CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Having identified the difficulties with the storage and transmission of data over long distances, research has led to a number of efficient image compression techniques to conserve bandwidth. A study of the literature available on the current problem reveals a large number of available techniques. Some of these techniques are mentioned in the Introduction. Each technique differs from the other technique in terms of Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR).

2.2 HISTORICAL BACKGROUND

Medical diagnosis becomes effective if it identifies the defective areas in limited processing. In medical images, some structures in the data are of interest. These structures typically occupy a small percentage of the data, but their analysis requires contextual information like locations within a specific organ or adjacency to sensitive structures. Therefore, while focusing on a particular region of the data, designated as a region of interest (ROI), contextual information surrounding that region is important. However, the same amount of detail is not required for the context and the ROI. Fuzzy C-means logic is used to separate out the Region of Interest from the whole image.

After performing segmentation contourlet and wavelet transforms are applied to significant region (ROI) and to the whole image. Several
algorithms like EZW (Embedded Zerotree Wavelet) (Shapiro’s, 1993) based on identifying image regions containing low coefficient values for all subbands, and code using a special symbol, the SPIHT (Set Partitioning in Hierarchical Trees) (Said Pearlman 1996), and the SPECK (Set Partitioning Embedded Block) (Islam. A. Pearlman 1999) exists for image compression.

The existence of tumors in MRI, CT scan is one of the most important signs, considered by radiologist is the biggest challenge in interpreting this huge amount of data precisely and effectively (Sebastien Piccand et al 2008). In this ROI technique, a special data structure that is based on a zerotree model is used to manipulate the region of interest more easily. The region of interest especially the tumor region in different modalities is of taken more care because of information content in that portion. If the regions of interests are usually of low contrast and noisy nature of the images, then preservation of image content in that region has been very difficult. Hence an image denoising and enhancement may be required to preserve the image quality, highlighting image features and suppressing the noise (Osher and Rudin 1990, Gilboa et al 2004). These enhancement techniques make very small tumor structures into more visible and the features of the tumors are made more evident hence the radiologist can be aided to retain the information content of the image named as ROI.

Different transform techniques exists for efficient image compression. Among them DCT, DFT, DWT, Contourlet transform finds its own significance in the relevant field. DCT separates images into parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are used to retrieve the image during decompression. Compared to other input dependent transforms, DCT has many advantages: (1) It has been implemented in single integrated circuit; (2) It has the ability to pack most information in fewest coefficients; (3) It
minimizes the block like appearance called blocking artifact that results when boundaries between sub-images become visible (Ken Cabeen et al).

The techniques that allow redundancy extraction use spatial frequency transforms (such as discrete cosine transform(DCT) or wavelet) that simplify the process of redundancy removal. The discovery of DCT (Ahmed Natarajan and Rao 1974) is an important achievement for the research community working on image compression. The DCT can be regarded as a discrete-time version of the Fourier-Cosine series which is a close relative of DFT, a technique for converting a signal into elementary frequency components. It can be computed with a Fast Fourier Transform (FFT). The DCT decompose data into multiple spatial frequency bands largely due to its energy concentration characteristics. Several perceptually based compression techniques have used DCT. Watson (1993) achieved superior compression results with the DCTune perceptual coding method, which uses DCT and then uses an image-dependent quantization matrix(based on the frequency sensitivity and contrast masking of the HVS at each spatial frequency) to modify the resulting DCT coefficients. Hontsch and Karam (1997) modified Watson’s image-dependent quantization matrix at the block level, based on the DCT coefficients within each block, achieving even better compression.

As stated above DCT represents an image as a superposition of cosine functions with different discrete frequencies. DCT provides excellent energy compaction but the use of uniformly sized blocks simplified the compression system and does not take into account the irregular shapes within real images. The block based segmentation of source image is fundamental limitation of the DCT based compression system as said by Bauer et al (1996). The degradation is known as blocking effect and depends on block size.
In recent time, much of the research activities in image coding have been focused on the DWT which has become a standard tool in image compression applications because of their data reduction capability (Lewis 1992), (Antonini 1992). In wavelet compression system the entire image is transformed and compressed as a single data object rather than block by block as in DCT based compression system. It allows a uniform distribution of compression error across the entire image. DWT offers adaptive spatial-frequency resolution (better spatial resolution at high frequencies and better frequency resolution at low frequencies) that is well suited to the properties of HVS. It can provide better image quality than DCT especially on high compression ratio (Grgic et al 1999). The 2-D 8x8 DCT algorithm requires 54 multiplication while DWT depends on the length of the wavelet filters, one multiplication per coefficient which accounts for better compression factor for an image.


The coding methods developed by Wu and Memom (1997) especially context-based, adaptive lossless image codec(CALIC) and Weinberger et al (2000) namely low complexity lossless compression for images demonstrated the quantitative techniques based on predictive techniques in the spatial domain. Whereas the lossless method developed by Pan et al(2007) under the name of Lossless image compression using binary
Wavelet Transform introduces no quantisation distortion and is completely invertible.

The method employed by Jian-wei Han and Jian-dong Fang (2008) uses different processing methods for the every sub-image compression after lifting wavelet. The sub-image with low frequency is compressed lossless by DPCM method, and the improved EZW coding and RLC method was used to compress the sub-images with high frequency.

A combined approach of image compression, based on the wavelet transform (Wang et al 1996) and vector quantization (Ruey Feng Chang and Wang 1992) was developed by Jayanta Kumar Debnath et al(2008). This method is applicable to those areas of digital images where high precision reconstructed image is required like medical imaging, criminal investigations etc. In the stated method, a 3-level 2-D DWT is firstly applied to the test image and then VQ is used to different subbands for compression. Ten subbands are created after the application of 3-level 2-D DWT using Self Organizing Feature Map (SOFM), and thus all these codebooks are used for all subbands individually. 3-level 2-D DWT is applied to images because the low frequency subband, which contains the maximum energy content of the original image, becomes of smaller size so that in the case of vector quantization this subband is treated with a codebook size of 7-bits only. Whole compression process of this work is divided into three steps, i) Codebook generation, ii) Encoding of the original image and iii) Decoding of the image.

In a method of image coding by Abdul (Adeel Mohammed and Javad Alirezaie 2005) wavelet transform splits the image into significant and insignificant coefficients of the image using mathematical morphology and self organizing feature map (MMSOFM). The significance map is preprocessed using mathematical morphology operators to identify and create
clusters of significant coefficients. A SOFM is then utilized to encode the significance map. Here the significant coefficients are determined using a global threshold for a high coefficient of the wavelet coefficients and significance map is created. After that clusters of significant coefficients are formed using mathematical morphology operator.

Mathematical morphology is the analysis of images in terms of their shape. It preserves edge information and create clusters of significant coefficients using dilations and erosions. The significance map obtained after mathematical morphology is vector quantized using a SOFM. The SOFM preserves the topological properties of the input i.e., points close to one another in the input space are mapped to same in the output space. The modified significance map obtained after vector quantization (VQ) is then used to obtain the significant coefficient from the original DWT coefficients. The significant coefficients obtained are quantized using a scalar quantization. Also this method does not need any special relationship to be defined among the coefficients.

In the proposed technique the whole image and the significant regions are subjected to undergo both wavelet and contourlet transforms and analysed.

The wavelet transforms fails in case if the image has smooth contours. In such cases contourlet transform is an efficient tool. Kilari Veeraswamy et al (2009) suggested a method which uses Laplacian Pyramid (LP) to capture the point discontinuities, followed by Directional filter bank (DFB) to link point discontinuities into linear structures. The coefficients of down sampled low pass version of LP decomposed image is compressed in lossless procedure by steps, viz., topological re-ordering of coefficients, scanning, prediction and calculation of residues. In addition, the coefficients of CT are quantized based on the energy in the particular band. Due to
multiresolution decomposition of CT, performance of compression is improved.

Further the scheme found by (Ramin Eslami and Hayder Radha MI 48824) a non-redundant WBCT constructs an embedded image coder. Due to differences in parent-child relationships between the WBCT coefficients and wavelet coefficients, a repositioning algorithm for the above said coefficients were developed that have similar spatial orientation trees.

Said and Pearlman (1996) developed the Spatial Orientation in Hierarchical Trees (SPIHT) algorithm for wavelet coding of images using parent child dependencies. In Contourlet transform two different parent child relationships depending on the number of directional decompositions in the contourlet subbands Po and Do (2003) are assumed. If the two successive scales in which the parent and children lie have the same number of directional decompositions, then the parent and children would lie in the corresponding directional subbands; however if the scale in which the children lie has twice as many directional subbands as the scale in which the parent lies, the four children will be in two adjacent directional subbands. These two directional subbands correspond to the directional decomposition of the directional subband in which the parent is located. Therefore, due to differences in parent-children dependencies between the WBCT and the wavelet transform, before applying the SPIHT algorithm, the transform coefficients in the WBCT are repositioned in such a way to be able to use a similar SPIHT algorithm. The above said method is well suited for images consisting of mainly textures and oscillatory patterns in spite of preserving the image integrity.

In a coding method developed by Guoan yang et al (2009) an image coding approach using wavelet-based adaptive contourlet transform was designed. This approach adopts the wavelet transform to implement subband
decomposition to replace laplace pyramid decomposition in contourlet transform, and hence the redundancy caused by the laplace pyramid decomposition can be eliminated. It chooses the directional filter banks as a key technique, combine SPIHT code, and realizes image compression coding called wavelet-based adaptive contourlet transform by rearranging the coefficient distribution and reproduces the texture information.

Set Partitioning in hierarchical trees (SPIHT) image compression algorithm based on Wavelet Transform can’t effectively express the image of the texture and contour. Contourlet transform can retain image details better because it avoids down sampling to high frequency subband, and the coefficient is also sparser than it of wavelet transform. A method was proposed by XI Zhi-hong and XIAO Yi-han (2009) a SPIHT algorithm for contourlet transform was proposed for its coefficient matrix characteristics and distribution. It protects details and texture, saves coding time with considerable PSNR and avoids critical sampling. It can be integrated into the current wavelet based embedded image-coding algorithm, and makes it easy to be implemented, effectively transferred and applied.

In a work proposed by Sara Parrilli et al (2008) a new image coding technique based on an hybrid contourlet-wavelet decomposition was developed. The encoder builds upon the SPIHT algorithm, which is modified to take into account the new hierarchical structure of the transform coefficients and the correlation between them. Both numerical results and visual quality confirm the potential of this approach, especially for images with high texture content. Even if the transform is slightly redundant the rate-distortion performance is good, especially for highly textured images.

In a method evolved by Xiaobo Qu et al (2008) developed a system to reduce the acquisition time in Magnetic Resonance Imaging (MRI). Compressed sensing MRI emerges to suppress the aliasing when under
sampling k-space data was employed. In their method, contourlet into compressed sensing to obtain a sparse expansion for smooth contours and non subsampled contourlet was employed to increase the redundancy of basis for magnetic resonance images. Compressed sensing MRI based on non subsampled contourlet transform (NSCT) suppresses the aliasing and improves the visual appearance of magnetic resonance images.

In a method proposed by Osslan Osiris Vergara Villegas et al (2006) an edge preserving lossy image coder was presented. An edge image is obtained from the original with a digital image processing module using four different filters: Canny, Sobel, Roberts and Prewitt, then the original image is domain transformed with wavelets or contourlets, and a pixel mapping from original domain to transformed is employed. For the compression, the edges points and the approximation image (which determines the compression factor) are selected; finally the image is decompressed in order to observe the reconstruction quality and edge preserving. Additionally, the results obtained from comparisons of error measures between original and decompressed images are shown and finally conclusions about the coder are presented.

The coding scheme of Chao Hsiung Hung and Hsueh-Ming HangIn (2008), designed two enhanced elements on the wavelet-based contourlet transform (WBCT) image coding scheme. A short-length 2-D non-separable directional filter bank was designed for reducing the calculation and speed up the filtering process. New zero coding context models are designed to improve coding efficiency. The compression scheme produces better visual quality images, with fine and regular texture at low bit rates. The short-length directional filter bank performs nearly as well as their long-length counterpart.

In a method proposed by Esakkirajan et al (2006) compression of images using contourlet transform and multistage vector quantization was
presented. The computation and storage requirements are the major difficulty in implementing a vector quantizer. In the full-search algorithm, the computation and storage complexity is an exponential function of the number of bits used in quantizing each frame of spectral information. The storage requirement in multistage vector quantization is less when compared to full search vector quantization. The coefficients of contourlet transform are quantized by multistage vector quantization. The quantized coefficients are encoded by Huffman coding to get better quality i.e., high peak signal to noise ratio (PSNR). The results obtained are tabulated and compared with the existing wavelet based ones.

The method proposed by Guosheng Gu and Yinwei Zhan (2009) presents an image coding technique based on contourlet transform which eliminates the redundancy by switching the LP decomposition step to separable wavelet transform. The transform is then optimized through a wavelet coefficient weighting process in order to enhance the visual quality in the image domain, and with that the directional filter bank (DFB) are employed to high frequency wavelet subbands. All the resulted subbands are efficiently coded with EBCOT. At the same bit rates, a gain of up to 0.3~0.6dB over JPEG2000 has been observed for standard images with directional features.

In a method developed by Ramaswamy et al (1998) an EZW lossless coding framework consists of three stages: (i) a reversible wavelet transform, (ii) an EZW data structure to order the coefficients and (iii) an arithmetic coding using context modeling was used. The set partitioning based EZW coding was used to split the coefficients into (i) significance map and (ii) residue map. The significance information was coded either by packing the individual bits or by grouping the bits into block of 2 x 2. In the work, discussions were made on the experiments conducted in the first and
second stage of the framework using the set partitioning based EZW coding to optimize the compression efficiency.

Liu Xuhong et al (2005) in their work presents an improved embedded zerotree wavelet (EZW) coding algorithm. According to the characteristic of coefficients and human visual system (HVS), an attempt is made to improve Shapiro’s EZW algorithm. The improved algorithm pays more attention to the edge of one image because human visual system (HVS) is sensitive to the distortion of image edge information. Experiments results show that the improved algorithm performs better than EZW in reconstruction image quality, especially in the case of low rate.

The method employed by Mei Zhu and Zhang Wei Li (2009) presents an improved image compression algorithm to make up a deficiency arising when the Embedded Zerotree Wavelet encoding (EZW) is employed to uniformly scan the low and high frequency coefficients. According to the feature of the wavelet transform’s energy distribution, the scalar quantization is used to quantify sub-band coefficients of high frequency in order to reduce the IZ (Isolated Zero); the threshold sequence is then adjusted in the process of the successive approximation quantization to minimize distortion when recovering images. Based on the analysis of the wavelet transform and EZW coding algorithms with the characteristics of wavelet transform coefficients, this method adopts the quantification factors to determine some coefficients of high frequency, followed by performing scalar quantization. This algorithm improves not only the accuracy of the scanning process, but also the PNSR as well as the quality of image reconstruction.

The method proposed by Jielong Chen and Jing Yang (2009) uses EZW in which the wavelet coefficients are decomposed into two groups and coded separately. Meanwhile, the subordinate pass is removed and the
location information of significant coefficients does not need to be kept in memory, So that the times of scan in the algorithm of the EZW are reduced. Thereby, the coding speed is much improved and the number of coding symbols is reduced. As the wavelet coefficient, especially the low-frequency sub-band coefficients are very large, it needs many times of scan, thus the encoding/decoding speed is relatively slow. The results show that there is much increase on the encoding/decoding speed and the volume of the coding symbols stream is greatly reduced, compared with the original algorithm. In addition, the improved algorithm keeps the characteristic of embedded stream and the parallel processing structure is especially suitable for hardware implementation.

In the method developed by Tong Yongmu and Zhang Xinghui (2010) adjusts the image coding compression ratio based on real-time network conditions can make the image transmission smooth. EZW coding supports for progressive transmission, and suitable for network transmission. In order to adjust compression ratio according to network congestion situation and improve image transmission speed on the network, this method proposes a EZW coding algorithm that can adjust compression rate according to TRR, a key network conditions parameter. The algorithm allows images to be transmitted on the network in quick succession.

EZW’s dominant passes need to scan the wavelet coefficient matrix multiple times, reducing greatly the speed of EZW. Hence, many authors have improved EZW, but these algorithms have not completely reduced redundant search, thus have not improved fully the coding speed. A thorough research should implement only necessary operations and eliminate unnecessary operations, Mow-Song Ng’s EZW encoding and decoding system is such a
typical successful example. But in this kind of algorithms, the coefficient-nodes in dominant list and subordinate list have to contain more information, reducing the encoding and decoding speed. Hence, this paper propounds a unified scheme for fast EZW encoding and decoding algorithms. This scheme encodes or decodes on an ordered linear list, and its coefficient nodes contain less information, improving the encoding and decoding speed to a certain degree. Many encoding and decoding algorithms using different scan order, including Mow-Song Ng’s algorithm, can be transformed into this unified scheme.

In a method proposed by Tang Guowei et al (2007) an improved EZW image coding algorithm based on lifting wavelet transform is proposed. The improved method deals with the lower frequency subband alone before carrying out zerotree quantization. In this way, the lower frequency coefficient that plays an important role in image reconstruction can be encoded by using improved zerotree quantization coding algorithm. The encoding efficiency and the quality of recovered image are raised without affecting the holistic compression ratio of image, and satisfactory recovery image can be obtained even in lower code rate. In this method lifting wavelet is used to improve the procedure of traditional wavelet transform. By modifying the scanning strategy of the wavelet coefficients and the quantization threshold the high and low frequency sub-bands are manipulated separately. The experiment results show that the improved method can improve the quality of the recovered image and the encoding efficiency making adjustments in the scan order of the coefficients.

Ganesh Bhokare et al (2005) proposed a technique which is an extension of the embedded zero wavelet tree coding technique to the M-Band
wavelet transform. Through this scheme, the efficiency of the embedded zero wavelet tree coding is increased with the use of 2-level quantization in EZW against, that finds extensive application as a variable bit-rate coder. The variable bit-rate is emulated as multiple scans. Hence graphs are plotted against the compression ratio or the PSNR versus the number of scans. An important inference is that, M-Band wavelet transform with M=Odd, exhibits special properties, as a result of which the EZW scheme performs much more efficiently with them. The performance gain, in both PSNR and compression, in M-band wavelet transform over the conventional 2-band wavelet transform is mainly due to the flexibility of coding of higher bands. It is possible to improve performance of M-band wavelet transform by using non-linear adaptive quantization. The main advantage of M-band (M > 2) wavelets over 2-band wavelets is frequency tiling which gives zoom in onto narrow band high frequency components of a signal, while simultaneously having a logarithmic decomposition of frequency channels which closely approximates HVS model & hence gives better compression than 2-band counterpart. However, in M-band wavelet system odd number of filter banks gives better compression than even number of bands.

This paper presents a low memory implementation of efficient lossy volumetric medical image compression using the Set Partitioning in Hierarchical Trees (SPIHT) algorithm proposed by Youngseop Kim and William A. Pearlman (1999). The coding units in this three-dimensional wavelet transform and compression method are short sequences of horizontal stripes cut from the sequence of slices in the volumetric image. As the compression degree increases, the boundaries between adjacent coding units became increasingly visible. Unlike video, where image frames are viewed under dynamic conditions, the volume image is examined under static
conditions and must not exhibit such boundary artifacts. In order to eliminate
them, we utilize overlapping and averaging both at the intra-slice and inter-
slice boundaries between adjacent and successive stripe sequences. This
technique smooths out considerably the variation in mean squared error
among different slices and suffers only an insignificant loss in performance
from that of a full memory implementation.

To segment out the ROI, Fuzzy clustering techniques, especially
fuzzy c-means (FCM) clustering algorithm, have been widely used in
automated image segmentation applications. However, as the conventional
FCM algorithm does not incorporate any information about spatial context, it
is sensitive to noise. To overcome this drawback of FCM algorithm in a
method develop by Y. Yang et al (2005), a novel penalized fuzzy c-means
(PFCM) algorithm for image segmentation is presented in this paper. The
algorithm is formulated by incorporating the spatial neighbourhood
information into the original FCM algorithm with a penalty term. The penalty
term acts as a regularizer in this algorithm, which is inspired by the
neighbourhood expectation maximization (NEM) algorithm and is modified
in order to satisfy the criterion of the FCM algorithm. The proposed algorithm
is effective and more robust to noise and other artifacts than the standard
FCM algorithm.

In a method proposed by Anton Bardera et al (2009) new image
segmentation algorithms based on a hard version of the information
bottleneck method are presented. The objective of this method is to extract a
compact representation of a variable, considered the input, with minimal loss
of mutual information with respect to another variable, considered the output.
First, a split-and-merge algorithm based on the definition of an information
channel between a set of regions (input) of the image and the intensity histogram bins (output) is introduced. From this channel, the maximization of the mutual information gain is used to optimize the image partitioning. Then, the merging process of the regions obtained in the previous phase is carried out by minimizing the loss of mutual information. From the inversion of the above channel, a new histogram clustering algorithm based on the minimization of the mutual information loss is presented, where now the input variable represents the histogram bins and the output is given by the set of regions obtained from the above split-and-merge algorithm. Finally, we introduce two new clustering algorithms which show how the information bottleneck method can be applied to the registration channel obtained when two multimodal images are correctly aligned.

For the two first algorithms, an information channel between the regions of the image and the histogram bins has been defined. Based on the preservation of mutual information, the spatial distribution and the histogram bins are maximally correlated. For the third algorithm, a channel between two multimodal images is defined, allowing to segment one image preserving the maximum information given by the other one. The main advantages of these methods are that do not assume any \textit{a priori} information about the images (e.g., intensity probability distribution) and that take into account the spatial distribution of the samples.

Xiao Xuan and Qingmin Liao (2007) Automated MRI (Magnetic Resonance Imaging) brain tumor segmentation is a difficult task due to the variance and complexity of tumors. In this paper, a statistical structure analysis based tumor segmentation scheme is presented, which focuses on the structural analysis on both tumorous and normal tissues. Firstly, 3 kinds of
features including intensity-based, symmetry-based and texture-based are extracted from structural elements. Then a classification technique using AdaBoost that learns by selecting the most discriminative features is proposed to classify the structural elements into normal tissues and abnormal tissues.

2.3 OBJECTIVES

The objectives of the present work are:

- To enhance the image under test through preprocessing.
- To segregate the Region of Interest (ROI) using Modified Fuzzy C means algorithm.
- To identify the significant region of the image under test and to the whole image wavelet transform is applied.
- To implement a Contourlet transform for smooth detection of edges to selected ROI and to the whole image.
- To estimate the performance of the Modified Embedded Zerotree algorithm.
- To validate the proposed algorithm and compare with the existing algorithms.

2.4 IMPLEMENTATION METHODOLOGY

The flow graph of the proposed medical image compression system for efficient image storage and transmission bandwidth is shown in Figure 2.1. The medical image has been obtained and processed using various techniques.
Figure 2.1 Flow graph of the Proposed algorithm model
2.5 ORGANIZATION OF THE THESIS

The thesis has been organized as follows

**Chapter 1** : Introduction about the work undertaken

**Chapter 2** : Review of literature

**Chapter 3** : Preprocessing of the image

**Chapter 4** : Segmentation of ROI using Fuzzy C means algorithm.

**Chapter 5** : Details of algorithm developed based on the significant portion of the image under test and the whole image and application of Contourlet Transform to EZW technique with results and discussion.

**Chapter 6** : Mathematical models for the application of wavelet transform to the selected significant portion and to the whole image with results and discussion.

**Chapter 7** : Conclusion and future scope of the work followed by references