technical Literature

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ABSTRACT

During the past decades, different solutions were proposed by researchers in order to protect the digital multimedia data against unauthorized duplication, distribution and manipulation of the multimedia data. Therefore one of the effective solutions of this problem is digital watermarking, which refers to a process of embedding code or some other information to proof the ownership of the data into digital image without affecting its visual quality. This paper presents a review on different digital image watermarking algorithms in frequency domain

Keywords: Watermarking; Discrete Wavelet Transform (DWT); Discrete Cosine Transform (DCT); Single Value Decomposition (SVD); PSNR; SSIM

INTRODUCTION

Advances in computer networking and high speed computer processors have made unauthorized duplication and distribution of multimedia data easy and virtually costless, and have also made copyright protection of digital media an ever urgent challenge. An effective way for copyright protection is digital watermarking, a process which embeds (hides) a watermark signal in the host signals to be protected (Sinha et al., 2014). Such information is embedded for many different purposes such as copyright protection, source tracking, telemedicine, piracy deterrence etc., and therefore it shall be embedded in a way that makes it difficult to be removed (Nin & Ricciardi, 2013). At the same time, the watermark should not transform the content of the work and it should be practically impossible for illicit users to remove or alter it (Bansal et al., 2016).

Watermarking techniques can be divided into four categories based on the type of information to be watermarked namely: text watermarking, image watermarking, audio watermarking and video watermarking (Sinha et al., 2014).

REVIEW OF SIMILAR WORKS

Kashyap and Sinha, (2012) implemented 2-level 2-D DWT based image watermarking algorithm, in which the watermark was embedded using alpha blending technique. In this algorithm, a host image was decomposed using 2-level 2-D DWT. Watermark image was also decomposed using 2-level 2-D DWT. The decomposed 2-level Low-Low (LL) frequency components of the host image and that of watermark image were multiplied by a scaling factor and then added using alpha blending formula, then finally inverse 2-level 2-D DWT was applied

to obtain watermarked image. The performance of the algorithm was tested using gray scale standard images of Lena image as original image and cameraman image as the watermark image, both the images were of equal size of 256 × 256. The values of MSE and PSNR were calculated for different values of the scaling factors. Experimental results showed that the quality of the watermarked image was dependent only on the scaling factor. The work did not consider the robustness and imperceptibility of the algorithm against intentional and unintentional attacks, which was its problem.

Singh *et al.*, (2012) proposed image watermarking algorithm in transform domain using DWT. In this approach, 4-level 2-D DWT is used to decompose host image and the watermarks bits are then embedded into the 4-level High-Low (HL) and Low-High (LH) frequency sub bands of the decomposed host image by modifying the coefficients in the block according to the embedding rule. Finally, inverse 4-level 2-D DWT is performed to obtain a watermarked image. The algorithm is tested using four different images (Baboon, Satellite, Lena and medical) as host images and binary image as watermark information. The performance of the algorithm is evaluated using PSNR. However, the PSNR values are calculated at different scaling factors, therefore as the scaling factor value is set to be high the PSNR value of the image decreases and the researchers did not consider subjecting the proposed algorithm to robustness test against noise, filtering, JPEG compression and other geometric attacks, meaning the algorithm is fragile against those attacks.

Al-Mansoori and Kunhu, (2012) presented a robust image watermarking algorithm for embedding logo information into all DubaiSat-1 satellite images in transform domain using DCT. In this approach, the watermark was embedded into the decomposed 2-D DCT coefficients of the host image using odd and even techniques. The proposed algorithms consisted of three methods, the first method embedded two bits of binary watermark logo inside the block based image with a secret key, the second method embedded two copies of two bits of binary watermark logo inside the block based image with a secret key, and the third method embedded three copies of two bits of binary watermark logo inside the block based image with a secret key. The performance of all the proposed algorithms was evaluated using attacks such as flipping, noising, resizing and rotation. The limitation of these algorithms was that the PSNR between the watermarked and original image was not high enough after rotation and resizing attacks for the first method and after flipping and noising attacks for the second method and the third method gave very low PSNR performance compared to the other proposed methods.

Santhi and Arulmozhivarman, (2013) proposed a novel and adaptive technique for visible and invisible watermarking in frequency domain using Hadamard transform and sigmoid function. The algorithm adaptively calculates the scaling factor based on the content of underlying host image. In embedding process, RGB host image is converted into YUV color space and the luminance channel Y is transformed using Hadamard transform and the watermark image is also transformed using Hadamard transform. The watermark is embedded by modulating the transformed coefficients of host image with that of watermark image. The robustness of the algorithm is evaluated using noise, low pass filtering, high pass filtering, median filtering, cropping, JPEG compression and geometric attacks. However the limitation of this scheme is that it is not robust against cropping and Gaussian noise and also as the JPEG

compression ratio increases the robustness tends to decrease as well as the visual quality of the watermarked image.

Singh et al., (2014) proposed a new robust image watermarking approach in transform domain for image authentication using DWT, DCT, and SVD. In this algorithm, DCT was applied over DWT to improve imperceptibility and robustness. 1-level 2-D DWT was applied to decompose the host image and it was followed by applying DCT and SVD on the High-High (HH) sub-band of the decomposed 1-level 2-D DWT host image. The SVD watermark image was embedded into SVD host image using orthogonal matrix to get the final watermarked image. The algorithm was complex and when the watermark data was embedded in high frequency components of the image, high frequency content of an image behaved like added noise and therefore noise removal algorithms such as filtering and sharpening destroyed it.

Ahmad et al., (2014) implemented image watermarking algorithm in transform domain using DWT. The host image and the watermark image were decomposed using 3-level 2-D DWT and then embedded LL sub band of decomposed watermark image into the LL sub band of decomposed host image using alpha blending technique. The performance of the algorithm was evaluated using PSNR. The algorithm recorded high performance for no attack cases. When attacks were applied, especially JPEG compression, by adding noise and filtering attacks, the watermarked image quality was below the minimum required level of 30 dB.

Vaidya and Mouli, (2015) proposed an adaptive robust watermarking algorithm for digital images in transform domain using DWT. The proposed algorithm is adaptive in the way that the embedding factor and scaling factor are calculated using Bhattacharyya distance and Kurtosis. In the embedding process, the watermark is embedded into the LL sub band of the transformed 2-level 2-D DWT host image. The algorithm was tested using eleven different gray scale images (airplane, Barbara, girl1, girl2, house1, house2, Lena, mandrill, original frame, peppers and tree) of size 256×25 and cameraman image of size 64×64 are used as host images and watermark image respectively. The performance of the algorithm is evaluated based on robustness and imperceptibility using PSNR and Normalized Correlation Coefficient (NCC) by applying different types of signal manipulations and geometric attacks to the watermarked image during communication such as noise attacks, cropping, rotation, scaling and translation. However this approach achieved robustness but the imperceptibility of the watermarked image is traded off. This may lead the attacker to know the exact location of the embedded watermark.

Rahman and Rabbi, (2015) designed the image watermarking algorithm in transform domain using combination of DWT and SVD with decomposition error. In this approach a host color image was separated into three respective color bands namely R G, and B and 4-level 2-D DWT was applied to decompose R band of the host image. SVD technique was applied to watermark matrixes and then embedded into the HL sub band of the decomposed R band of the host image and finally the inverse 4-level 2-D DWT was applied to obtain the watermarked image. The performance of the algorithm was evaluated using RGB image of size 512×512 as a host image and secret matrixes of size 64×64 as a watermark image. The designed scheme registered less robustness against attacks such as rotation and Gaussian high pass filtering with PSNR values not above the 30dB required by robust algorithm.

Haribabu *et al.*, (2016) developed a novel invisible digital image watermarking algorithm

in transform domain using DWT. In this approach, 1-level 2-D DWT is applied to decompose the intensity component of HIS color space of host image and gray scale image was used as watermark. In the embedding process, LL sub band coefficients of the host image and the watermark image are subjected to 8 × 8 block processing and their blocks entropies are compared and scaled with a scaling factor. And finally inverse 1-level 2-D DWT is applied to obtain the watermarked image. The performance of the proposed algorithm is evaluated in terms of PSNR and MSE using color images of size 512 × 512 as host images and gray scale image of size 256 × 256 as watermark. However, the scheme provide robustness against noise and brightness only but the researchers did not take in consideration the case of geometric attacks and other signal processing manipulations which when subjected may result in the imperfection of the algorithm.

Malonia and Agarwal, (2016) proposed a digital image watermarking scheme in frequency domain using DWT and AP algorithms. This technique inserted the binary watermark bits into the host image using AP. In the embedding process, 1-level 2-D DWT was applied to decompose RGB host image and then watermark bits were embedded into the HH, HL, and LH sub bands of the decomposed host image. The performance was tested using different host standard images of Lena, Baboon, and Barbara of size 512 × 512 and a QR code image of size 48 × 48 as watermark image. The result showed that by applying different signal processing manipulations and geometric attacks on watermarked images, the technique revealed that the PSNR and SSIM values were above 50 dB and 0.2, respectively.

APPLICATIONS

Digital image watermarking methods can be found in a wide variety of applications and may be classified as follows:

Copyright Protection

Copyright information can be embedded as a watermark into a host image whenever a new work is produced. This watermark can be used as evidence, if any dispute in ownership of the digital data. It gives the evidence to provide information on who is the owner of this image (Mehto & Neelesh, 2015).

Medical Applications

Watermarking can be used in medical images for different purposes. It is used to protect the patient's information from unauthorized people. Protection and authentication of such images are now becoming increasingly very significant in telemedicine field where images are easily distributed over the internet (Chahal & Khurana, 2013)..

Authentication and Integrity Verification

Watermarking process can be used for image authentication (Yusof & Khalifa, 2007) where by the watermark is embedded to detect if the image has been modified or not. Integrity verification can be achieved by using fragile or semi fragile watermark which has low robustness to modification in an image (Singh & Chadha, 2013).

Broadcast and Publication Monitoring

Digital watermark can also be embedded inside broadcast video and audio. A visible logo on a corner of television picture is a good example of visible watermark (Mehto & Neelesh, 2015). This application is used to monitor unauthorized broadcast station (Jabade & Gengaje, 2011).

CONCLUSION

It is evident from the reviewed literature that the effects of both geometric attacks and signal processing manipulations on watermarked images have been major challenges in digital image copyright protection. Consequently research has so far focused on developing robust algorithms to mitigate these effects. Most of the work done so far on image watermarking tends to enhance the robustness and imperceptibility of the watermarked image by using 2-D transformation algorithms such as; DCT, SVD, DWT or combinations of two or all of these transform methods for image transformation and these have been identified to possess limited properties that make them less efficient. Therefore the proposed algorithm employed Discrete Orthonormal Stockwell Transform (DOST) to achieve improved robustness and imperceptibility of watermarked image. This approach, to the best of my understanding based on all the reviewed literature, is innovative as it has not been applied for any digital image watermarking standard so far.

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