International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 12, Issue 5 (May 2016), PP.01-07

Roi Based Advanced Image Compression Technique For Telemedicine System

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Abstract:- Medical images used at medical facilities are now commonly digitalized due to corresponding advances in information technology. Digital imaging technologies have acquired sufficient reliability and cost effectiveness to convince imaging providers to shift from film based to filmless department. New algorithm for image compression based on wavelets has been recently developed. Regarding which, this paper represents the implementation of encoder and decoder for the region of interest based still image compression using the discrete wavelet transform. The region of interest part is the diagnostically important part for the doctor to diagnose the disease. In this work, ROI part is compressed using lossless compression method and the background region is compressed using the lossy compression method. Since it is focused mainly on the ROI part, this technique leads to achieve good compression ratio around 1:50, depends on the size of the ROI being selected. Also it provides an efficient transmission of such a large size of medical images over the limited bandwidth channels at very low bits per pixel value. The work is carried out using matlab environment. The implementation of this algorithm is mainly to assist the telemedicine system and to reduce the data storage requirement.

Keywords:- ROI, wavelets, compression, telemedicine, DWT

I. INTRODUCTION

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). Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography (EEG), magnetoencephalography (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.

In the clinical context, medical imaging is generally equated to radiology or "clinical imaging" and the medical practitioner responsible for interpreting (and sometimes acquiring) the images is a radiologist. 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.

As a field of scientific investigation, medical imaging constitutes a sub-discipline of biomedical engineering, medical physics or medicine depending on the context: Research and development in the area of instrumentation, image acquisition (e.g. radiography), modelling and quantification are usually the preserve of biomedical engineering, medical physics and computer science; Research into the application and interpretation of medical images is usually the preserve of radiology and the medical sub-discipline relevant to medical condition or area of medical science (neuroscience, cardiology, psychiatry, psychology, etc) under investigation. Many of the techniques developed for medical imaging also have scientific and industrial applications.

Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal). In the case of ultrasonography the probe consists of ultrasonic pressure waves and echoes inside the tissue show the internal structure. In the case of projection radiography, the probe is X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat.

II. METHODOLOGY

This section discusses starting from the architecture of the project, the procedure, different types input images, the file formats, important regions of the images(ROI), size of the images, implementation of the algorithm and the performance matrices called compression ratios, signal to noise ratio (SNR) and bits per pixel value (BPP).

The step by step procedure for implementation is as follows:

Step 1: Reading the medical image.
Step 2: Selection of the Region of interest part and its mask.
Step 3: Performing of Discrete wavelet transform (DWT) for the complete image.
Step 4: Separation of all the coefficients of DWT.
Step 5: Performing the MAXSHIFT operation for the ROI region of the transformed image.
Step 6: Performing entropy coding for the compressed and scaled data.
Step 7: Transmission of the coded image.
Step 8: Reception of the compressed image data.
Step 9: Performing Entropy decoding to reconstruct the original data bit .
Step 10: Performing inverse Discrete wavelet transform to reconstruct back the image with original ROI part.
Step 11: Defining the ROI, calculating the BPP and SNR.

Figure 3.1 shows the architecture of the ROI based medical image compression system. Wherein figure 3.1 (a) shows the encoder part and figure 3.1(b) shows the decoder part. These functional blocks describe the overall operation of the transmission and reception system. Implementations of the different blocks are discussed in detail in this chapter

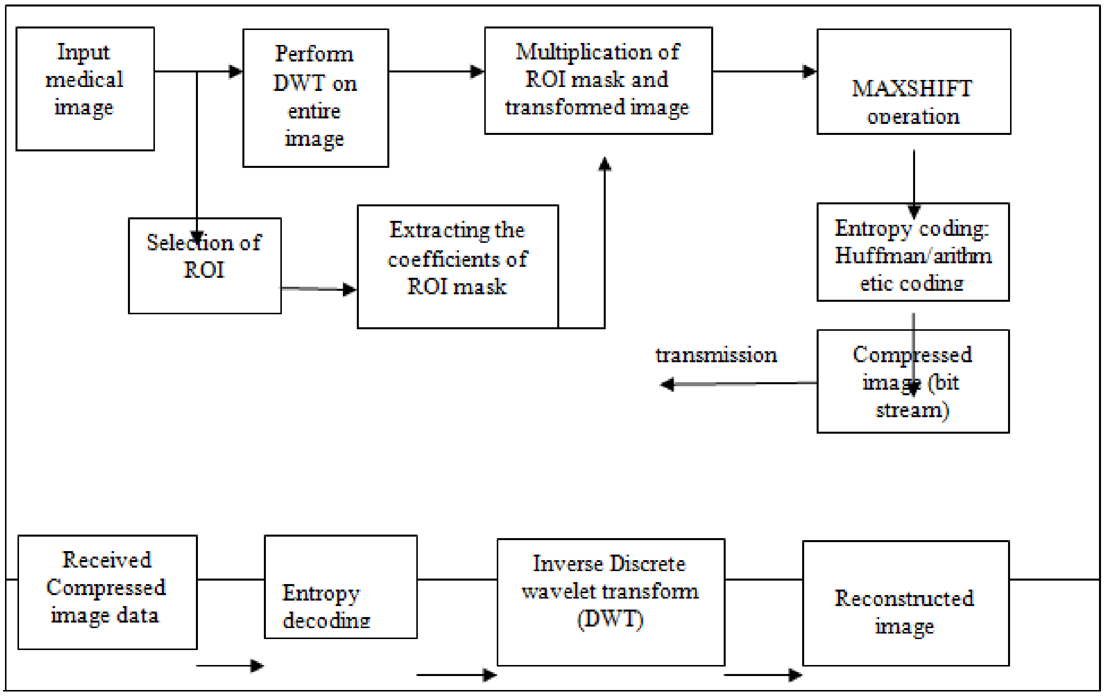


Figure: Decoder

Figure: proposed architecture of the ROI based medical image compression.

A. Input Medical Images

Cat scans are a specialized type of x-ray. The patient lies down on a couch which slides into a large circular opening. The x-ray tube rotates around the patient and a computer collects the results. These results are translated into images that look like a "slice" of the person. CT is very good for imaging bone structures. In fact, it's usually the imaging mode of choice when looking at the inner ears. It can easily detect tumors within the auditory canals and can demonstrate the entire cochlea on most patients.

MRI is a completely different, Unlike CT it uses magnets and radio waves to create the images. No x-rays are used in an MRI scanner. The patient lies on a couch that looks very similar the ones used for CT. They are then placed in a very long cylinder and asked to remain perfectly still. The machine will produce a lot of noise and examinations typically run about 30 minutes. The cylinder that patient are lying in is actually a very large magnet. The computer will send radio waves through patient body and collect the signal that is emitted from the hydrogen atoms in patient cells. This information is collected by an antenna and fed into a sophisticated computer that produces the images. These images look similar to a CAT scan but they have much higher detail in the soft tissues. Unfortunately, MRI does not do a very good job with bones.

One of the great advantages of MRI is the ability to change the contrast of the images. Small changes in the radio waves and the magnetic fields can completely change the contrast of the image. Different contrast settings will highlight different types of tissue. Another advantage of MRI is the ability to change the imaging plane without moving the patient. The top two images are what we call axial images. This is what you would see if you cut the patient in half and looked at them from the top. The image on the bottom is a coronal image. This slices the patient from front to back. Most MRI machines can produce images in any plane. CT cannot do this.

B. Medical Image File Format

These formats store images as bitmaps (also known as pixmaps).The medical imaging machines commonly produces the images in different types of format, Depends upon the manufacturing company and the types of the application. Some of the file formats are JPEG/JFIF, Exif, TIFF, RAW etc. RAW refers to a family of raw image formats that are options available on some machines. These formats usually use a lossless or nearly-lossless compression, and produce file sizes much smaller than the TIFF formats of full-size processed images from the same machines.

C. Uncompressed File Formats for the Medical Images

The PNG (Portable Network Graphics) file format was created as the free, open-source successor to the GIF. The PNG file format supports truecolor (16 million colors) while the GIF supports only 256 colors. The PNG file excels when the image has large, uniformly colored areas. The lossless PNG format is best suited for editing pictures, and the lossy formats, like JPG, are best for the final distribution of photographic images, because in this case JPG files are usually smaller than PNG files. The Adam7-interlacing allows an early preview, even when only a small percentage of the image data has been transmitted.

The BMP file format (Windows bitmap) handles graphics files within the Microsoft Windows OS. Typically, BMP files are uncompressed, hence they are large; the advantage is their simplicity and wide acceptance in Windows programs.

Netpbm format is a family including the portable pixmap file format (PPM), the portable graymap file format (PGM) and the portable bitmap file format (PBM). These are either pure ASCII files or raw binary files with an ASCII header that provide very basic functionality and serve as a lowest-common-denominator for converting pixmap, graymap, or bitmap files between different platforms. Several applications refer to them collectively as PAM format (Portable Any Map).

D. Haar Wavelets

In this project it is used the Haar basis wavelet transform, which is a simplest wavelet transform. We first discuss how one-dimensional image elements can be decomposed using Haar wavelets, and then describe the actual basis functions in two dimensional methods applicable for the 2D medical image compression.
To get a sense for how wavelets work, let's start with a simple example. A one dimensional "image" with a resolution of four pixels, having values [9 7 3 5]
It can be represent this image in the Haar basis by computing a wavelet transform. To do this, first average the pixels together, pair wise, to get the new lower resolution image with pixel values [8 4]
Clearly, some information has been lost in this averaging process. To recover the original four pixel values from the two averaged values, it needs to store some detail coefficients, which capture the missing information. In this example, it chooses 1 for the first detail coefficient, since the average we computed is 1 less than 9 and 1 more than 7. This single number allows here to recover the first two pixels of the original four-pixel image. Similarly, the second detail coefficient is -1, since 4 + (-1) = 3 and 4- (-1) = 5.

Resolutions	Averages	Detail coefficients
4	[9 7 3 5]	
2	[8 4]	[1 -1]
1	[6]	[2]

Finally, it define the wavelet transform (also called the wavelet decomposition) of the original four-pixel image to be the single coefficient representing the overall average of the original image, followed by the detail coefficients in order of increasing resolution.

Thus, for the one-dimensional Haar basis, the wavelet transform of the original four-pixel image is given by

[6 2 -1 1]

The way of computing the wavelet transform, by recursively averaging and differencing coefficients is called a filter bank. The original image had four coefficients, and so does the transform. Also given the transform, it can reconstruct the image to any resolution by recursively adding and subtracting the detail coefficients from the lower resolution versions. This could be implemented using basis functions but now as it is required to concentrating on the compression of the two dimensional medical images let's move on to complete basis function of the 2d haar wavelets. Before going, let us define the generalized basis function of both 1D and 2D

E. Maxshift Operation

After decomposing or transforming the input medical image using DWT, next to apply Maxshift operation to scale the ROI region to higher bit plane and the remaining part called background area to scale down. The advantage of using maxshift is that it takes the scaling value default.

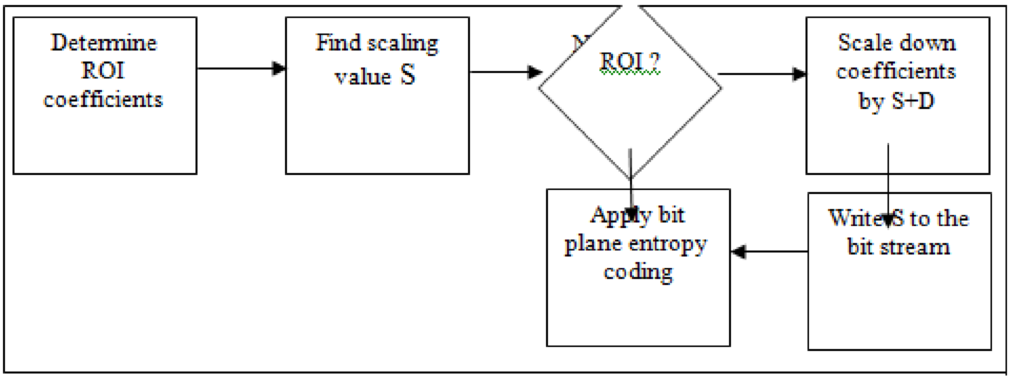


Figure: Flowchart of the MAXSHIFT operation of ROI.

The MAXSHIFT method is an extension of the scaling based ROI coding method. During ROI coding, a binary mask is generated in the wavelet domain for distinction of the ROI from the background as shown in results ahead. In the scaling based ROI coding, the bits associates with the wavelet coefficients corresponding to an ROI are scaled to higher bit planes than the bits associated with the non ROI portion of the image. The figure 3.4 shows the block diagram of scaling the wavelet coefficients.

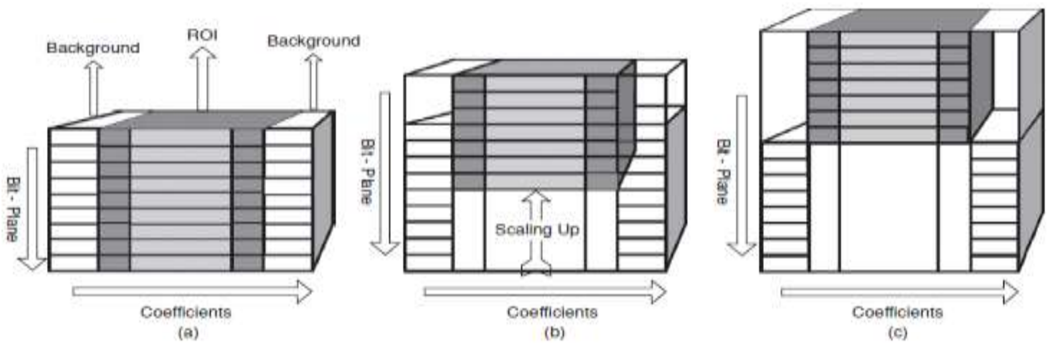


Figure : D representation of scaling (a) Full image compression (b) ROI scaling based method (c) MAXSHIFT method

The basic principle of the maxshift method is to find the minimum value in the ROI and the maximum value in the background and then scale the wavelet coefficients in ROI in such a manner that the smallest coefficient in the ROI is always greater than the largest coefficients in the background. So that the bit planes are encoded in the order of the most significant bit (MSB) plane first to the least significant bits (LSB) plane last.

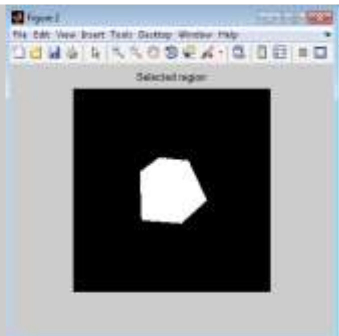
F. Entropy Coding

Entropy coding is a process to convert bit stream into another form, which is suitable to transmit with reduced bit stream. There are so many coding methods like Huffman, arithmetic, etc. Here used the Huffman coding technique. Huffman coding is a statistical technique which attempts to reduce the amount of bits required to represent a string of symbols. The algorithm accomplishes its goals by allowing symbols to vary in length. Shorter codes are assigned to the most frequently used symbols, and longer codes to the symbols which appear less frequently in the string (that's where the statistical part comes in). Arithmetic coding is another statistical coding technique.

III. RESULTS

All This section mainly shows the experimented results of the implemented algorithm. Each steps of the algorithm is executed in the Matlab and all the expected results are discussed below. Figure 4.1 shows the Overview of the GUI model, the algorithm is developed in Matlab using graphical user interface (GUI), this is the platform of matlab which enables to develop a devise without any hardware requirement.
At the start of execution, it has to select the browse push button on the GUI model. So that it calls window to make select the medical images on which the compression takes place.

Figure: Overview of the GUI, Loaded with selected scanned image



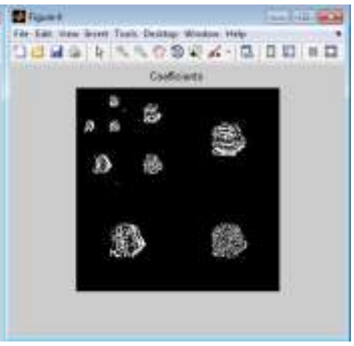


Figure: Selection of ROI **Figure: Mask of the ROI** **Figure : after DWT Operation**

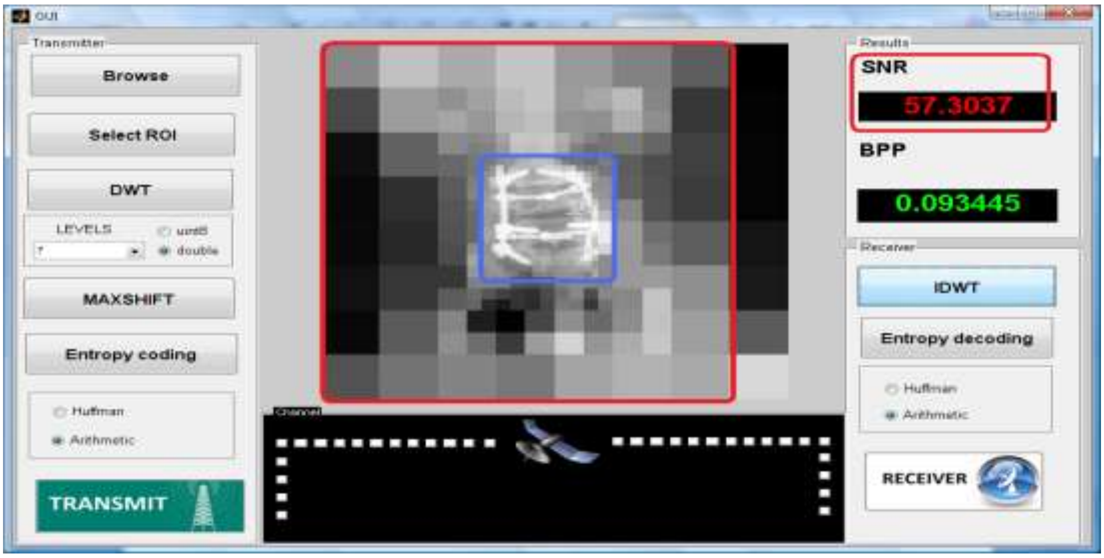


Figure: overview of the GUI after complete execution of the algorithm

The tested results are as follows

Table: Experimental results

Type of image	Levels of DWT	Bits per pixel (BPP)	SNR	Compression ratio
Pelvis.bmp	1	0.42181	57.165	1:18.97
Pelvis.bmp	2	0.23332	57.4078	1:34.287
Pelvis.bmp	3	0.19466	57.441	1:41.097
Pelvis.bmp	4	0.18091	57.4403	1:44.220
Pelvis.bmp	5	0.18132	57.4416	1:44.1208
Pelvis.bmp	6	0.18754	57.4614	1:42.6575
Pelvis.bmp	7	0.15723	57.6387	1:50.88

Table: Testing of different types of Images.

Bone2 .bmp	-	0.18414	57.4249	1:43.44
mri1.bmp	-	0.21372	57.263	1:37.43
TissuCT.bmp	-	0.10310	57.8501	1:77.7931
Knee.png	-	0.21075	57.213	1:37.959

IV. CONCLUSIONS

The work shows the state-of-the-art ROI coding techniques applied to medical images. Initially aimed to develop the algorithm to compress both 2D and 3D images. Because of the time constraints work has been completed only with the 2D image compression. And it can also be done by compressing the raw data of the images which are provided by machine before they take into pixel form. In this design good compression ratio is achieved which is about 1:20 to 1:100(depends on the size of ROI) ratio with very good signal to noise ratio. It has been tested all the intermediate results and observed. ROI coding preserves image quality in diagnostically critical regions by performing advanced image compression, enabling better image examination and addressing issues regarding image handling and transmission in telemedicine systems. Therefore, ROI coding is considered quite important in distributed and networked electronic healthcare. The results presented so far from the research community are promising for the future. It is now necessary to adapt the existing algorithms in order to decrease complexity. This will enable their use in portable and mobile devices, which have limited computing power, allowing the support of moving and commuting physicians.

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