Chapter 1 Introduction

1.1 Telemedicine

The trend in medical imaging is increasing toward direct digital image acquisition. Currently, many modalities such as CT (computed tomography), MRI (magnetic resonance imaging), PET (positron emission tomography), SPECT (single-photon emission computed tomography), and DSA (digital subtraction angiography) produce images directly in digital form. It appears that telemedicine and digital image processing will eventually completely replace conventional film (hard copy) imaging in medicine.

Telemedicine is the provision of health care services via electronic transmission of medical information among different sites. It includes a wide and rapidly expanding array of technologies and approaches for communicating patient data, voice, and images in order to assist, augment or replace in-person clinical encounters.

Telemedicine is becoming more and more attractive with the improvements in computer technology and the growth of the information super-highway. It is now being used or tested in many areas of health care such as pathology, surgery, physical therapy, radiology and so on. Telemedicine makes it possible to save time and expense in transporting the patient to the health care expert in the central city hospital or transporting the expert to the patient. Thus, health care service quality is improved while the cost is simultaneously reduced. Another application of telemedicine is to let doctors have rapid access to patient records and be able to retrieve vital patient information in multiple formats.

1.2 Motivation

In spite of wide application of telemedicine, it still faces major challenges since vast quantities of digital imaging data are generated, transmitted and stored in a medical
imaging environment. For instance, a typical hospital might generate on the order of 1000 gigabytes of image data per year, almost all of which has to be kept and archived. A single 2048*2048 X-ray image may use 4 megabytes and even a single MRI volume may use 1.5 megabytes. Transmitting this X-ray image and MRI volume over a telephone line operating at 56K bps (bits per second) may take around 10 minutes and 4 minutes respectively, which is indeed very inefficient.

In order to boost performance, either the bandwidth of the communication channel should be increased or some compression during transmission should be applied or both. In practice, bandwidth of the communication channel will be limited by the nature of the channel (e.g. fading) and the technology. Moreover, the situation of narrow-band communication cannot be totally eliminated in the near future especially in many rural areas. As a result, most researchers are trying to develop optimal compression methods to achieve compression ratios of 50:1 or higher to achieve practical storage and transmission times.

Various PACSs (picture archiving and communication systems) have been developed in the medical environment to alleviate the problems associated with the increasing volumes of medical image data. Most PACSs derive their functionality from the international DICOM (digital imaging and communication in medicine) standard to specify communications protocols, image query and retrieval commands and storage standards. However, one serious disadvantage of PACS is its inefficiency to reduce the large amounts of homogeneous data accumulating in radiology image databases. For instance, multiple parallel slices, with each slice representing a different cross section of the body part being imaged, will be generated in a single examination by most commonly used digital modalities such as MRI, CT, PET, and SPECT. Multiple slices generated in this way are referred to as a 3-D (three-dimensional) image set. They are normally anatomically or physiologically correlated to each other. In other words, there are some image structural similarities between adjacent slices. As a result, more efficient compression can be achieved by exploring the correlation between slices instead of compressing an image set slice by slice.
This proposal is aimed at finding a novel and efficient lossless compression scheme, which exploits the dependencies that exist among pixel intensities in three dimensions, to compress a whole set of medical images. A progressive decoding is implemented to transmit a rough version of the image at different bit rates to boost the performance of the telemedicine since validity of the data can be determined at a very low bit rate. Furthermore, this proposed research includes some examples that demonstrate the use of intermediate results from the lossless compression scheme for simple computer assisted diagnosis based on some prior knowledge.