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Reversible Image Watermarking Using Lifting Wavelet Transform And Arithmetic Coding

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ABSTRACT

In this paper, a lossless image watermarking system has been presented, which uses the lifting wavelet transform (LWT) with integer to integer lifting scheme with all wavelets to host image. Also it provides Wavelet Transform domain technique and arithmetic coding technique to improve the quality of watermarked image. Experiments are conducted to find peak signal to noise ratio using different wavelet families.

Keywords- *lifting wavelet transform (LWT), integer to integer lifting scheme, arithmetic coding, Wavelet Transform, wavelet families.*

I. INTRODUCTION

In digital watermarking or Steganography, an invisible signal is usually embedded into a digital medium, such as an image, audio, or video data to protect it from unauthorized use and alteration, so that the content of information and the source can be authenticated. Reversible data embedding, which is also called lossless data embedding, embeds invisible data called payload into a digital medium such as image in a reversible fashion so that the original image and the payload is lossless recovered. Alternative terms for reversible watermarking are “lossless”, “distortion free”, “invertible”, “erasable” watermarking. The most important requirement of lossless watermarking is that any difference (distortion) between the original image and the watermarked image should be perceptually invisible. The human visual system (HVS) is the perceptual phenomenon that can be exploited to achieve this requirement.

A watermark is put into the media and cannot be removed or altered easily. The watermarking process introduces irreversible degradation of the original medium. Even though the degradation is less, it may not be acceptable to certain applications, like military and medical use .So there is a need for a reversible watermark which completely recovers the original image. If the embedding algorithm and embedding parameters are available, it is possible to detect the watermark from the marked medium to recover the original medium. But most watermarking algorithms apply some non-linearity to optimize the performance of the algorithm. Therefore, a reversible watermark must be designed such that it can be removed to restore the original medium without any reference to information beyond what is available in the watermarked medium .

The proposed scheme divides an input image into non overlapping blocks of a given size and Integer wavelet transform is taken for each small block and then data is embedded into the high-frequency wavelet coefficients of each block. Various block sizes and their performance are studied in it. [7] Yousefi, S. explains a lossless data hiding method using integer wavelet transform in which small coefficients of the high frequency subband are modified to embed data. The histogram modification is done to prepare enough space for data hiding [8]. Shaowei Weng proposes the reversible integer transform using the correlations among four pixels in a quad. Data embedding is done by expanding the differences between one pixel and each of its three neighboring pixels. To improve the hiding capacity, difference expansion and companding technique is used in the embedding process. [9] Hyoung Joong Kim Proposes a difference expansion method with simplified location map and better embedding capacity can be achieved with new expandability [10]. In this paper, a novel reversible watermarking scheme with high embedding capacity for digital images is proposed.
To achieve the reversibility, integer-to-integer wavelet transforms are used.

II. LIFTING WAVELET TRANSFORM(LWT)

LWT with standard 4-tap orthonormal filter with two vanishing moments is used for digital image watermarking. LWT is an alternative approach for DWT to transform image into frequency domain [11] for real time applications. Lifting wavelet is the second generation fast wavelet transform. In this, translation and dilation are not fundamental to obtain lifting wavelets. In lifting wavelet transformation, up and down sampling is replaced simply by split and merge in each of the level. The polyphase components of the signal are filtered in parallel by the corresponding wavelet filter coefficients, producing the better result than up and down-sampling which is required in traditional DWT approach [12].

In comparison with general wavelets, reconstruction of image by lifting wavelet is good because, it increases smoothness and reduces aliasing effects [13]. Employing LWT reduces loss in information, increases intactness of embedded watermark in the image and helps to achieve the reversibility of watermark.

When we transform an image block consisting of integer-valued pixels into wavelet domain using a floating point wavelet transform and the values of the wavelet coefficients are changed during watermark

embedding, the corresponding watermarked image block will not have integer values. When we truncate the floating point values of the pixels, it may result in loss of information and reversibility is lost. The original image cannot be reconstructed from the watermarked image. In conventional wavelet transform done as a floating-point transform followed by a truncation or rounding it is impossible to represent transform coefficients accurately. Information will be potentially lost through forward and inverse transforms. In view of the above problems, an invertible integer to integer wavelet transform based on lifting is used in the proposed scheme. It maps integers to integers which are
preserved in both forward and reverse transforms. There is no loss of information.
Wavelet or subband decomposition associated with finite length filters is obtained by a finite number of primal and dual lifting followed by scaling.

III. ARITHMETIC CODING:

We use the arithmetic coding technique to compress a part of the original image and store the compressed data together with necessary authentication information as the payload. The payload is then embedded within the original image with consideration of the HVS. Due to this, the watermarked image contains no perceptible artifacts. During the extraction phase, we extract the payload, restore the exact copy of the original image and verify the authenticity.

IV. PROPOSED SCHEME

In the proposed approach the watermark data is embedded directly as bytes instead of in bits. The original image is preprocessed by performing integer LWT of the image. Now Integer Wavelet Transform IWT is performed to decompose the image into its components namely
approximate coefficient, Horizontal coefficient, Vertical coefficient and Diagonal coefficient. Now apply the arithmetic coding on these component and then embedd the watermarked data
After embedding the components are combined. Now Inverse integer wavelet transform is taken to obtain the watermarked image. The reverse is done to extract the embedded watermark data. The original image and watermark data are extracted exactly without any loss of data.

1. Perform LWT to decompose the image and obtain the subband approximate, diagonal, horizontal and vertical components namely A, D, H and V.
2. Separate the D,H and V components.
3. Apply arithmetic coding on the diagonal, horizontal and vertical Components.
4. Embed the watermarked data in coded diagonal, horizontal and vertical Components.
5. Apply inverse LWT will give watermarked image.

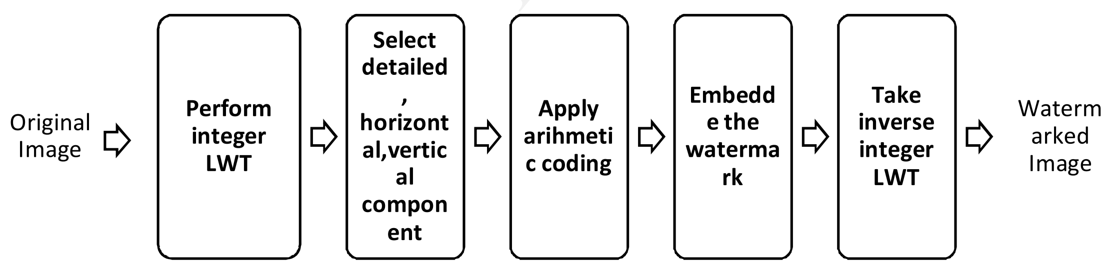

Figure 1 Embedding Method

A. Steps in Embedding

1. Let $R\ \{P\ ,\ P\ ,......Pn\ \}\ 1\ 2 =$ represent the set of all neighboring pixel pairs in one direction and $i\ p$ be a single pair for all i=1 to n.
2. let $\{\ \}\ m\ W W ,W ,......W\ 1\ 2 =$ represent the watermark data where each $\in \{0,1,2,.....,9\}\ \ i\ W$ are used to represent ASCII characters. The same digits can represent Text or image watermark.

Starting with the first pixel pair P1,

1. For each pixel pair Pi , find the minimum of Pi=(Xi,Xi+1), Let the minimum value be Y and the maximum value be Z.
2. Let Q=Z/2 and if Y > Q then the pixels Pi are expandable. Else search for the next expandable pair.
3. Now embed the first watermark data byte W1 directly as the difference between these pixels. Else go to step 1. Embed the byte as differences between the pixels Else go to the next pair.

4. Scan through each pixel pairs and repeat the above process till all watermark data bytes in the set W are embedded.

B. Extraction of Watermark

Extraction of Watermark and Original Image is done through reverse process of the above steps by scanning through the pixel pairs in the entire image .

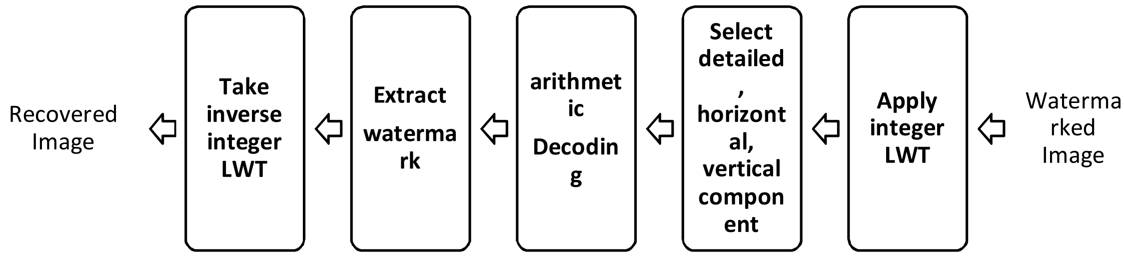

Figure 2 Extraction Method

V. EXPERIMENTAL RESULTS

For demonstrating the performance of the proposed watermarking algorithm following measures are carried out, A performance measuring parameter PSNR is estimated. The embedding capacity and the quality of the watermarked image are represented by bit per pixel (bpp) and PSNR in decibels, respectively. To explore the performance of the proposed algorithm, experiments are performed on gray scale 'lena'images of size 512x512 and color 'car' image of size 256x256.

Table I&II shows the image quality in PSNR for various wavelet families on the commonly used images. Some wavelets show better performance than others. For (ex) db, cdf, haar wavelets show higher performance than others.

Table I&II: Image Quality Tested for Grayscale lena and color car Images for each payload using different wavelet families

GRAYSCALELENA	**IMAGE**
Lifting Schemes	PSNR
lazy	28.17
haar	31.48
db1	31.48
db2	31.12
db3	30.67
Cdf1.1	31.48
Cdf1.3	31.48
Cdf1.5	31.35
Cdf2.2	33.20
Cdf2.4	33.15
Cdf2.6	33.19
Cdf4.2	28.91
Cdf4.4	30.01
Cdf4.6	30.28
Cdf6.2	22.82
Cdf6.4	24.88
Cdf6.6	25.57

Table I

CLR CAR IMAGE	
Lifting Schemes	PSNR
Lazy	28.32
Haar	31.64
db1	31.64
db2	31.82
db3	31.39
Cdf1.1	31.64
Cdf1.3	31.64
Cdf1.5	31.59
Cdf2.2	32.375
Cdf2.4	32.02
Cdf2.6	32.14
Cdf4.2	29.57
Cdf4.4	30.01
Cdf4.6	30.29
Cdf6.2	24.85
Cdf6.4	26
Cdf6.6	25.57

Table II

(a) (b)

Figure1: Original and Watermarked grayscale lena Image a) Original image b)33.20db watermarked image using cdf2.2 wavelet.

(a) (b)

Figure2: Original and Watermarked color car Image a) Original image b) 32.75db watermarked image using cdf2.2 wavelet.

VI. CONCLUSION

We present a reversible watermarking technique with higher embedding capacity. The experimental results show that our proposed algorithm is better, since it allows for a higher capacity for almost all images and better PSNR compared to the other methods proposed so far. The most important feature of our proposed algorithm is the consideration of the HVS during embedding, and hence the artifacts are completely imperceptible The experimental results prove that the proposed algorithm is better than the existing algorithms. The proposed method also can be used for color images. It also works on both smooth and textured images.

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