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Research Article

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Compression of medical images with edge preservation

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ABSTRACT

Compression of the image is achieved using image compression techniques that remove visual information that is not perceived by the human eye. The emphasis in medical applications is to preserve important image features that contribute towards accurate diagnosis. Edges in the medical images are vital for accurate detection of boundaries of lesions and tumors, which in turn requires the preservation of edges. In this paper, method to preserve edges to achieve a decompressed image with a higher content of visual information is presented. Edge detection is a frequently used technique to extract the edge information in image compression system. For preserving the edges of the images, the compression algorithm is combined with edge detection.

Key words: Edge detection; Medical imaging; Image compression; Edge preservation

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INTRODUCTION

The image compression schemes can be classified into two categories, namely: Lossless compression and Lossy compression. In lossless image compression, the reconstructed image is numerically and visually identical to the original image. The level of image compression achieved can be represented by compression ratio (CR). The CR achieved for lossless techniques are typically around 2:1 to 3:1 [1]. In lossy image compression, higher CR can be achieved when compared to lossless compression techniques but the reconstructed image contains degradations relative to the original image. A lossy compression method is called visually lossless when the loss of information caused by compression method is invisible for an observer.

Edge information is an important feature that must be preserved by the medical image compression system. While compressing the image, errors occur usually at edges than inside uniform regions due to loss in high frequency components. Regaining those edges is very important in medical images, as edges in a digital image provide significant information about the objects contained within the image. In images, edges characterize object boundaries and are therefore useful for segmentation, boundary detection, object recognition, image registration, and so on.

In medical images, edges indicate the boundary of region of diagnosis, say lesion or tumor and classify the boundaries between various anatomical structures and tissues in the image. As edges contribute towards accurate diagnosis, edge preservation is a vital step in medical image processing to get exact size and location of diagnostically significant regions. Hence, the medical image compression algorithm must be developed such that the edges are preserved.

Gradient-based edge detection methods are simple to implement but they are sensitive to noise. Laplacian-based edge detection method fails to find the orientation of edges. Canny edge detector which is an optimal edge detector is widely used in many applications [2] and [3]. The medical image compression algorithm proposed by [4] uses Canny edge detector to detect edges.

The developed medical image compression method uses canny edge detector for detecting the edges. The following sections present materials and methods, experimental results and conclusions.

EXPERIMENTAL SECTION

The edges of original medical images are extracted using Canny edge detector. The location of the edges in the edge extracted image is used to identify the edges in the original image. From these locations original edge pixels are extracted. The original medical images are decomposed using one level Daubechies wavelet filter into approximation subband and detail subbands [5,6]. The compression algorithm developed in the proposed work uses approximation subband coefficients only. Optimum number of significant coefficients is selected to achieve compression. The threshold for selection of coefficients is computed which depends on the information content of the image for achieving compression without any observable loss of information. The threshold is determined by examining the number of occurrences of each coefficient. The coefficient with high frequency of occurrence in approximation subband is the initial threshold. The approximation coefficients are compared with the initial given threshold and the coefficients that are equal to the threshold are identified as significant coefficients. The remaining coefficients of the approximation subband are retained.

Using the chosen significant coefficients by the above procedure, the pixel information is reconstructed by performing Inverse Discrete Fourier Transform (IDFT). In the reconstructed pixel information using IDFT the edges are replaced with the original edge pixels which ensures that edges of the image are well preserved. Peak Signal to Noise Ratio (PSNR) is calculated as given in Equation (1) by comparing original image of size pixels with reconstructed image:

$$PSNR\ in\ dB = 10\ \log_{10}\left(\frac{255^2}{MSE}\right) \tag{1}$$

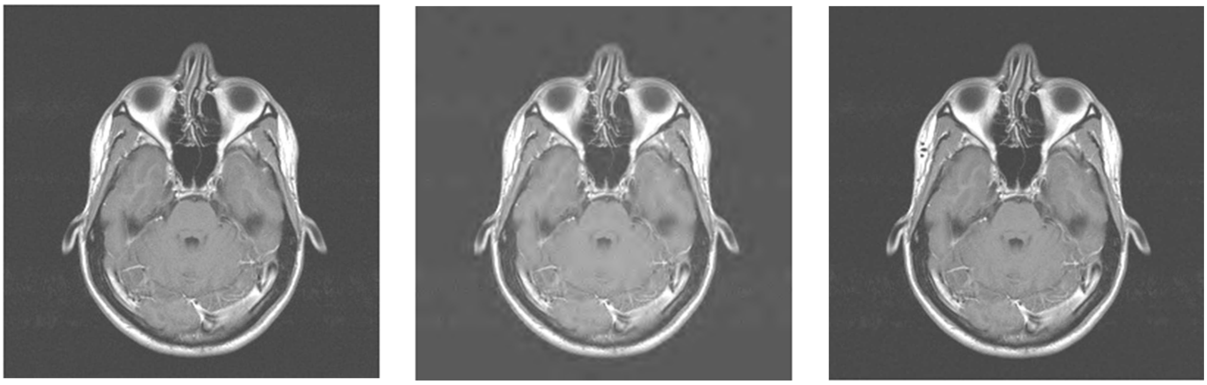
where MSE is Mean Square Error.

The work is proposed for yielding best visual quality images with PSNR equal to or greater than 36 dB, as there are no visual degradations in images reconstructed with PSNR greater than 36 dB [7-9]. If PSNR is greater than or equal to 36 dB, the procedure of selection of coefficients is stopped. If the condition is not arrived, then the procedure of identifying significant coefficients from the remaining approximation coefficients is continued, by comparing with their next subsequent threshold which is the coefficient with number of occurrences lesser than the previous threshold and greater than the retained coefficients. The procedure is repeated till PSNR is greater than or equal to 36 dB is obtained. Then the significant approximation coefficients and edge information are Huffman coded [10,11].

In the reconstruction stage, the compressed image is decoded and IDWT is performed. The edges of the decompressed image are replaced with the decoded edge information.

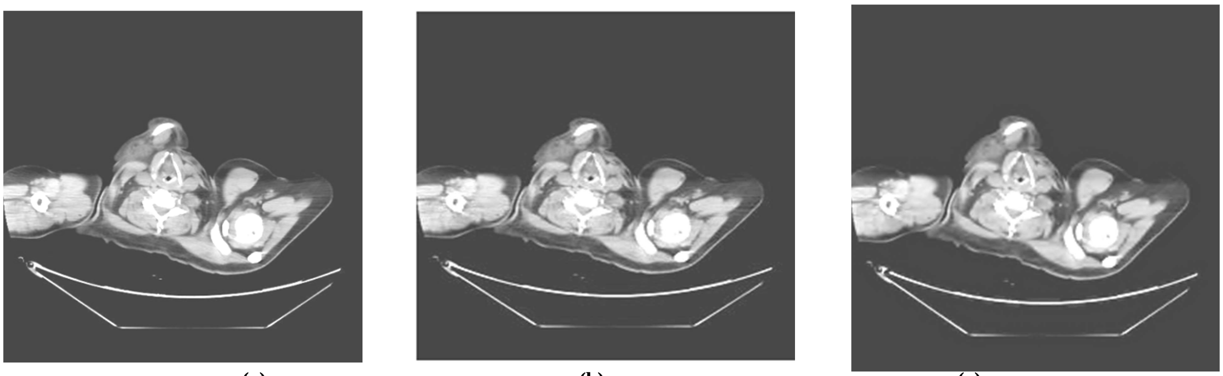
RESULTS AND DISCUSSION

The proposed method has been tested for MRI and CT images. Figure 1 and Figure 2 present the result of MRI and CT images compressed with the proposed method. The original MRI image and reconstructed image using SPIHT algorithm [12] and the proposed method are shown in Figure 1 (a) - (c), respectively. The original CT image and reconstructed image using SPIHT and the proposed method are given in Figure 2 (a) - (c).



(a) (b) (c)

Figure 1 (a) Original MRI image (b) Reconstructed image using SPIHT (CR = 6.1, PSNR = 37.38 dB) (c) Reconstructed image using the proposed algorithm (CR = 6.7, PSNR = 36.97 dB)



(a) (b) (c)

Figure 2 (a) Original CT image (b) Reconstructed image using SPIHT (CR = 8.6, PSNR = 36.60 dB) (c) Reconstructed image using the proposed algorithm (CR = 8.9, PSNR = 36.62 dB)

Table 1 compares objective measures CR and PSNR obtained for MRI and CT images using proposed method and SPIHT. Here PSNR equal to or greater than 36 dB is considered for both the methods for comparison. The tabular results prove that the proposed method works better than SPIHT. CR obtained with the proposed method is high compared to SPIHT for PSNR equal to or greater than 36 dB. For example, while observing the results in case of CT image 2, using SPIHT, CR is 6.0 with PSNR of 36.86 dB, but in the proposed algorithm increased CR of 7.2 is achieved with a higher PSNR of 36.88 dB. This shows that higher CR is achieved than SPIHT with better image quality. Higher compression with better image quality is obtained in the proposed method.

Table 1 Comparison of PSNR and CR of the proposed algorithm with SPIHT for medical images

Images	SPIHT		Proposed algorithm	
	CR	PSNR (dB)	CR	PSNR (dB)
MRI image 1	6.1	37.38	6.7	36.97
MRI image 2	8.7	36.42	9.1	36.79
MRI image 3	6.9	36.05	7.6	36.47
CT image 1	8.6	36.60	8.9	36.62
CT image 2	6.0	36.86	7.2	36.88
CT image 3	7.4	36.18	8.1	36.53

The advantage of the proposed algorithm is its low complexity as it involves one level wavelet decomposition whereas SPIHT results are produced with three level wavelet decomposition. The proposed method uses the extracted edge information to reconstruct the edges with accuracy. From the figures, it can be seen that edge preservation improves the visual fidelity of the reconstructed images over that of SPIHT images.

CONCLUSION

The compression algorithm proposed in this paper uses the threshold to identify the significant coefficients of the image. For preserving the vital information of the image, edge detector extracts important edge information. Edge preservation improves the fidelity of the reconstructed image. The proposed algorithm yields better subjective quality images with higher compression compared to SPIHT for same objective quality of PSNR equal to or greater than 36 dB.

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