ISSN 2395-695X (Print)
ISSN 2395-695X (Online)
Available online at www.ijarbest.com

International Journal of Advanced Research in Biology Ecology Science and Technology (IJARBEST)
Vol. I, Special Issue I, August 2015 in association with VEL TECH HIGH TECH DR. RANGARAJAN DR. SAKUNTHALA ENGINEERING COLLEGE, CHENNAI
National Conference on Recent Technologies for Sustainable Development 2015 [RECHZIG'15] - 28th August 2015

DETECTION OF WATERMARK IMAGES USING DISCRETE WAVELET TRANSFORM

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ABSTRACT

A watermark is a technique to identify image which appears in various shades when it is viewed by transmission of light which is caused by thickness or by density of variations that is present in the paper. In many analysis like numerical, functional analysis, a discrete wavelet transform (DWT) is used to detect the invisible images. It is a wavelet transform in which the wavelets are sampled and analyzed discretely. In other words the wavelet transforms, has a key advantage that it captures both frequency *and* location information that are hidden in the image. This paper illustrate the detection of non-visible watermarked images using a popular watermarking techniques, called" DISCRETE WAVELET TRANSFORM" .Based on some of the predefined rules the discrete set of wavelet is implemented and translated to obtain the images which are hidden.

Introduction

Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Wavelets are an extremely useful tool for coding images and other real signals. Because the wavelet transform is local in both time (space) and frequency, it localizes information very well compared to other transforms. Wavelets code transient phenomena, such as edges, efficiently, localizing them typically to just a few coefficients.

This thesis deals with the different types of edge detection techniques, mainly concentrating on the two major categories Gradient and Laplacian. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. The Laplacian method searches for zerocrossings in the second derivative of the image to find edges.

Given the wavelet transforms values wavelet analysis can be done in the wavelet domain by comparison of wavelet coefficients that account for the edges. The detection of the maxima or inflection points is generally a key factor for analyzing the characteristics of the non-stationary signals. The wavelet transformation has been proved to be a very promising technique for the multiscale edge detection applied both to 1-D and 2-D signals.

The dyadic wavelet transforms at two adjacent scales are multiplied as a product function to magnify the edge structures and suppress the noise. Unlike many multiscale techniques that first form the edge maps at several scales and then synthesize them together, we determined the edges as the local maxima directly in the scale product after an efficient thresholding. It is shown that the scale multiplication achieves better results than either of the two scales, especially on the localization performance.

1. 2D Discrete Wavelet Transform

2D Discrete Wavelet Transform (2D DWT) [1, 6] is used in image processing as a powerful tool solving to image analysis, denoising, image segmentation and other. 2D DWT can be applied as a convolution of a selected wavelet function with an original image or it can be seen as a set of two matrices of filters, row and column one. Using a separability property of DWT, the first part of decomposition consists of an application of row filters to the original image. The column filter are used for further processing of image resulting from the first step. This image decomposition [1] can by mathematically described by Eq. (1)

$$\mathbf{C} = \mathbf{X} \cdot \mathbf{I} \cdot \mathbf{Y}$$

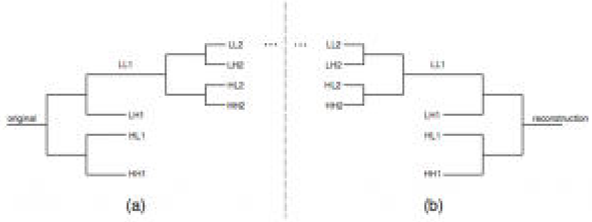
where $\mathbf{C}$ is the final matrix of wavelet coefficients, $\mathbf{I}$ represents an original image, $\mathbf{X}$ is a matrix of row filters and \textbf{Y} is a matrix of column filters.

In the first level of decomposition of 2D DWT, the image is separated into four parts. Each of them has a quarter size of the original image [6]. They are called approximation coefficients (LowLow or LL), horizontal (LowHigh or LH), vertical (HighLow or HL) and detail coefficients (HighHigh or HH) [2, 6], see Fig.1. Approximation coefficients obtained in the first level can be used for the next decomposition level. Inverse 2D Discrete Wavelet Transform used in image reconstruction is defined by Eq. (2)

$$\mathbf{I}_{rec} = \mathbf{X}^{-1} \cdot \mathbf{C} \cdot \mathbf{Y}^{-1}$$

For the orthogonal matrices this formula can be simplified into Eq. (3)

$$\mathbf{I}_{rec} = \mathbf{X}^{T} \cdot \mathbf{C} \cdot \mathbf{Y}^{T}$$



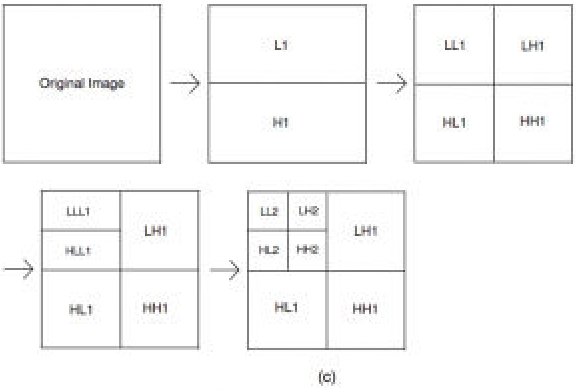


Figure 1: 2D DWT decomposition into two levels: (a) Image decomposition, (b) Image reconstruction, (c) Scheme of decomposition up to the second level

2. Edge Detection Methods Using Wavelet Transform

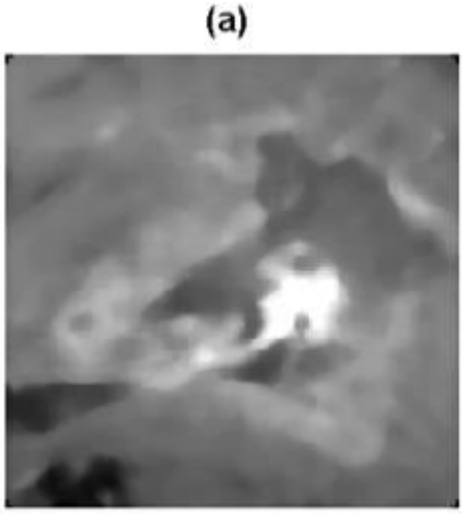
This paper deals with several methods of edge detection using wavelet transform. MRI images were processed by mentioned methods. Image thresholding and median filtering were used for images preprocessing. Daubechies, Symlet and Coiflet function families were studied in the treatment of real images.

2.1 Simple Method Using Modification of Approximation Coefficients

2D DWT decomposition separates an image into the four parts, each of them contains different information of the original image. Detail coefficients represent edges in the image, approximation coefficients are supposed to be a noise. A proper modification of approximation coefficients is the easiest way for edge detection.

2.1.1 Approximation coefficients replaced by zeros

The principle of the simplest method of edge detection is based on replacing of all approximation coefficients by zeros. This modification removes low frequencies from the image. The image is reconstructed using only the remaining wavelet coefficients. By means of this method the most expressive edges are found.



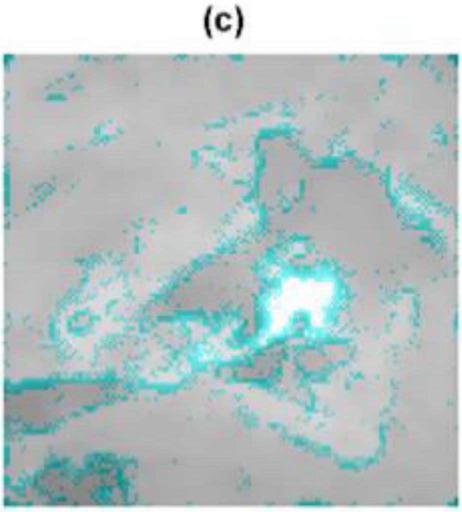


Figure 2: MR image – an area with a brain tumor: (a) Original image, (b) Edges found by replacing approximation coefficients by zeros (using Haar wavelet function), (c) Edges projection into the original image

2.1.2 Modification of approximation coefficients by simple edge detectors

Another method of edge detection is a modification of approximation coefficients by other simple edge detector such as Canny, Sobel, Prewitt, etc. [3]. The simple detector is applied to the approximation coefficients obtained in the first level of decomposition. The image is reconstructed from remaining coefficients and from modified approximation coefficients. This method provides sufficient results, especially with Canny detector use.

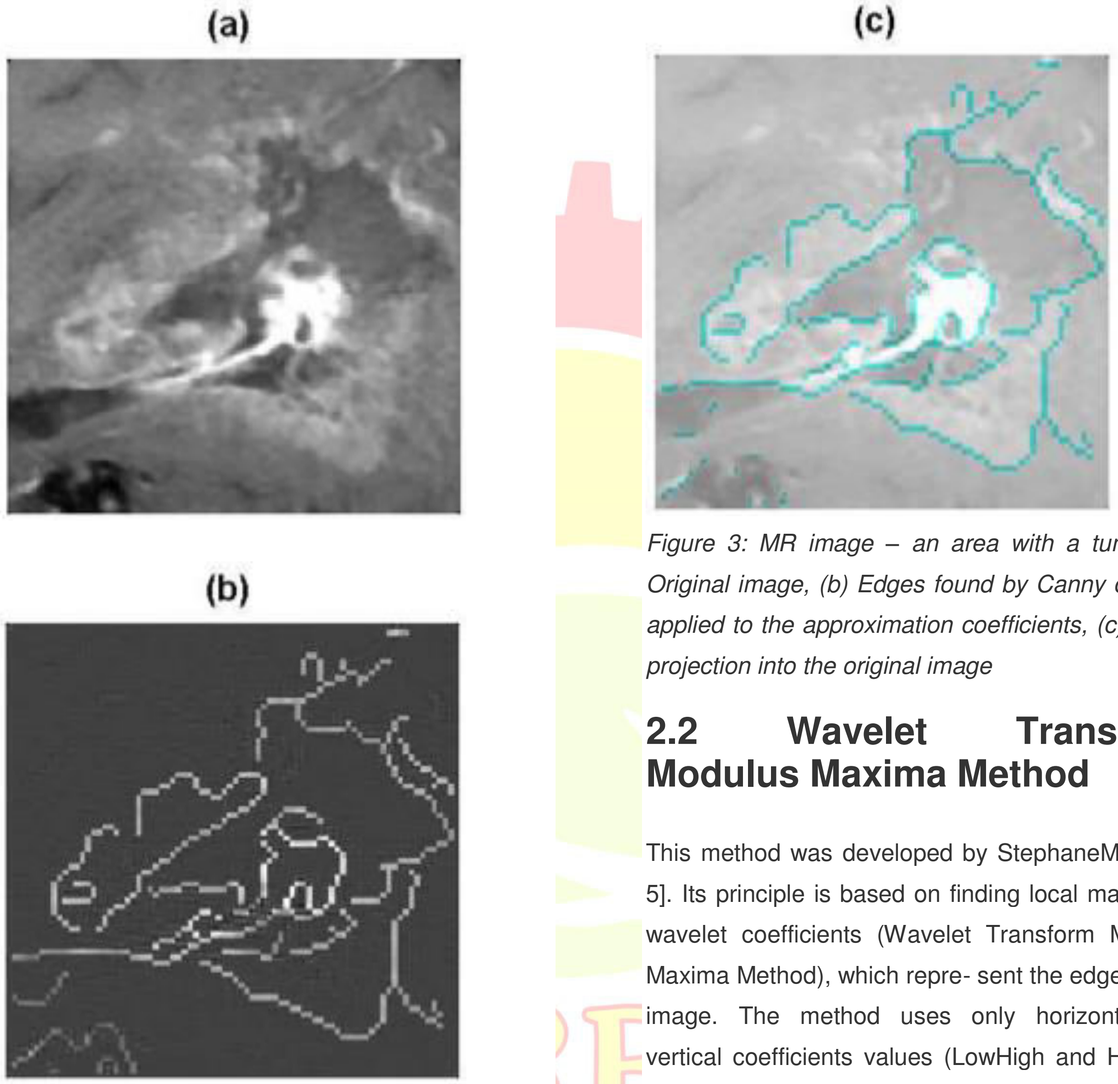


Figure 3: MR image – an area with a tumor: (a) Original image, (b) Edges found by Canny detector applied to the approximation coefficients, (c) Edges projection into the original image

2.2 Wavelet Transform Modulus Maxima Method

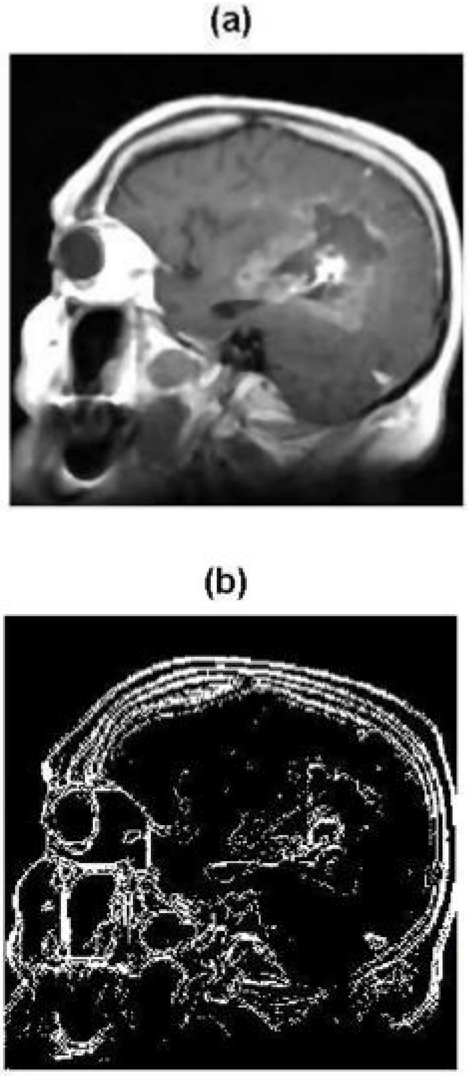
This method was developed by StephaneMallat [4, 5]. Its principle is based on finding local maxima of wavelet coefficients (Wavelet Transform Modulus Maxima Method), which repre- sent the edges in the image. The method uses only horizontal and vertical coefficients values (LowHigh and HighLow coefficients 1) from each level of wavelet decomposition. Wavelet transform modulus is defined by Eq. (4)

$$f(u,v,2^j) = \sqrt{|W^1 f(u,v,2^j)|^2 + |W^2 f(u,v,2^j)|^2}$$

for each pair of horizontal and vertical coefficients $|W^1 f(u,v,2^j)|^2$ a $|W^2 f(u,v,2^j)|^2$ at the same position in matrices. A matrix of the gradient angles for the same pairs of coefficients is evaluated according to Eq. (5)

$$\alpha = \arctan\left(\frac{W^2 f(u,v,2^j)}{W^1 f(u,v,2^j)}\right)$$

Points in the original image for which values of $Mf(u, v, 2^j)$ are local maxima in one-dimensional neighborhood in the direction of gradient are supposed to be edge pixels. These points are distributed according the boundary of important structures in the image. To recover edges, found individual maxima are chained.



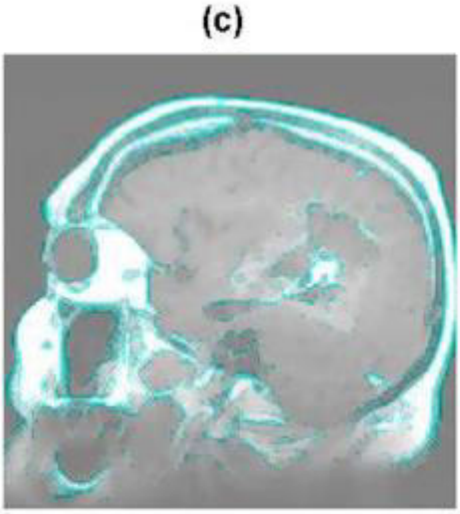


Figure 4: MR image: (a) Original image, (b) Edges found by wavelet maxima using Haar wavelet function, (c) Edges projection into the original image

3. Results

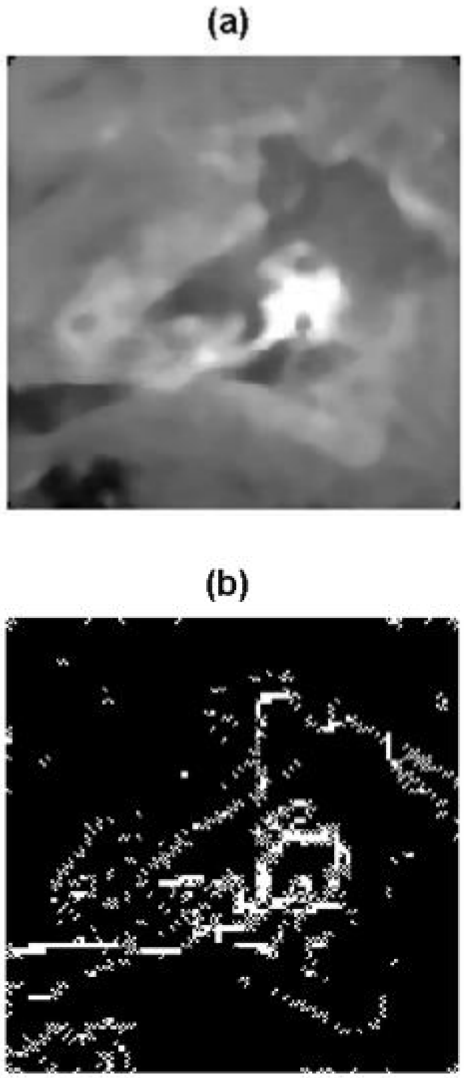
A comparison of edge detection methods is not easy because of difficult edge determination in the image. Especially in the medical images there is a lot of textures in the image background that makes this task ambiguous. Rating of each method is attitudinal. Methods mentioned in part 2 were tested in the set of the MR images using different wavelet functions.

Methods which use a modification of approximation coefficients, provide the simplest way to edge detection using wavelet transform. A method using approximation coefficients replacing by zeros finds edges well but edges are bad located, see Fig. 2. This method also locates a lot of false edges coming from textures in the image background.

The method that applies simple detector to approximation coefficients provides better results; a dependency upon a detector used must be mentioned, as well. Gradient detectors, such as

Sobel or Prewitt, return acceptable edges but these edges are bad located, again the best results are provided by Canny detector, see Fig. 3.

The Wavelet Transform Modulus Maxima Method finds edges in all directions in image. Its results seems to be not sufficient for edge detection. Although the comparison between directions of gradient has been set up very leniently, edges found are not connected, see Fig. 4, 5. A complex wavelet function use could help to improve results of edge detection in real images.



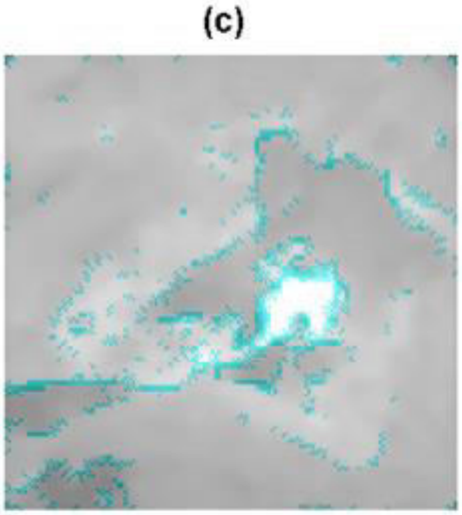


Figure 5: MR image – an area with the tumor: (a) Original image, (b) Edges found by wavelet maxima using Haar wavelet function, (c) Edges projection into the original image

Conclusion

The thesis deals with the comparison of edge detection of images using traditional edge detection operators (Prewitt, Sobel, Frei-chen and Laplacian of Gaussian) and Discrete Wavelet Transformation (DWT) using Haar, Daubechies, Coifman and Biorthogonal wavelets. It also deals with the edge detection of noisy images and the optimization of the wavelets for edge detection.

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