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Analysis of Wavelet Le Gall 5/3 transform in Image Watermarking

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Abstract— **The increasing importance of digital media brings new challenges, as it is now straightforward to duplicate and even manipulate multimedia content. There is a strong need of security services in order to keep the distribution of digital multimedia work both profitable and reliable for the customer. To overcome these limitations, watermarking comes into picture. Watermarking technology plays an important role in securing the business as it allows placing an imperceptible mark in the multimedia data to identify the legitimate owner; track authorized users via fingerprinting or detects malicious tampering of the document.**

This paper studies the use of wavelet Le Gall 5/3 transform watermarking. The central idea is to find out the performance of using Le Gall 5/3 wavelet transform in image watermarking by observing PSNR and WPSNR. The required background in DWT theory is briefly introduced. Our focus is on invisible watermarks.

DWT Le Gall 5/3 is considered for watermarking and the results are analyzed.

Index Terms— **Watermarking, DWT, PSNR, WPSNR, Le Gall 5/3 transform.**

I. Introduction

Cryptography and steganography have been used in history as means to add secrecy to communications during times of war and peace. As technology developed and detection methods improved, more effective methods of hiding information were developed.With the advent of the Internet, steganography has found new applications. Digital watermarking includes a number of techniques that are used to imperceptibly convey information by embedding it into the cover data [1].

Digital watermarking is the process of embedding information into a digital signal. In visible watermarking, the information is visible in the picture or video. Typically the information is a text or logo, which identifies the owner of the media. In invisible watermarking, information is added as digital data to audio, picture or video, but it cannot be perceived as such. An important application of invisible watermarking is to copyright protection systems, which are intended to prevent or deter unauthorized copying of digital media. In robust watermarking applications, the extracted algorithm should be able to correctly produce the watermark, even if the modifications were strong.

II Discrete Wavelet Transform

Wavelet transform decomposes a signal into a set of basis functions called wavelets. Wavelets are obtained from a single prototype wavelet y (t) called mother wavelet by dilations (scaling) and translations (shifting) [4].

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) \quad (1)$$

In “(1)” ‘a’ is the scaling parameter and ‘ b’ is the shifting parameter.

A. The DWT of an Image

The procedure goes like this. A low pass filter and a high pass filter are chosen, such that they exactly halve the frequency range between themselves. This filter pair is called the Analysis Filter pair. First, the low pass filter is applied for each row of data, thereby getting the low frequency components of the row. But since the lpf is a half band filter, the output data contains frequencies only in the first half of the original frequency range. So, by Shannon's Sampling Theorem, they can be subsampled by two, so that the output data now contains only half the original number of samples. Now, the high pass filter is applied for the same row of data, and similarly the high pass components are separated, and placed by the side of the low pass components. This procedure is done for all rows. Next, the filtering is done for each column of the intermediate data. The resulting two-dimensional array of coefficients contains four bands of data [3], each labeled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high). The LL band can be decomposed once again in the same manner, thereby producing even more sub band**.** The process can then be repeated to compute multiple “scale” wavelet decomposition, as in the 2 scale wavelet transform shown below in figure.

This can be done up to any level, thereby resulting in a pyramidal decomposition.

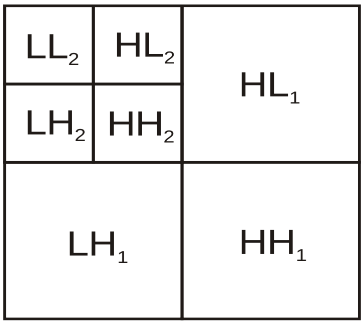

fig 1 : 2 scale 2 dimensional DWT

As mentioned above, the LL band at the highest level can be classified as most important, and the other 'detail' bands can be classified as of lesser importance, with the degree of importance decreasing from the top of the pyramid to the bands at the bottom.

B. Wavelet Le Gall 5/3 Transform

A wavelet Le Gall 5/3 Transform has 5 and 3 taps in the low and high pass analysis filters, respectively [2]. The shortest biorthogonal scaling and wavelet function with 2 regularity factors (or vanishing moments) at analysis and synthesis, denoted (2,2) is attained with The Le Gall 5/3 synthesis scaling function is a linear B-spline, which is the reason for the name spline 5/3.

The Le Gall 5/3 wavelet analysis low-pass filter H_0 (z) and the high pass filter H_1 (z) are shown in " (2)" and "(3)".

$$H_0(z) = \frac{-z^{-2} + 2z^{-1} + 6 + 2z^{1} - z^{2}}{8} \qquad (2)$$

$$H_1(z) = z^{-1}\,\frac{-z^{-1} + 2 - z^{1}}{2} \qquad (3)$$

The synthesis filters are shown in "(4)" and "(5)"

$$G_0(z)= \frac{z^{-1}+2+z^{1}}{2} \qquad (4)$$

$$G_1(z)= z\;\frac{-z^{-2}-2z^{-1}+6-2z^{1}-z^{2}}{8} \qquad (5)$$

Le Gall 5/3 wavelet is the shortest symmetrical (to avoid boundary artifacts) biorthogonal wavelet with two vanishing moments. In addition, it has been shown that the Le Gall 5/3 wavelet has the maximum vanishing moments for its support.

III Methodology

There are many new recently added filters, which operate in the wavelet domain. Effort is being done to implement one of these in the watermarking technique. Analysis is being done to find out the performance of using Le Gall 5/3 in watermarking.

Three different images were taken for the analysis. The images are named as B1, B2 and B3.

Image quality of the watermarked image was observed by finding out the PSNR (peak signal to noise ratio), WPSNR (weighted peak signal to noise ratio).

At the detection stage, the good or bad recovery of the message from the watermarked image was decided by the parameters and the quality of the message observed through visualization.

1.First of all, considering only one image, for different levels of this image, PSNR and WPSNR were observed.

2. For Le Gall 5/3 values of the parameters were observed at different levels and the best-suited level decomposition was decided.

3.Then at that particular level decomposition, the same parameters were found for the other two images also namely B2 and B3.

The images results of only one image are shown in this paper to avoid unnecessary lengthy essay.

IV Performance Metrics

A PSNR

The phrase peak signal-to-noise ratio, abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images *I* and *K* where one of the images is considered a noisy approximation of the other is defined as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left\| I(i,j) - K(i,j)\right\|^2 \qquad (6)$$

PSNR is given as " (7)" or "(8)":

$$PSNR = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right) \qquad (7)$$

$$= 20\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \qquad (8)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with *B* bits per sample, MAX_I is 2^B-1. For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE (mean squared error) is the sum over all squared value differences divided by image size and by three.

Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, where higher is better. Acceptable values for wireless transmission quality loss are considered to be about 20 dB to 25 dB.

B. Weighted PSNR (WPSNR)

A different quality measurement suggested in [5] is WPSNR. A simple approach to adapt the classical PSNR for watermarking application consist in the introduction of different weights for the perceptually different regions oppositely to the PSNR where all regions are treated with the same weight. "(9)" WPSNR uses an additional parameter called the Noise Visibility Function (NVF) that is a texture masking function as a penalization factor. NVF uses a Gaussian model to estimate how much texture exists in any area of an image.

$$WPSNR = 10 \log_{10}\left(\frac{L_{max}^2}{MSE \times NVF}\right) \qquad (9)$$

$$NVF(i,j) = \frac{1}{1 + \theta\sigma_x^2(i,j)} \qquad (10)$$

In "(10)" $\sigma^2_x(i, j)$ denotes the local variance of the image in a window centered on the pixel with coordinates (i, j) and θ is a tuning parameter corresponding to the particular image.
For flat regions, the NVF (noise visibility function) is close to 1. And for edge or textured regions NVF is more close to 0. This indicates that for smooth image, WPSNR approximately equals to PSNR. But for textured image, WPSNR is a little bit higher than PSNR.

V RESULTS AND DISCUSSION

In this paper, Wavelet Le Gall 5/3 transform has been analyzed. In this work, the hidden data to be embedded in the image was taken to be the 'signatures'. This hidden data is the watermark. MATLAB have been used for finding out the results.
Three images B1, B2 and B3 were taken for the analysis purpose. The message to be embedded is shown in figure 3. The message is in the form of a specimen signature.

Fig 2: Original image B1

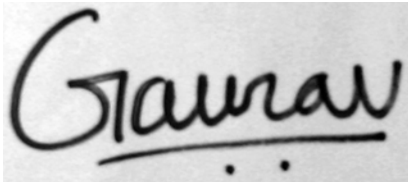

Fig 3: Embedded Message

Firstly, considering only image B1, for different decomposition levels of this image, PSNR and WPSNR were calculated for Le Gall 5/3. It was found that at decomposition level 2, PSNR was better than at level 1. As it can be seen from the table 1, level 2 was preferred over level 1since it showed a higher PSNR and WPSNR. So at level 2 the parameter values were calculated for the three images as shown in table 2. The watermarked images at level 1,2 and 3 are shown in figures 4,5 and 6 respectively.

TABLE 1:
LE GALL 5/3 TRANSFORM AT DIFFERENT LEVELS FOR IMAGE B1.

LEVEL	PSNR (in db)	WPSNR (in db)
1	53.5546	-9.9489
2	68.1673	-0.9740
3	68.1673	-0.9740

Fig 4: Watermarked image for Le Gall 5/3 at level 1

Fig 5: Watermarked image for Le Gall 5/3 transform at level 2

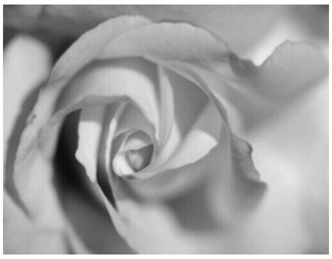

Fig 6: Watermarked image for Le Gall /3 transform at level 3

TABLE 2
PARAMETER VALUES FOR LE GALL 5/3 TRANSFORM AT LEVEL 2

	B1 (512*512)	B2 (512*512)	B3 (512*512)
PSNR (in db)	68.1673	66.2328	66.0766
WPSNR (in db)	-0.9740	-1.8600	-1.9533

PSNR should be high to ensure good image quality.
For image B1, Le Gall 5/3 showed a PSNR value of 68.1673 db.
Similarly for WPSNR Le Gall 5/3 showed a value of –0.9740 db.

Fig 7: Recovered Message

The recovered message showed a PSNR value of 4.1022 db and WPSNR value of –39.8112db.

VI CONCLUSION AND FUTURE SCOPE

It has been observed from this work that if there is a requirement of quality of watermarked image, then Le Gall 5/3 showed good values of PSNR and WPSNR at decomposition level 2 and above as compared to level 1.
Taking other transforms such as DCT, wavelet CDF 9/7 and lifting wavelet transform could do the related work. One method of embedding and extracting of Digital watermark is by using of palette images. It has been found that it helps in saving storage space and reduces transmission time.
The studies can be extended further by different type of embedded images (such as infrared images) and by improving the quality of the embedded image.

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