ABSTRACT

Medical images play an important role in diagnosis and treatment procedures. These medical images have high spatial and gray-level resolution for providing better diagnosis and hence generate large amount of data creating storage and transmission problems. Compression of medical images could minimize storage space and allow fast transmission. In this research, five techniques have been proposed for the compression of medical images, which provide good compression ratio and also preserves the diagnostically significant information. Five different image modalities have been compressed using the proposed methods which include Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasound (US), Coronary Angiogram (CA) and Functional Magnetic Resonance Imaging (fMRI). The proposed methods have been assessed through objective measures like Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) etc. and through subjective measures by the opinion of physicians in the corresponding field. The proposed schemes have also been evaluated on comparison with existing compression standards like Joint Photographic Experts Group (JPEG), lossy JPEG 2000 and also with the existing compression techniques for the corresponding medical image modality.

A Two-Dimensional (2-D) lossy compression algorithm using bilinear interpolation has been proposed for medical images in Chapter 2. The proposed method presents a technique for the classification of image blocks as significant or insignificant on the basis of threshold value of variance. The corner pixels of the blocks are stored and the remaining pixels are obtained by

bilinear interpolation. The difference between the original and interpolated image is calculated and the difference is transmitted along with the bilinear coefficients. At the receiving end, images are reconstructed with corner pixels. The difference is added only to the significant blocks. The experimental results show that the proposed technique yields better performance in terms of CR and PSNR compared to JPEG standard.

A 2-D lossy compression technique based on Contrast Sensitivity Function (CSF) has been proposed for medical images in Chapter 3. In the proposed technique, the image is decomposed into subbands by biorthogonal wavelet Cohen-Daubechies-Feauveau (CDF) 9/7. CSF based quantization factors are calculated and applied to the transformed coefficients. The transformed coefficients are then thresholded using “minimaxi” method. This threshold estimator recognizes the function which yields the minimum MSE. A uniform quantization is performed on the thresholded coefficients to bring the data in to the range $[0,2^{Q}-1]$. Then a lossless Binary Matrix Technique (BMT) is applied to the quantized coefficients where the most probable value is stored once, which in turn compresses the data further. In the decoder side, inverse operation is performed to obtain the reconstructed image. The simulation results indicated that the CR is improved in proposed method compared to the existing CSF based compression scheme and the encoding and decoding time of the proposed method is less compared to existing wavelet based Set Partitioning in Hierarchical Trees (SPIHT) and Set Partitioned in Embedded Block (SPECK) coding schemes.

A 2-D lossy image compression algorithm constructed by Wavelet Based Contourlet Transform (WBCT) and Binary Array Technique (BAT) has been proposed in Chapter 4. In WBCT, the high frequency subband obtained from wavelet transform is further decomposed into multiple directional subbands by Directional Filter Bank (DFB) to obtain more directional information. In WBCT the coefficient relationships have changed as it has more directions. The differences in parent-child relationships are managed by repositioning algorithm. The repositioned coefficients are then subjected to quantization. The quantized coefficients are further compressed by BAT where the most frequently occurring value is coded only once. The proposed method has been experimented with CT and MRI images, the results indicated that the processing time of the proposed method is less compared to wavelet based SPIHT and SPECK coders. The evaluation results obtained from Radiologists indicated that the proposed method could reproduce the diagnostic features of CT and MRI images precisely.

A lossy compression method for Three-Dimensional (3-D) coronary angiogram video sequences has been proposed in Chapter 5. In the proposed method the significant regions are detected and are represented by a binary mask the same mask is further sub-sampled to be equivalent to the size of subbands at different levels. The angiogram image sequence is divided into frames and is transformed using WBCT. The parent-child relation differences are managed by using a repositioning algorithm. The coefficients corresponding to insignificant areas of two levels of WBCT are made zero and then the coefficients are SPECK coded. The approach eliminates the low level contourlet coefficients of diagnostically insignificant regions of coronary angiogram image sequence. The proposed method has been applied to real-time angiogram image sequences. The results showed that the method proposed, outperforms JPEG 2000 both in CR and PSNR and wavelet based SPIHT in CR maintaining a similar PSNR. The evaluation results obtained from trained cardiologists indicated that the proposed method could reproduce the diagnostic features of angiogram more clearly compared to JPEG 2000. The results also indicated that the encoding and decoding time of the proposed method is less compared to 3-D SPIHT and wavelet based SPIHT.

A lossy compression method for Four-Dimensional (4-D) fMRI images has been proposed in Chapter 6. In the proposed method, the image slices of fMRI data are rearranged so that the redundant slices form a sequence. The significant (organ) and insignificant (background) regions are detected from the sequence and the significant region is represented in the form of binary mask. The mask is sub-sampled to be equivalent to the size of subbands at lowest level. The image sequence is divided into slices and transformed using WBCT. The insignificant coefficients identified by binary mask, corresponding to lowest level of WBCT are made zero. Then the coefficients are SPECK encoded. The method removes the insignificant contourlet coefficients corresponding to the insignificant regions of fMRI data set. The experimental results confirm that the proposed method obtains better CR and PSNR compared to JPEG standard and bandelet transform based fMRI compression scheme.

Chapter Seven is a summation of the thesis contribution with suggestions for future research.