CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

There are numerous challenges in telemedicine which require sophisticated implementation methods. This chapter presents a review on the basic technology behind telemedicine, key issues identified and solutions to address those issues. In the current work, the major challenges identified in telemedicine technology namely the bandwidth constraint are addressed by some of the novel compression methodologies. In addition, segmentation and soft computing techniques are also presented.

2.2 TELEMEDICINE TECHNOLOGY

Yang Xiao et al (2007) presented the usage and future potentials of telemedicine technology with examples. A brief discussion about LINCOS project was also presented. A detailed discussion on various technical issues like compression, artificial intelligence was presented. Medical sensors, home monitoring systems, Electrical Medical Records EMRs which were considered the future of telemedicine systems was also briefed upon.

The major goals and benefits offered by telemedicine were described by Zach (1996). Direct patient examination, patient information sharing and physician information gathering were the services offered by
telemedicine. The author also threw light upon some of the barriers existing in the implementation of telemedicine technology.

Planning and implementing telemedicine systems requires multiple dimensions to be considered. Over the last few decades, a number of new definitions and terms were coined. There arose a need for a single taxonomy to define all related terms. The taxonomy proposed by Bengisu Tulu et al (2005) compared current and future telemedicine efforts and also aids in understanding needs and participating in next generation health care environments.

Mishra et al (2008) have highlighted the present state of telemedicine in India. There are lots of efforts initiated by the private and the public sector in order to improve the quality of medical services. Digital medical libraries have also been introduced.

Amrita Pal et al (2005) presented a detailed study on the current state of telemedicine in a developing country like India. Owing to the majority 70% of the Indian population living in rural areas, the authors discuss the necessity of telemedicine in India and have also presented a case study on three scenarios and discussed some of the crucial factors for telemedicine to be actively implemented still further.

Xue and Liang (2007) analyzed the telemedicine diffusion in one of the largest countries namely China. The authors surveyed how telemedicine had evolved in China. The telemedicine networks available in China and an analysis on some of the factors that inhibit the growth of telemedicine diffusion were described.

One other developing country which had realized the importance of telemedicine and e-health is Pakistan. Many telemedicine projects were
initiated in order to improve on the standard of quality health services to the rural population. Asif Zafar Malik (2007) presented a detailed report on telemedicine in Pakistan. He briefed on the existing telemedicine scenario in the country, the projects identified and undertaken by the telemedicine facility in Pakistan and finally the role played by the Pakistan government in successful implementation of telemedicine in the country.

A primary objective of telemedicine is that the dynamic images need to be transmitted to a distant location in order to provide consultation remotely. Johannes Stahl et al (2000) designed a teleconferencing system and validated for interventional cardiology. The paper also described various compression, transmission and display methods in order to provide high quality service to the rural population.

Moghadas et al (2008) defined a telemedicine health care system which can be used for monitoring the patient in an emergency situation. The proposed telemedicine system consisted of a portable/non portable telemedicine section and a portable/non portable base section. The use of TCP/IP makes the operability of systems in a telemedicine environment more efficient.

Woodward et al (2001) developed a mobile telemedicine system to be used with third generation networks. Mobile telephones are interfaced with sensors to the patient’s body in order to transmit the medical data and facilitate remote patient consultation.

A fast developing trend in telemedicine is the tele home care. Figueredo and Dias (2004) implemented telemedicine through mobile telephony to monitor the patients from home eliminating the need for patient transfers from home to hospitals. Tele home care proved very useful in emergency situations.
Virendra Sinha et al (2012) discussed the various technical issues, their drawbacks in India. A set of standards need to be implemented. They have discussed telemedicine in terms of neuron surgical emergencies and recommend the standards to be constantly refined for successful implementation of this growing technology.

2.3 MEDICAL IMAGE COMPRESSION

Sukhwinder Singh et al (2007) proposed an effective compression for teleradiology. The technique was based on adaptive threshold value based on variance for block classification. At the same compression ratio, there has been an improvement in the quality of the reconstructed image.

Kinsner (2002) in his paper provides an overview of the most significant compression methods and techniques. He also gave an insight into some of the denoising methods. Compression methods were evaluated objectively and subjectively by various compression metrics like delay, efficiency and complexity.

Ghrare et al (2009) proposed a new lossless coding algorithm used in teleradiology and telemedicine. The proposed algorithm was based on the binary and the gray scale matrix and tested on MRI and CT scan images. The results showed better compression ratios than the existing lossless methods and allowed perfect reconstruction of the original image.

The effect of compression on three different types of CT images (chest, liver and adrenal) was performed by Ghrare et al (2008). Images were compressed using a lossy wavelet transform and the images have been evaluated for their quality.
A novel tree clustering and pattern matching algorithm for fast Huffman decoding was proposed by Seung Bae Choi and Lee (1995). It resulted in faster symbol search and effective use of memory.

A detailed study of image compression using Discrete Wavelet Transform DWT and DCQ Dynamic Contrast based Quantization has been done and a graph plot between PSNR and bits per pixel values have been plotted for different sub band levels. (Logashanmugam and Ramesh 2008). A detailed comparison of the first level sub bands has been presented.

As far as medical images are concerned, several research processes are reported for effectiveness of loss-less compression. One such paper by Clunie (2000) evaluated the effectiveness of traditional and state of the art approaches of loss-less compression of grayscale medical images. The JPEG-LS process (ISO/IEC 14495-1) and the loss-less mode of the proposed JPEG 2000 scheme (ISO/IEC CD15444-1), which are standard schemes that may be incorporated into DICOM, was evaluated. Three thousand, six hundred and seventy-nine (3,679) single frame grayscale images from multiple anatomical regions, modalities and vendors, were tested. Combined JPEG-LS and JPEG 2000 performed equally well for all kinds of images. Both out-performed existing JPEG. It was found that the use of standard schemes could achieve state of the art performance, regardless of modality. Further, it was found that JPEG-LS is simple, easy to implement, consumes less memory, and is faster than JPEG 2000, though JPEG 2000 will offer lossy and progressive transmission.

Another interesting paper by Chan and Chang (2005) performed lossless medical image compression by building a modified S-tree structure to make each block contain similar pixels. The medical images have a very close pixel-to-pixel correlation. In order to preserve this characteristic, a loss-less
medical image compression method was developed. It was found that this method could reduce the required number of bits to record those pixels. The experimental results also show that this method is better than other methods in almost all cases.

A comparative study of lossless compression algorithms for gray scale document images was presented by Savakis (2000). Experimental results revealed highest compression for CALIC and JPEG-LS algorithms.

A novel lossless image compression algorithm based on prediction to minimize the storage costs was presented by Knezovic et al (2007). The proposed predictor could also be used for image segmentation.

A performance analysis of various compression schemes namely Huffman encoding, LZW, Arithmetic coding and Transform based coding methods have been performed and validated on high resolution image categories like mammograms and chest X-rays (Gopinath Kuduvalli and Rangaraj 1992) for use in a telemedical application.

Aaron Deeverand Hemami (2003) adapted developed a projection technique which used the concept of prediction for predicting the wavelet coefficients. This method was found to decrease the first order entropy of transform coefficients. This method serves as a generalized framework for many wavelets based lossless compression algorithms.

Eleftherios Kofidis (1999) developed a system based on a combination of DWT and EZW compression. A novel RLE encoder is proposed for the role of an entropy encoder. The proposed encoder has the capability of selective compression, thereby leading to a higher compression ratio and also preserving the critical information at the same time. The
selective compression capability could be used in many medical imaging applications including the telemedical society.

Another efficient image compression scheme based on DWT and fuzzy c means clustering was developed by Karras et al (2000) in which different compression ratios are applied to the wavelet coefficients in different ROI s. This paper aims in exploiting the co relation characteristics of the wavelet coefficients and the second order characteristics of the images. The reconstructed images need to be smoothened at the boundaries.

Mohit Gupta and Londhe (2011) analyzed three near lossless image compression methods of different entropy encoders namely NLIC, Run Length Encoding RLE with Discrete Cosine Transform DCT and SPIHT with Discrete Wavelet Transform DWT. The three compression methods were analyzed over various parameters like Compression ratio, PSNR, MSE and RMSE. The proposed techniques greatly improves the transmission speed thereby resulting in efficient storage of the imaging data.

Suresh et al (2009) proposed a research on evaluating the performance of Magnetic Resonance images coding with Shape Adaptive Discrete Wavelet Transform. The proposed scheme could perform better than existing wavelet based coding schemes by an average of 1dB better than wavelet packet SPIHT coding and nearly 2dB better than conventional wavelet SPIHT coding.

Goh Han Keat et al (2005) proposed a method to enhance the performance of secure image using wavelet compression. The research work included Embedded Zerotree Wavelet (EZW) compression that is selected as a compression algorithm for this research, Arithmetic Entropy Encode algorithm that is used to further reduce the size of image file and finally streaming encryption algorithm RC4 that is used to encrypt the digital image...
content. The methodology provided information on how to reduce image file size and to increase security protection and also flow modification has been proposed to maximize the compression efficiency.

Javed et al (2008) offered a simple and lossless compression method for compression of medical images. The proposed Wavelet Based Medical Image Compression through Prediction scheme was used to achieve high compression. Coefficient graphic method for selection of prediction variables is a simple method in which predicted and original coefficients of a sub band are plotted for comparison. This method avoided the multicollinearity problem which was the main contribution.

Hua Li and Zhu (2008) presented a new lossless compression scheme named Differential Pulse Code Modulation-Integer Wavelet Packets Transform DPCM-IWPT combining DPCM and IWPT. The proposed method performed much better without any computational overhead and yielded purely lossless compressed images.

Lei Wang et al (2008) presented a lossy to lossless image compression scheme. Reversible Integer Discrete Cosine Transform RDCT was used here. This method performed well for lossy and lossless compression.

Diez Garcia et al (2005) presented a novel lossless compression method for volumetric medical datasets based on 3D adaptive prediction. Least Square Estimation in 3-D scheme was adopted which extended the still image coding in addition to apply information from third space dimension. LSE 3D achieved better performance on ECHO and PET volumes when applied to different volumes of medical imaging test.
Liying Ma and Khorasani (1995) had as an objective of their study, the application of an adaptive constructive one-hidden-layer feed-forward neural network (OHL-FNNs) to image compression. Comparisons with fixed structure neural networks were performed to demonstrate and illustrate the training and the generalization capabilities of the proposed adaptive constructive networks. The influences of quantization effects as well as comparison with the baseline JPEG scheme were also investigated. It was demonstrated through several experiments that very promising results could be obtained as compared to presently available techniques in literature.

Daugman (2002) had recently proposed a neural network model for computing the discrete 2-D Gabor transform. Gabor transform had proved to be very useful for image compression and analysis. The computation of the Gabor transform was very complicated as Gabor elementary functions were not orthogonal to each other. The author used a least squares error criterion and a gradient based weight adjustment rule, which might be implemented by using an adaptive control signal that was the difference between a feed-forward signal and a feedback signal.

Pinho (1993) introduced a new method for digital image compression that combined two non-traditional techniques namely, adaptive block size image segmentation and artificial neural networks. An algorithm for image compression using these techniques was proposed and some experimental results were presented. All compression parameters (i.e. the output values of the hidden units) were uniformly and scalar quantized to 6 bits. The study also stressed that, owing to the adaptive block size capability reduced the number of parameters to implement compression system.

Cheng-Chang Lu and Yong Ho Shin (1992) proposed to implement vector quantization (VQ) for image compression based on neural networks.
Separate codebooks for edge and background blocks were designed using Kohonen self-organizing feature maps to preserve edge integrity and improve the efficiency of codebook design.

Sang Joon Lee et al (2011) proposed a methodology for real-time data compression and transmission algorithm between e-health terminals for periodic ECG signal. This method can be used as data transmission method for limited bandwidth communication. ECG data can be efficiently compressed even under limited communication resources when the proposed algorithm was used.

2.4 MEDICAL IMAGE SEGMENTATION

Alfred Bruckmann and Uhl (2000) investigated the selective compression technique which is of great interest in telemedicine. Techniques with different functionalities are compared.

The application of Region Of Interest ROI coding in telemedicine is proposed. The ROI s are coded by wavelet based lifting and tiling methods to provide a better compression ratios. SPIHT is also used in encoding the ROI (Rajkumar and Latte 2011). The final encoded data is formed by integration of all the ROI s, background information and a header. The header contains the number and resolution of the ROIs. The proposed technique was also tested on real world images.

Another effective segmentation based compression in telemedicine is the segmentation based multi-layer SML coding scheme (Xin Bai et al 2004) for lossless image compression. An unseeded region growing approach was used to extract the ROIs and coded by JPEG 2000 approach. Thus, a lossless compression scheme was developed with different levels of reconstruction quality in different parts of the image according to their role in
diagnosis. This method was also used in content based image retrieval and semantic progressive transmission in telemedicine.

Ping-Lin Chang and Teng (2007) devised a segmentation technique using a self-organizing map SOM to extract the ROI. It is a two stage approach in which the SOM identifies a number of representative colors. In the second stage, the SOM determines the dominant colors among the representative colors. This method was found to effectively and efficiently handle different types of medical images.

Doukas and Maglogiannis (2007) surveyed state of the art ROI coding techniques applied on medical images. These included ROI techniques for still images, volumetric images and video sequences.

Doukas et al (2005) discusses a PACS application for viewing DICOM medical images which used wavelet compression with ROI coding support. Wavelet compression could produce lossless and lossy images accurately according to the application in which it is used is required.

Pervez Akhtar et al (2008) implemented the MAXSHIFT scaling method which proved very effective both objectively and subjectively. The diagnostically important regions namely the Region of Interest on CT images was coded by the proposed method and proved very useful in teleradiology.

Chuan-Yu Chang (2008) proposed a progressive learning vector quantization neural network (PLVQNN) in combination with a preprocessing procedure for automatic thyroid segmentation and volume estimation using computerized tomography (CT) images. Thyroid region segmentation and volume estimation was a prerequisite step to diagnosing the pathology of the thyroid gland. It was seen that the proposed method could effectively segment thyroid glands and estimate the thyroid volume.
Maulik (2009) proved the efficiency of genetic algorithms in medical image segmentation, thereby improving the flexibility of the segmentation procedure. Evolutionary techniques like genetic algorithms are effective since objective function of the medical images are discontinuous and complex. Issues like fitness scaling are discussed to avoid premature convergence.

Mendi et al (2009) proposed a method of extracting ROI by segmentation based on visual attended locations. Chan-Vese active contour model is used for image segmentation and attended locations are determined by Saliency Toolbox. Combining these two techniques minimizes the user interaction and speeds the complete segmentation process. The proposed compression technique is based on the hypothesis that image resolution exponentially decreases.

2.5 SOFT COMPUTING TECHNIQUES FOR IMAGE RETRIEVAL

Jose and Mythili (2009) described a hybrid approach for content based image retrieval. A two-step approach in which the first step was a neural network based self-organizing map and a genetic algorithm based search technique was included in the second step, thereby doubling the doctor’s accuracy over diagnosis of a disease. The proposed approach was used to retrieve digital mammograms.

Daniele and Datcu (2012) defined a content based color image retrieval system based on the concept of Fast Compression Distance FCD. Computationally less complex, it can be used on very large data sets.
Arevalillo-Herraez et al (2011) proposed a CBIR system combining relevance feedback; genetic algorithm and distance based learning. The effect of crossover and mutation have also been evaluated.

Ali Ashtari et al (2010) proposed a regularization approach in breast imaging applications. It is a combination of neural network and genetic algorithm and termed NNRGA Neural Network Real Genetic Algorithm. This method was able to reconstruct both high and low contrast images.

A neuro genetic approach to feature selection in disease classification was attempted by Shanthi et al (2008). The challenge was to identify and select a good combination of input variables, in order to improve the performance of the neural network. A Genetic algorithm was introduced to select the inputs. This approach has been tested on patients with Stroke disease.

Sushmita Mitra et al (2002) provided a rich survey on data mining using soft computing approaches. An extensive literature on the various soft computing tools, data mining functions and genetic algorithm for optimal solutions has been dealt with.

Sang Cheol Park et al (2011) developed a new Computer aided detection scheme for detection of pulmonary embolism shown on CT images. Many methods to improve on CAD performance were also investigated.

A Linear Vector quantization based algorithm was developed and analyzed for combined compression and classification. The ODE method of stochastic approximation was used to show the convergence of the algorithm. (John Baras and Dey 1999).
Mehdi Kashei et al (2012) proposed a hybrid model of artificial neural networks using multiple linear regression models in order to get more precise classification accuracy. The model could be used for a 2 class and a multi class problem.

Farzad Zargari et al (2008) proposed an image retrieval technique in the compressed domain for JPEG (2000) images. The packet header information was decoded for image retrieval. It performed better than pixel based Gabor filter and many wavelet based retrieval methods.

Boaz Lerner et al (2007) proposed two solutions to solve a multi class classification task which uses a small imbalanced database of patterns. The first solution was to hierarchically decompose the classification task and then to balance the data by up sampling the minority classes.

Khashman and Dimililer (2009) trained a neural network to relate the imaging data to the optimum compression ratio. The type of compression used was Haar wavelet. Medical radiograph images were compressed and the trained neural network could recognize the optimum compression ratio. A recognition rate of 95.65% was obtained by the proposed methodology.

Shuiwang Ji and Jieping Ye (2008) proposed a unified framework for Linear Discriminant Analysis LDA by a transfer function. They showed that the matrix computations in LDA algorithms could be simplified.

Rahman et al (2006) presented content-based image retrieval framework for various collections of medical images of different modalities, anatomical regions, acquisition views, and biological systems. Mono-hierarchical coding scheme was used to classify the images manually. The algorithm performance was characterized with respect to error rate and precision-recall.
A medical image categorization technique was studied and implemented by Florea et al (2006) in which images was categorized after extraction of textual and statistical features.

Jiang et al (2010) presented a detailed study on how neural networks could be used in medical imaging. They provided a detailed description as to how a given network could be used to solve a problem and how medical images could be analyzed, processed and characterized.

Mukta Paliwal and Usha Kumar (2009) presented a detailed survey on the feed forward neural networks available in literature. Their study also gave an insight about the various statistical techniques used for prediction and classification problems.

Nezamabadi-pour Hossein et al (2009) presented a novel methodology which combined both visual and semantic features for image retrieval. The classifier used here is the fuzzy k neural network classifier. During the process of retrieval, the network weights were updated by the relevance feedback from the users. Since a considerable amount of relevance feedbacks were provided by the users, the system showed good improvement than most existing systems.

Feature selection is done by a set of filter and wrapper approaches by a Bayesian classification model in order to treat a medical condition of patients affected with a kind of hypertension. A number of Bayesian classification models were also proposed (Rosa Blanco et al 2005).

The wavelet features from different sub bands are independent. The dependence between features from different sub bands is investigated and a new wavelet feature selection model based on statistical dependence is presented by Ke Huang and Aviyente (2008).
Bors (2001), in his paper discussed the properties and applications of Radial Basis Function Networks (RBF). The physical and statistical significance of the elements composing the network are presented. A few of the training algorithms are also introduced and real time applications of RBF networks are presented.

2.6 INFARCT CLASSIFICATION OF BRAIN IMAGES

Chris Cocosco et al (2003) presented a novel, fully automatic, adaptive, robust procedure for brain tissue classification procedure from 3D magnetic resonance head images. K nearest neighbor classifier was used for the purpose of classification. The classification procedure is robust against variability in the image quality through a non-parametric implementation: no assumptions are made about the tissue intensity distributions.

Salim Lahmiri and Boukadoum (2011) proposed a three-stage approach for design, consisting of second-level discrete wavelet transform decomposition of the image under study, feature extraction from the LH and HL sub-bands using first order statistics, and subsequent classification with the k-nearest neighbor (k-NN), learning vector quantization (LVQ), and probabilistic neural networks (PNN) algorithms. The experimental results also show that using an ensemble classifier improves the correct classification rates.

El-Sayed et al (2009) presented two hybrid techniques for the classification of the magnetic resonance human brain images. The proposed hybrid technique consists of three stages, namely, feature extraction, dimensionality reduction, and classification. In the first stage, features related with MRI images using discrete wavelet transformation (DWT) were obtained. In the second stage, the features of magnetic resonance images (MRI) were reduced using principles component analysis (PCA) to the more
essential features. In the classification stage, two classifiers based on supervised machine learning were developed. The first classifier based on feed forward back-propagation artificial neural network (FP- ANN) and the second classifier based on k-nearest neighbor (k-NN). The classifiers were used to classify subjects as normal or abnormal MRI human images. A classification with a success of 95.6% and 98.6% was obtained by the two proposed classifiers FP-ANN and k-NN respectively.

Bagher Ebadian et al (2009) proposed a method to study the ischemic stroke using Artificial Neural Network (ANN). The method identifies the extent of ischemic lesion recovery. Experiments using new dataset showed that the prediction made by the ANN had an excellent overall performance and was very well correlated to the 3-month ischemic lesion on T2-Weighted image.


Gutierrez-Celaya et al (2011) automated the evaluation of stroke chronic patient’s motor functions. The proposed method help predict rehabilitation possibilities of patients after stroke. The MLP is trained to discriminate statistical patterns of brain activations using non-correlated independent image parameter vectors.

Yazid Cherfa et al (2007) proposed a segmentation system based on edge and region cooperation for MR brain images. The proposed segmentation uses a dual edge-region method for extracting the stroke lesion. Experimental results show that the result from the proposed method is very close to that of manual measurements carried out by neurologists.
Mayank Chawla et al (2009) presented an automated method for the purpose of detection and classification of stroke disease from CT images. The proposed algorithm carries the advantage in detecting all types of stroke and a two level classification scheme is used here.

A new model for stroke prediction using FFD Fourier Fractional Dimensionality was proposed by Che Azemin et al (2010). The retinal vasculature was analyzed using FFD after image enhancement at various scales.

Christodoulou et al (2003) proposed an effective methodology in order to identify a group of patients at risk of stroke based on texture features extracted from high resolution ultrasound images of carotid plaques. In this work, a modular system using different texture characteristics and classifiers were proposed for the differentiation of carotid plaques.

Joyce Chiang et al (2006) proposed a novel method of classification for patients affected with stroke and healthy patients. It is built upon on the classification of surface electromyographics EMG signals by a linear support vector classifier.

Edward Sazonov et al (2009) described a novel methodology in order to automatically recognize the postures and activities of patients affected with stroke. This may provide a feedback to stroke affected patients for an effective rehabilitation program. Support vector classification used in this work provided a high degree of accuracy. Linear and Gaussian kernel SVM were implemented. A notable feature was that the Gaussian kernel classifier performed better when compared to the linear kernel classifier when ascending stairs. The proposed system could automatically recognize postures of patients recovering from stroke disease.
In order to improve on the effectiveness of image retrieval systems, a novel generative model which could automatically annotate the images were proposed Thien Dinh et al (2011). The proposed model was validated on ischemic stroke images. The high scalable property of this approach enables this model to be applied to large databases. Moreover, the proposed framework could efficiently handle incorrect segmentation of input data as well as missing values in the training set.

Andrius Usinskas et al (2004) described a method to efficiently segment ischemic stroke regions from features like mean, standard deviation and gray level co-occurrence matrix methods. The feature vector was calculated for each sliding window position and Euclidean distances were compared to group similar feature vectors. There was no training set used in this method. The thresholding procedure was performed to show to determine 2 classes namely stroke and no stroke.

2.7 SUMMARY

This chapter discussed the necessity and the benefits of telemedicine technology to be implemented in a developing nation like India. The effect of image segmentation and compression on medical images was also highlighted. Papers related to image retrieval have also been presented. Feature extraction and feature selection techniques and various classification models available in literature were briefed upon. Some papers on the emerging trend of neural network classifiers and evolutionary computing techniques like genetic optimization were explained. The challenge is to improve technology in each area of the compressed image retrieval process such that it can be used effectively for telemedicine.