ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 05, pp.50326-50329, May, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

WATERMARKING USING DISCRETE WAVELET TRANSFORM (DWT)

***Sureshkumar Natarajan and Sneha Raju Das**

Department Electronics and Telecommunication, Vishwaniketan Institute of Management Entreprenuership and Engineering Technology, India

ARTICLE INFO

Article History:
Received 21st February, 2017
Received in revised form
17th March, 2017
Accepted 22nd April, 2017
Published online 23rd May, 2017

Key words:
Discrete Wavelet Transform, Sub bands, Multiresolution, Image Decomposition, PSNR.

ABSTRACT

Amongst the existing techniques of employing digital Watermarking into an image the proposed paper imposes on one of the most efficient methods, called the DWT method which is counted as a vital tool by researchers. The idea of the proposed paper is to hide the actual image beneath a cover image before transmission, to protect the main information from piracy (Md. Maklachur Rahman, 2013). This is achieved by decimating the main image elements by a factor c with respect to the cover image. The true receiver of this encoded information on the other end subjects it to an extraction algorithm to detach the cover image from the main image. The image is first decomposed into sub bands of varying frequencies using the method of Discrete Wavelet Transform (DWT), followed by inducing watermark into the lower frequencies (LL Band) to secure data over the network. This emphasizes on the bandwidth efficiency of the image. The peak signal-to-noise ratio calculated in this paper is a proof of the level of effective reconstruction of the image, as it is the objective of any data transmission and reception.

Citation: Sureshkumar Natarajan and Sneha Raju Das. 2017. "Watermarking using discrete wavelet transform (dwt)", *International Journal of Current Research*, 9, (05), 50326-50329.

INTRODUCTION

The extensive growth in technology has given birth to a new generation of people whose lives are thought of to be impossible without the latest gadgets and electronic devices which have made the human life far more comfortable and easy at hand. All of these deal with a huge amount of data among which, a few of them are highly confidential and need to be secured. With such rapid advancements, the problems of piracy and measures of security is a great deal in today's world. With a view to contribute towards such problems various techniques have been researched and worked upon. One among such techniques is the Watermarking which can again be implemented using various methods like the Discrete Cosine transform (DCT), Singular Value decomposition (SVD) and many more. But the Watermarking technique using Discrete Wavelet Transform (DWT) is the latest technique which is discussed to be the most efficient technique among the rest in terms of compression.

Advantage of Wavelet Transform over Fourier Transform: Since the late 1950's the Fourier Transform has been used as the main tool for transform based processing of images However, the newly emerged technique called as the Wavelet Transform has made compression, transmission and analysis of images easier.

***Corresponding author:** **Sureshkumar Natarajan,**
Department Electronics and Telecommunication, Vishwaniketan Institute of Management Entreprenuership and Engineering Technology, India.

Secondly, the reconstruction or synthesis of the image after subjecting it to various processing is accurate without loss of information whereas, the Fourier Transform provides only frequency details which are temporal and can be lost when the image is subjected to transformation process.

Discrete Wavelet Transform (DWT): The concept of Wavelet Transforms is developed on the basis of small waves called as the wavelets, hence the name Wavelet Transform. It has been identified as a powerful tool in signal processing that supports Multiresolution theory of images. The nomenclature Multiresolution is because the image is analyzed and represented at more than one resolution. The Multiresolution theory is the idea of unifying various techniques from various interests like sub band coding from signal processing, quadrature mirror filtering from digital speech recognition and pyramidal image processing (Rafael C. Gonzalez, Richard E. Woods). This supports the fact that an image is a 2D array of pixel intensities that vary across the image to form various edges and homogenous regions. In the proposed paper the image is decomposed into various bandlimited frequency regions so as to reassemble the frequency fragments to synthesize the original image without any error. The decomposition and reconstruction processes are achieved using digital filters and decimators. The significance of the Wavelet Transform is that it is sensitive to row, column and diagonal variations that give the measure of intensity variations along the horizontal, vertical and diagonal edges of the image.Consider an image $f(x,y)$ of size $M \times N$. For a 2D DWT let the Scaling function be $\varphi(x,y)$, 2D wavelet along horizontal be $\Psi^{H}(x,y)$, vertical be $\Psi^{V}(x,y)$and diagonal be $\Psi^{D}(x,y)$ where each function is the product of one-dimensional result. So,

$$\varphi(x,y) = \varphi(x)\varphi(y) (1)$$

$$\Psi^{H}(x,y) = \Psi(x)\varphi(y) \quad (2)$$

$$\Psi^{V}(x,y) = \varphi(x)\Psi(y) (3)$$

$$\Psi^{D}(x,y) = \Psi(x)\Psi(y) (4)$$

Now the Two-Dimensional Discrete Wavelet Transform for an image is given by

$$W_{\varphi}(j_{0,}m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\varphi_{j_0,m,n}(x,y) \quad (5)$$

$$W_{\Psi}^{i}(j_{,}m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\Psi_{j,m,n}^{i}(x,y) (6)$$

where $i = \{H, V, D\}$

Two-Dimensional inverse Discrete Wavelet Transform is given by

$$f(x,y) = \frac{1}{\sqrt{MN}} \sum_{m} \sum_{n} W_{\varphi}\left(j_{0,m,n}\right)\varphi_{j_0,m,n}(x,y) + \frac{1}{\sqrt{MN}} \sum_{i=H,V,D} \sum_{j=j_0}^{\infty} \sum_{m} \sum_{n} W_{\Psi}^{i}(j,m,n)\Psi_{j,m,n}^{i}(x,y) \ (7)$$

Following is the block diagram of the single level 2D Wavelet Transform, first by applying 1D Wavelet Transform along the rows which we call as the row operation followed by another 1D transform along the column called as the column operation.

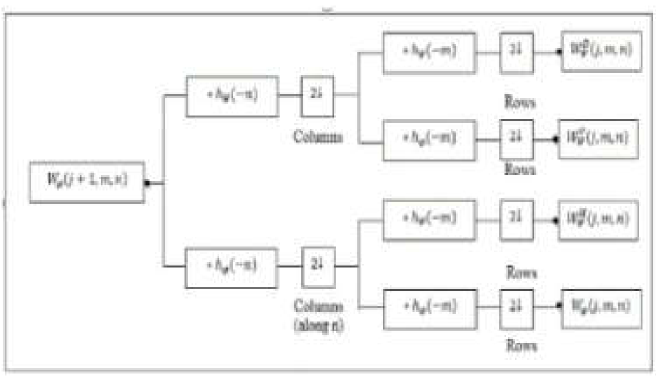

Fig.1. Block diagram of single level 2D Wavelet Transform

In the block diagram above, an image having a 2D array of pixels is passed through the first bank of filters with a low pass filter on the top and a high pass filter at the bottom. Each of these filters filter out the low and high frequencies of the image respectively and the filtered values are given to the down counter also called as the decimator which samples out alternative values for the next stage of decomposition. This completes the column operation. The sampled values of low and high frequencies are again passed through a couple of low and high pass filer sets and then through the corresponding decimators along the rows to give a set of four different values of frequency bands, each carrying their own significance as shown. This completes the single level decomposition of the image (Asna Furqan, Munish Kumar, 2015).

$W_{\Psi}^{D}(j,m,n)$ = LL Band = approximate / average of LPF values

$W_{\Psi}^{V}(j,m,n)$ = LH Band = horizontal details
$W_{\Psi}^{H}(j,m,n)$ = HL Band = vertical details
$W_{\varphi}(j,m,n)$ = HH Band = diagonal details

These values can again be decomposed using another set of filter banks and this stage will be said to be the second level decomposition of the image. So, the idea of the proposed paper is to induce watermarking into the LL band as it consists of almost the vital part of information of the image. Neglecting the other three bands will not keep us from obtaining accurate results. Another reason for not applying watermark into the higher frequencies is due to the fact that the higher frequencies are lost while image compression and scaling and it is very less immune to distortions caused by various signal processing techniques. While the idea of embedding watermark into higher frequencies has so many disadvantages, there still exists one advantage. Introducing watermark into higher frequencies gives a better quality of image as they contain the finer details of the image.

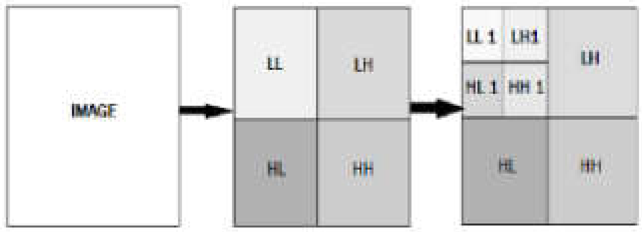

Fig.2. Frequency sub band second level decomposition of an image (Asna Furqan and Munish Kumar, 2015)

The idea of decomposing the image into various sub bands paves the way for watermarking different frequencies as watermarking applied to different frequencies have their own significance in robustness against a separate set of instances. While each of them have their advantages and disadvantages, inducing watermark into the lower frequencies (LL band) makes the image robust against low pass characteristics such as lossy compression, JPEG compression, filtering, wiener filtering, Gaussian noise, scaling and cropping and inducing watermark into the higher frequencies (HH band) makes it robust against high pass characteristics such as image histogram, histogram equalization, brightness and contrast changes and gamma correction (Alexander Sverdlov *et al.*,).

Watermarking using DWT Technique:

Algorithm:

Step1: An image which is to act as the cover image is stored into a variable.
Step2: The image is converted into gray scale and resized.

Step3: Two-dimensional DWT is performed using the HAAR transform. This is the single decomposition of the cover image.
Step4: Another stage of decomposition called the second level decomposition is applied to the lower frequency values of the image that are obtained after the first level decomposition.
Step5: Steps 1 to 4 are again performed over another image which is the key image to be protected.
Step6: Watermarking is embedded into the image by scaling the lower frequencies of the key image by a constant value 0.0001 with respect to the same level frequencies of the cover image.
Step7: Inverse DWT is performed over the watermarked image to convert it from the frequency domain into pixel domain to enable the picture to be visualized.Fig.3. indicates the flowchart of how watermarking of the image is done using DWT technique.

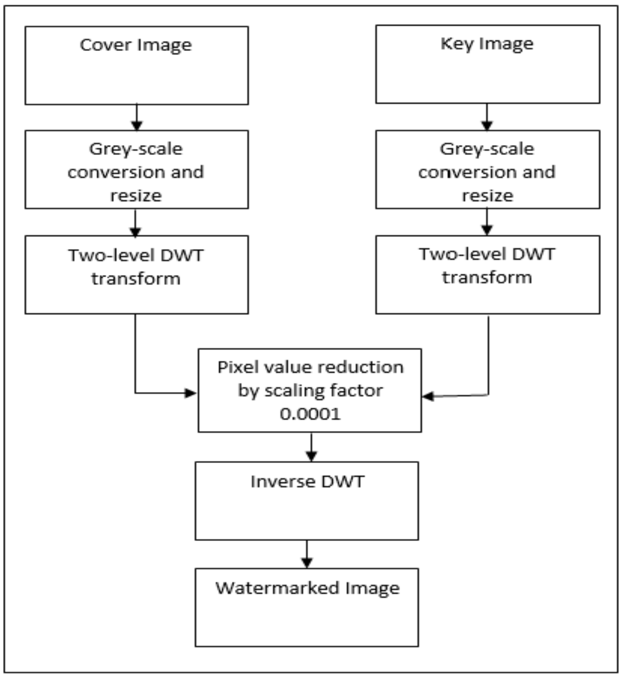

Fig.3. Flowchart indicating watermarking using DWT technique

Extraction of the Watermarked Image

Algorithm:

Step1: A two-level 2D DWT is performed over the watermarked image to decompose it into various frequencies.
Step2: The scaling factor is withdrawn and the lower frequencies of the cover image are parted from the key image. With this, the pure form of key image is obtained.
Step3: This image is now subjected to inverse DWT to enable it to be visualized.

Fig.4. indicates the flowchart of how to extract the original from the watermarked image.

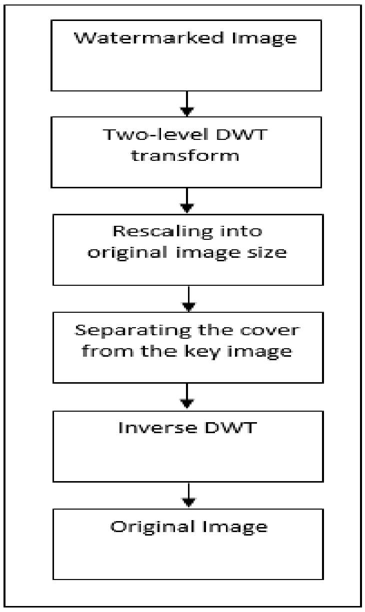

Fig.4. Flowchart indicating extraction of original image from the watermarked image

PSNR Calculation

The PSNR computes the peak signal-to-noise ratio in decibels between two images. This ratio is often used as a quality measurement between the original image and the reconstructed image. Higher the PSNR, better is the quality of the reconstructed image. PSNR is given in the equation (8).

$$10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (8)$$

where, MSE – Mean Square Error

$$MSE = \frac{\left(\sum_{X=1}^{M}\sum_{y=1}^{N}\left(f^\wedge(x,y) - f(x,y)\right)\right)}{(M \times N)}$$

where, $f(x,y)$is the noise-free image and $f^\wedge(x,y)$ is the filtered or the reconstructed image.

EXPERIMENTAL RESULTS

Figure (a) shows the cover image used to secure theactual image. Figure (b) shows the actual imagewhich is to be secured over the transmission. Figure(c) shows the Watermarked image that carries the actual image hidden beneath the cover image that is made visible. Figure (d) shows the Original actual image after extracting it from the cover image.

(a)Cover Image

(b)Key Image

(c)Watermarked Image

(d)Extracted Image

Fig.5. (a) to (d) shows the experimental results

Conclusion

The proposed paper gives a detailed description of image watermarking technique using DWT transform and is a proof of high efficiency of the transform in terms of excellent image compression and reconstruction of the original image from the watermarked image. The resulting peak signal-to-noise ratio has been calculated and has been proved to be better than other PSNRs comparatively, as higher the PSNR, better is the image quality after reconstruction, which is the objective of any safe transmission.

As watermarking is concentrated into the lower band of image frequencies, the effective bandwidth efficiency is taken care of by this method. The value of PSNR which we obtained in this paper is 39.2401. Hence the proposed method is concluded to be a reliable means of safer transmission and reception of information.

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