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Selection of Wavelet Families for Biomedical Image Compression

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Abstract: - There are several types of lossy image compressions available; to achieve higher degree of compression without any significant loss in the diagnosability of the medical image we choose different type of wavelet function to compress different types of medical images. A typical still image contains a large amount of spatial redundancy in plain areas where adjacent picture elements (pixels) have almost the same values. It means that the pixel values are highly correlated. However we have several types images with us and there pixel correlativity might not be in same fashion therefore any specific wavelet function cannot give optimum result for each type of images. This Paper is focused on selecting the most appropriate wavelet function for a given type of bio medical image compression. In this paper we studied the behavior of different type of wavelet function with different type of medical images and suggested the most appropriate wavelet function that can perform optimum compression for a given type of images. The wavelet function that gives the maximum compression for a specific type of image will be the most appropriate wavelet for that type of bio medical image compression.

Keywords: - Image compression, Wavelet transforms, Biomedical images, Peak Signal to Noise Ratio, Compression ratio.

I. INTRODUCTION

Image compression is the process of encoding information using fewer bits (or other information bearing units) than an un-encoded representation would use through use of specific encoding schemes. Compression is useful because it helps to reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth (computing). On the downside, compressed data must be decompressed, and this extra processing may be detrimental to some applications. For instance, a compression scheme for image may require expensive hardware for the image to be decompressed fast enough to be viewed as its being decompressed (the option of decompressing the image in full before watching it may be inconvenient, and requires storage space for the decompressed image). The design of data compression schemes therefore involves trade-offs among various factors, including the degree of compression, the amount of distortion introduced (if using a lossy compression scheme), and the computational resources required to compress and uncompress the data. Digital Image compression is the application of data compression on digital images. Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages with the development of science and technologies.

Medical imaging has had a great impact on the diagnosis of diseases and surgical planning. However, imaging devices continue to generate more data per patient, often 1000 images or ~500 MB. These data need long-term storage and efficient transmission. Current compression schemes produce high compression rates if loss of quality is affordable. However, medicine cannot afford any deficiency in diagnostically important regions. An approach that brings a high compression rate with good quality in the ROI is thus necessary. The main reason for preserving regions other than ROI is to let the viewer more easily locate the position of the critical regions in the original image, and to evaluate possible interactions with surrounding organs.

In the biomedical images we have some constraints of compression; we cannot compress biomedical images above a certain compression level because the distortion after decompression in the biomedical images should not be much as the diagonasability of the image will get hampered if the distortion is high. So we have to make a proper balance between the compression level and the distortion in the image.

In recent years, many studies have been made on wavelets. Wavelet means a “small wave”. 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. When medical images are to be processed at multiple resolutions, Wavelet

Transforms are the mathematical tool of choice. Wavelet analysis has the ability to perform local analysis. Wavelet transform (WT) represents an image as a sum of wavelet functions (wavelets) with different locations and scales. Any decomposition of an image into wavelets involves a pair of waveforms: one to represent the high frequencies corresponding to the detailed parts of an image (wavelet function) and one for the low frequencies or smooth parts of an image (scaling function).

II. WAVELET TRANSFORM

Wavelet compression involves a way analyzing an uncompressed image in a recursive fashion, resulting in a series of higher resolution images, each "adding to" the information content in lower resolution images. The primary steps in wavelet compression are performing a discrete wavelet Transformation (DWT), quantization of the wavelet-space image sub bands, and then encoding these sub bands. Wavelet images by and of themselves are not compressed images; rather it is quantization and encoding stages that do the image compression. Image decompression or reconstruction, is achieved by carrying out the above steps in reverse and inverse order. Thus, to restore the original image, the compressed image is decoded, dequantized, and then an inverse- DWT is performed. Because wavelet compression inherently results in a set of multi-resolution images, it is well suited to working with large imagery which needs to be selectively viewed at different resolution, as only the levels containing the required level of detail need to be decompressed. Wavelet mathematics embrace an entire range of methods each offering different properties and advantages. For example, it is possible to compress 3 or more dimensional imagery using wavelets. Wavelet compression has not been widely used because DWT operation takes a lot of compute power, and because historical techniques perform the DWT operation in memory or by storing intermediate results on hard disk. This limits either the size of the image that can be compressed, or the speed at which it can be compressed. The following diagram shows wavelet based compression and decompression method.

Fig 1: Wavelet based image Compression

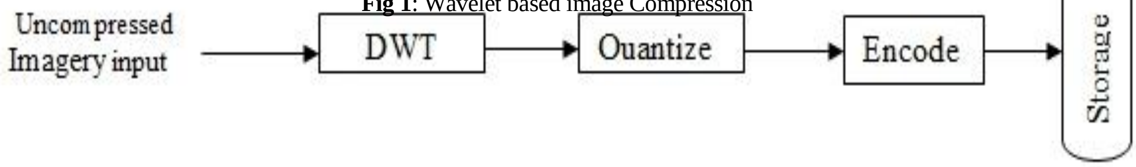
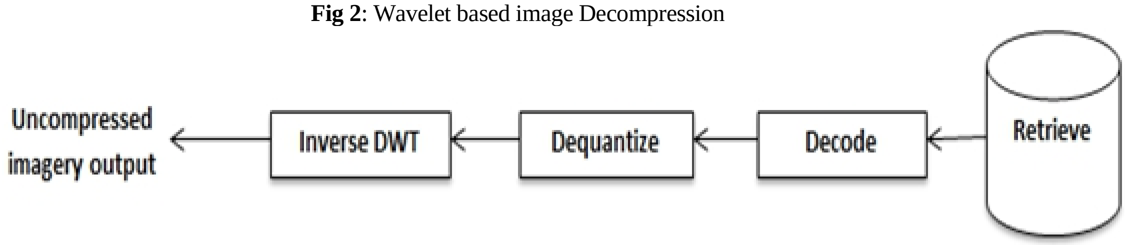


Fig 2: Wavelet based image Decompression



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More recently, the wavelet transform has emerged as a cutting edge technology, within the field of image analysis. Wavelets are a mathematical tool for hierarchically decomposing functions. Though rooted in approximation theory, signal processing, and physics, wavelets have also recently been applied to many problems in Computer Graphics including image editing and compression, automatic level-of detail control for editing and rendering curves and surfaces and animation. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios. Over the past few years, a variety of powerful and sophisticated wavelet-based schemes for image compression have been developed and implemented.

III. WAVELET FAMILIES

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. Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in numerous applications. These are also called Maxflat wavelets as their frequency responses have maximum flatness at frequencies 0 and R. This is a very desirable property in some applications. The Haar, Daubechies, Symlets and Coiflets are compactly supported orthogonal wavelets. These 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

A. Haar- This wavelet is discontinuous, and resembles a step function.

B. 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.

C. Symlets- The symlets are nearly symmetrical wavelets. The properties of the two wavelet families are similar

D. Meyer- The Meyer wavelet and scaling function are defined in the frequency domain. They are symmetric in shape.

E. 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 and the other for reconstruction instead of the same single one, interesting properties are derived.

F. Daubechies- Daubechies are compactly supported orthonormal wavelets and found application in DWT. Its family has got nine members in it.

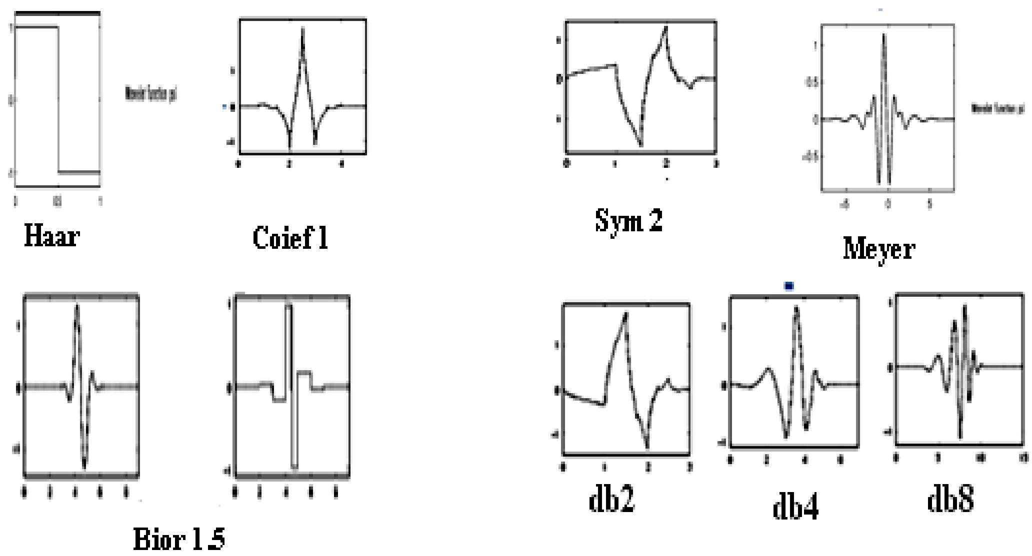

Fig 3: Different types of Wavelet families

IV. BIO MEDICAL IMAGES

The term image refers to a two-dimensional light intensity f (x, y), where x and y denote spatial coordinates and the value of f at any point (x, y) is proportional to the brightness (or gray level) of the image at that point. . The elements of such a digital array are called pixels (picture elements), or more commonly pixels. Images are built up of pixels that contain color information and are aligned with the Cartesian coordinate system. The zero point is found at the top-left corner of the image (in PostScript, for example, the zero point is found at the bottom-left corner of the page).

Some of the medical imaging techniques that play a very important role in medical science are described below,

A. X Rays

X-rays use beams of ionizing radiation to expose photographic film. Placing the human body between the beam and the film leaves an image of the body on the film. When radiation penetrates into the tissues easily black areas are seen, for example air in the lungs on a chest x-ray. Bones appear white because they are hardest to penetrate. X-rays are a good way of looking at bones and air inside the human body but they do not show up soft tissues well.

Fig 4: X Ray

B. US Scan

Ultrasound scans uses high frequency sound waves, which are emitted from a probe. Ultrasound is cyclic sound pressure with a frequency greater than the upper limit of human hearing. 20 kHz serves as a useful lower limit in describing ultrasound. The echoes that bounce back from structures in the body are shown on a screen. The structures can be much more clearly seen when moving the probe over the body and watching the image on the screen.

Fig 5: US Scan

C. MRI Scan

MRI - images are similar to CT images except they show up the details of soft tissue better. MRI scans do not use X-rays but use a strong pulsed magnetic force to polarize cells - line up and measure the energy given off by the electrons when they bounce back into their normal orbits in-between pulses. An MRI scanner is a device in which the patient lies within a large, powerful magnet where the magnetic field is used to align the magnetization of some atomic nuclei in the body, and radio frequency magnetic fields are applied to systematically alter the alignment of this magnetization. This causes the nuclei to produce a rotating magnetic field detectable by the scanner and this information is recorded to construct an image of the scanned area of the body.

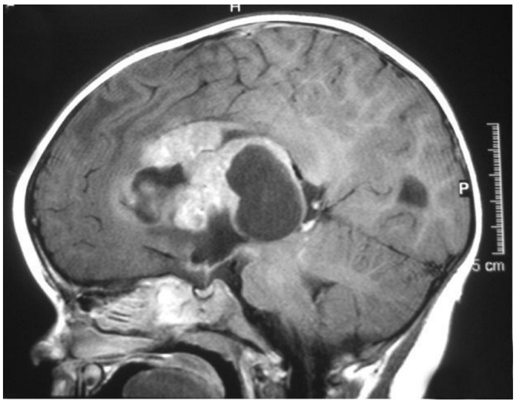

Fig 6: MRI Scan

D. Mammogram

Mammography is the process of using low-dose X-rays to examine the human breast. It is used to look for different types of tumors and cysts..Digital mammography, also called full-field digital mammography (FFDM), is a mammography system in which the x-ray film is replaced by solid-state detectors that convert x-rays into electrical signals. These detectors are similar to those found in digital cameras. The electrical signals are used to produce images of the breast that can be seen on a computer screen or printed on special film similar to conventional mammograms. From the patient's point of view, digital mammography is essentially the same as the screen-film system.

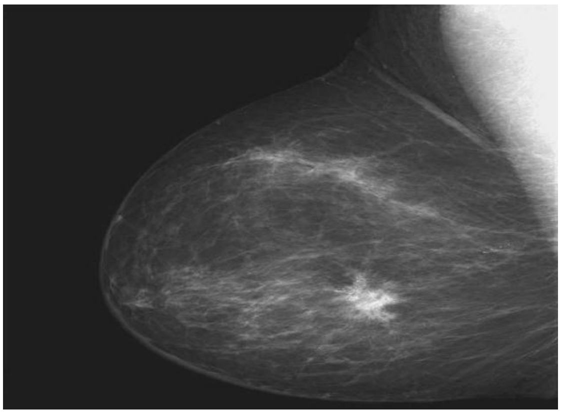

Fig 7: Mammogram

V. PROPOSED METHODOLOGY

The usual steps involved in compressing and decompressing of image are

• Load original Image.
• Generate Compressed Image.
• Use Thresholding command for denoising.
• Calculate compression ratio
• Calculate PSNR for the image.
• Obtained Reconstructed image.

Compression ratio: It also known as compression power is a computer-science term used to quantify the reduction in data-representation size produced by a data compression algorithm. The data compression ratio is analogous to the physical compression ratio used to measure physical compression of substances, and is defined in the same way, as the ratio between the uncompressed size and the compressed size:

Compression Ratio = Uncompressed Size/Compressed Size

In measuring the quality of the reconstructed image, two mathematical metrics are used. One of them is MSE, which measures the cumulative square error between the original and the compressed image. The other is the peak signal-to reconstructed image measure known as PSNR.

While these two measurements may not be the best approach to measure an image, they do provide a guide to the quality of the reconstructed image. In general, a good reconstructed image is one with low MSE and high PSNR. That means that the image has low error and high image fidelity.

The compression is executed in two steps first we perform first level of image decomposition and the second level of image decomposition takes place. After second level of decomposition we reconstruct the compressed image and calculate the threshold of the compression and PSNR. The threshold and PSNR are set in a way that their values will always be a constant for a given type of image compression. We keep on repeating this compression for different type of wavelet functions and calculate the compression ratio that can be achieved with each of them.

VI. RESULTS AND DISCUSSIONS

A. Analysis of X-Ray Images

For X-Rays Images we have analyses the compression ratio with different wavelet functions for PSNR =45. By this analysis we have observed that for X Ray Images "Daubechies" wavelet can perform relatively better than other Wavelet functions. By using "Daubechies" Wavelet we can achieve compression ratio up to 10.251. Table below shows Compression ratio of X-ray images for different wavelet functions

Table I: Compression ratios for X-Ray

TYPE OF WAVELET	CR
Haar Wavelet	7.3257
Coiflets Wavelet (coif5)	9.0428
Daubechies Wavelet (dB4)	10.251
BiorthogonalWavelet (bior6.8)	10.045

B. Analysis of MRI images

For MRI Images we have analyses the compression ratio with different wavelet functions for PSNR = 45. By this analysis we have observed that for MRI Images "Haar" wavelet can perform relatively better than other Wavelet functions. By using "Haar" Wavelet we can achieve compression ratio up to 6.6501.Table below shows Compression ratio of MRI images for different wavelet functions

Table II: Compression ratios for MRI

TYPE OF WAVELET	CR
Haar Wavelet	6.6501
Coiflets Wavelet (coif5)	4.4004
Daubechies Wavelet (dB4)	5.5108
BiorthogonalWavelet (bior6.8)	4.9228

C. Analysis of US images

For US Images we have analyses the compression ratio with different wavelet functions for PSNR = 45. By this analysis we have observed that for US Images "Biorthoganal" wavelet can perform relatively better than other Wavelet functions. By using "Biorthoganal" Wavelet we can achieve compression ratio up to 6.4111.Table below shows Compression ratio of US images for different wavelet functions

Table III: Compression ratios for US

TYPE OF WAVELET	CR
Haar Wavelet	5.5923
Coiflets Wavelet (coif5)	5.8861
Daubechies Wavelet (dB4)	6.2591
Biorthogonal Wavelet (bior6.8)	6.4111

D. Analysis of Mammography Images

For Mammo Images we have analyses the compression ratio with different wavelet functions for PSNR = 45. By this analysis we have observed that for Mammo Images "Daubechies" wavelet can perform relatively better than other Wavelet functions. By using "Daubechies" wavelet we can achieve compression ratio up to 10.5045.Table below shows Compression ratio of Mammo images for different wavelet functions.

Table IV: Compression ratios for Mammo

TYPE OF WAVELET	CR
Haar Wavelet	8.8074
Coiflets Wavelet (coif5)	9.812
Daubechies Wavelet (dB4)	10.5045
Biorthogonal Wavelet (bior6.8)	10.4192

VII. CONCLUSION AND FUTURE SCOPE

In our study we have applied different Wavelet functions on different type of biomedical images for a fix PSNR value and calculated the compression ratio.

After analysis we have found that, for X-Ray Images “Daubechies” can provide the best result as its compression ratio is 10.251.For MRI Images “Haar” gives better result in comparison to other Wavelet functions it provide compression ratio approximately 6.6501.For Ultrasound Images “Biorthogonal” provides the better result and its compression ratio is 6.4111. For Mammography Images “Daubechies” perform the most compression as it can provide compression ratio up to 10.5045. This result is outcomes of the analysis given above. In this analysis we fix the threshold and PSNR of the image compression and use different type of wavelets to compress each image at the given Threshold and PSNR value.

In this thesis, we have considered the methods only for best compression but, the choice of optimal wavelet depends on the method, which is used for picture quality evaluation. We have done compression ratio measures but should also use objective and subjective picture quality measures. The objective measures such as PSNR and MSE do not correlate well with subjective quality measures. Therefore, we should PQS as an objective measure that has good correlation to subjective measurements. After this we will have an optimal system having best compression ratio with best image quality

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