A Review on Wavelet based Compression using Medical Images

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ABSTRACT: Image compression is a method through which we can reduce the storage space of images, videos and is helpful to increase storage and transmission process's performance. Wavelet based Image Compression scheme is used to compress the images which helps to reduce the size of images. The method uses different metrics such as peak signal to noise ratio, mean squared error, & percentage compression rate measured the performance to compare the results. The aim of compression is to achieve good quality compressed image making the storage and transmission more efficient. This paper studied the image compression comparison based on wavelets using different medical images and identified the best appropriate wavelet transform.

Keywords: Image Compression, Wavelet, Haar, Daubechies, Biorthogonal, Coiflet.

I. INTRODUCTION

With the increasing development and demand of multimedia products, the issue of insufficient bandwidth of network and storage of memory device are found. So the data compression becomes more and more significant for reducing the data redundancy to save more hardware space and transmission bandwidth. In computer science and information, data compression or source coding is the process of encoding information using fewer bits or other information-bearing units than an unencoded representation. Compression is used because it helps to reduce the consumption of expensive resources such as hard disk space or transmission bandwidth.

The basic goal of image data compression is to reduce the bit rate for transmission and storage while either maintaining the original quality or providing an acceptable fidelity. Image compression involves reducing the size of image files, while retaining necessary information. The resultant image is called the compressed image and is used to reconstruct the image which results as the decompressed image. Image Compression, the art and science of reducing the amount of data required to represent an image is one of the most useful and commercially successful technologies in the field of digital image processing. The number of images that are compressed and decompressed daily is staggering, and the compressions and decompressions themselves are virtually invisible to the user.

Image compression addresses the problem of reducing the amount of data required to represent a digital image. It is a process that intend to compact representation of an image by reducing the image storage or transmission requirements. The goal of image compression is to reduce the image file size without affecting the quality of an image. The term data compression refers to the process of reducing the amount of data requirement to represent a given quantity of information. In this definition, data and information is not the same thing; data means by which information is conveyed. Because various amounts of data can be used to represent the same amount of information and representations that contain repeated or irrelevant information are said to contain redundant data.Let *b* and *b'* denote the number of bits in two representations of the same information, the relative data redundancy *R* of the representation with *b* bits isR = 1- $\frac{1}{c}$

Where C, commonly called the compression ratio, is defined as

$$C = \frac{b}{b'}$$

Compression is achieved by the removal of one or more of the three basic data redundancies:

- Coding Redundancy
- Interpixel Redundancy

- Psychovisual Redundancy

Coding redundancy is present when less than optimal code words are used. Interpixel redundancy results from correlations between the pixels of an image. Psycho visual redundancy is due to data that is ignored by the human visual system (i.e. visually non essential information). The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the visual quality of the reconstructed image as close to the original image as possible.

Image compression systems are composed of two distinct structural blocks: an encoder and a decoder. As shown in the fig 1, the encoder is responsible for reducing the coding, interpixel and psycho visual redundancies of input image. In first stage, the mapper transforms the input image into a format designed to reduce interpixel redundancies. The second stage, qunatizer block reduces the accuracy of mapper's output in accordance with a predefined criterion. In third and final stage, a symbol decoder creates a code for quantizer output and maps the output in accordance with the code. These blocks perform, in reverse order, the inverse operations of the encoder's symbol coder and mapper block. As quantization is irreversible, an inverse quantization is not included.
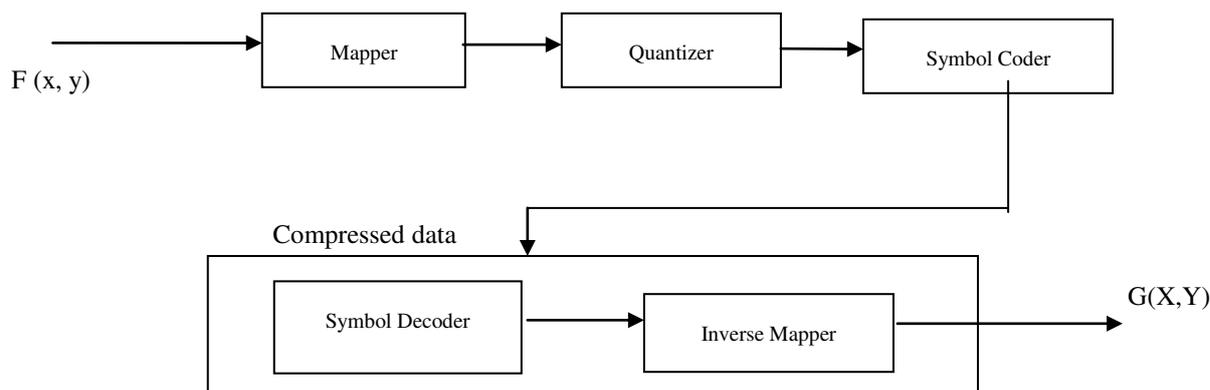
Figure 1: Functional Block Diagram of an Image Compression System

A. Need of compression

In a raw state, image can occupy a large amount of memory both in RAM and in storage. Image compression reduces the storage space required by an Image and the bandwidth needed when streaming that image across a network.

B. Benefits of compression

- It provides a potential cost savings associated with sending less data over switched telephone network where cost of call is really usually based upon its duration.
- It not only reduces storage requirements but also overall execution time.
- It also reduces the probability of transmission errors since fewer bits are transferred.
- It also provides a level of security against illicit monitoring.

C. Medical Imaging

Medical imaging is the technique and process used to create images of the human body (or parts and function thereof) for clinical purposes (medical procedures seeking to reveal, diagnose, or examine disease) or medical science (including the study of normal anatomy and physiology). Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are not usually referred to as medical imaging, but rather are a part of pathology. As a discipline and in its widest sense, it is part of biological imaging and incorporates radiology (in the wider sense), nuclear medicine, investigative radiological sciences, endoscopy, (medical) thermography, medical photography, and microscopy (e.g. for human pathological investigations). A majority of diagnostic imaging centers are located in California, followed by Texas and Florida.

Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography (EEG), magneto encephalography (MEG), electrocardiography (EKG), and others, but which produce data susceptible to be represented as maps (i.e., containing positional information), can be seen as forms of medical imaging. Up until 2010, 5 billion medical imaging studies had been conducted worldwide. Radiation exposure from medical imaging in 2006 made up about 50% of total ionizing radiation exposure in the United States.

In the clinical context, "invisible light" medical imaging is generally equated to radiology or "clinical imaging" and the medical practitioner responsible for interpreting (and sometimes acquiring) the images are a radiologist. "Visible light" medical imaging involves digital video or still pictures that can be seen without special equipment. Dermatology and wound care are two modalities that utilize visible light imagery. Diagnostic radiography designates the technical aspects of medical imaging and in particular the acquisition of medical images. The radiographer or radiologic technologist is usually responsible for acquiring medical images of diagnostic quality, although some radiological interventions are performed by radiologists. While radiology is an evaluation of anatomy, nuclear medicine provides functional assessment.

II. WAVELET BASED IMAGE COMPRESSION

A wave is an oscillating function of time or space and is periodic. In contrast, wavelets are localized waves [1]. Wavelet means a "small waves". The smallness implies to a window function of finite length. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. A wavelet is a waveform of effectively limited duration that has an average value of zero. Wave in itself refers to the condition that this function is oscillatory [4]. Wavelets are mathematical tools for hierarchically decomposing functions. Wavelet Transform has been proved to be a very useful tool for image processing in recent years. It allows a function which may be described in terms of a coarse overall shape, plus details that range from broad to narrow [3].

Wavelets are mathematical functions which help in describing the original image into an image in frequency domain, which can further divided into sub band images of different frequency components. Each component is studied with a resolution matched to its scale [2]. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale [10].

The fundamental idea behind wavelets is to analyze according to scale. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. In wavelet analysis, the scale that we use to look at data plays a special role. Wavelet algorithms process data at different scales or resolutions. If we look at a signal with a large "window," we would notice gross features. Similarly, if we look at a signal with a small "window" we would notice small features. There are many members in the wavelet family, a few of them that are generally found to be more useful, are as per the following Haar wavelet is one of the oldest and simplest wavelet. Therefore, any discussion of wavelets starts with the Haar wavelet. Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in numerous applications.

Haar- This wavelet is discontinuous, and resembles a step function.
Coiflets- The wavelet function has 2N moments equal to 0 and the scaling function has 2N-1 moments equal to 0. The two functions have a support of length 6N-1.
Symlets- The symlets are nearly symmetrical wavelets. The properties of the two wavelet families are similar.
Meyer - The Meyer wavelet and scaling function are defined in the frequency domain.
Biorthogonal- This family of wavelets exhibits the property of linear phase, which is needed for signal and image reconstruction. By using two wavelets, one for decomposition (on the left side) and the other for reconstruction (on the right side) instead of the same single one, interesting properties are derived.
Daubechies- Daubechies are compactly supported orthonormal wavelets and found application in DWT. Its family has got nine members in it [4].

III. COMPARATIVE STUDY

It has been already explained that the Image Compression is of two types, lossy and lossless. Different Scientists have put their work in the field of compression. Our first problem is to select the most appropriate wavelet transform for a

medical image compression. In this, we are going to analyze the behaviour of different type of wavelet transforms with different type of medical images and identify the most appropriate wavelet transform that can perform optimum compression for a given medical images. Thus, the problem taken for this research work is divided into some objectives which are as follows.

A. **Objectives:**
- Study of Image Compression.
- Study of different wavelet transformation.
- Pointing out the pros and cons of the wavelet transformations.
- Comparison of all different wavelet transformations.

B. Comparison Model

The comparison model focuses on the above objectives which are helpful to find the most appropriate wavelet transform that can perform optimum compression. In this paper, we have studied the performance of different wavelet transforms on different medical images. Fig 2 shows the basic design of the comparison model.
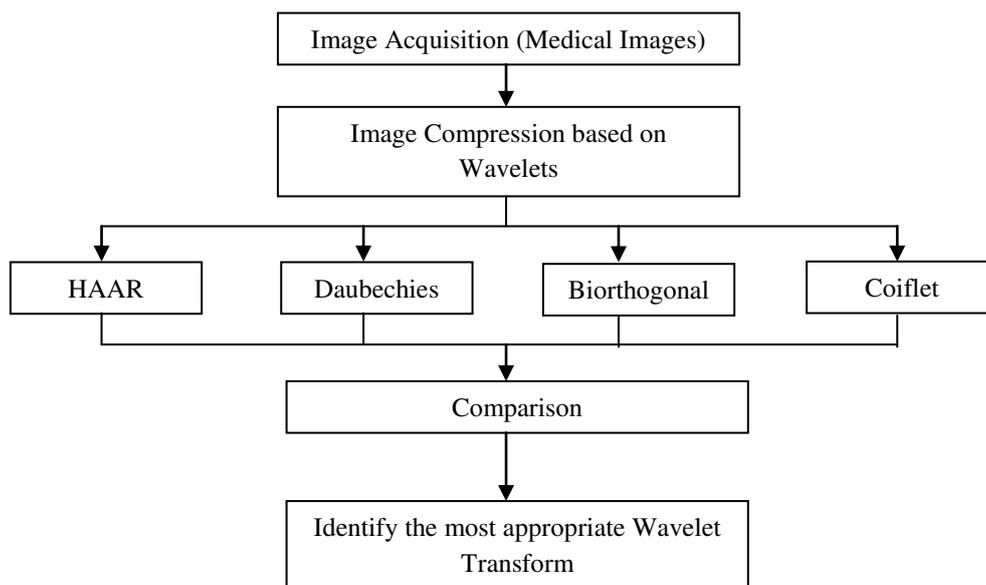
Figure 2: Basic Design of Comparison Model

There are number of phases while we are studying the image compression based on different wavelets. They are:

C. Image Acquisition:
The first stage of any compression system is the image acquisition stage. After the image has been obtained, various methods of processing can be applied to the image to perform the many different tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable. In this phase a number of samples are collected which are different type of medical images that is CT Scan, ECG, Fundus, Infrared Image, Mammography, MRI, US Image and X-Ray images.

D. Image Compression based on Wavelets:
There are different members in the wavelet family, Haar wavelet is one of the oldest and simplest wavelet. Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in numerous applications. The Haar, Daubechies and Coiflets are compactly supported orthogonal wavelets. These

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wavelets along with Meyer wavelets are capable of perfect reconstruction. The Meyer, Morlet and Mexican Hat wavelets are symmetric in shape. The wavelets are chosen based on their shape and their ability to analyze the signal in a particular application. Biorthogonal wavelet exhibits the property of linear phase, which is needed for signal and image reconstruction. By using two wavelets, one for decomposition (on the left side) and the other for reconstruction (on the right side) instead of the same single one, interesting properties are derived.

E. Comparison: In the comparison phase, all the results of compression using Haar, Daubechies, Biorthogonal & Coiflet Wavelet are compared and identify the best appropriate wavelet transform for compression using different type of medical images. Comparison is on the basis of different parameters to measure the quality of image & their compression ratio.

IV. CONCLUSION

A result from a comparative study of Wavelet based Image Compression is presented in this paper. In this paper, Comparative study is on the basis of some parameters calculated in previous works. From the results we studied that the Daubechies transform gives a higher percentage of compression for MRI, Fundus and Infrared images, Haar transform gives a higher percentage of compression for ECG images, Biorthogonal transform gives a higher percentage of compression for X-ray images and Coiflets transform gives a higher percentage of compression for CT, US and Mammography images, at constant PSNR.

In this work we present the Comparative study of wavelet based compression quite successfully. Still there is some hope of improvement. If we can use optimization algorithm with more image samples for the compression, the results could have been better. So, future work could go on the direction of optimized systems using artificial intelligent techniques.

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BIOGRAPHY

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