Department of Electrical and Computer Engineering

hSITE - Healthcare Support through Information Technology Enhancements

Pre-Processing of Multi-Channel EEG for Improved Compression Performance using SPIHT

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Introduction

A novel technique for Electroencephalogram (EEG) compression is proposed. This technique makes use of the inter-channel redundancy present between different EEG channels of the same recording and the intra-channel redundancy between the different samples of a specific channel. It uses Discrete Wavelet Transform (DWT) and Set partitioning in hierarchical trees (SPIHT) in 2-D to code the EEG channels. Smoothness transforms are added in order to guarantee good performance of SPIHT in 2-D. Experimental results show that this technique is able to provide low distortion values for high compression ratios (CRs). In addition, performance results of this method do not vary a lot between different patients which proves the stability of the method when used with recordings of different characteristics.

Set partitioning in hierarchical trees (SPIHT)

The Set-Partitioning in Hierarchical Trees (SPIHT) is a coding algorithm that exploits the relationships between the wavelet coefficients across the different scales at the same spatial location in the wavelet sub-bands [1]. Exact bit usage control can be achieved using the SPIHT algorithm. SPIHT targets the coding of the position of significant wavelet coefficients and the coding of the position of zero-trees in the wavelet sub-bands. It was originally suggested for the compression of 2-D images, thus it exploits the basic characteristics of this type of data.

Compression Scheme

The compression scheme is shown in Fig. 1.

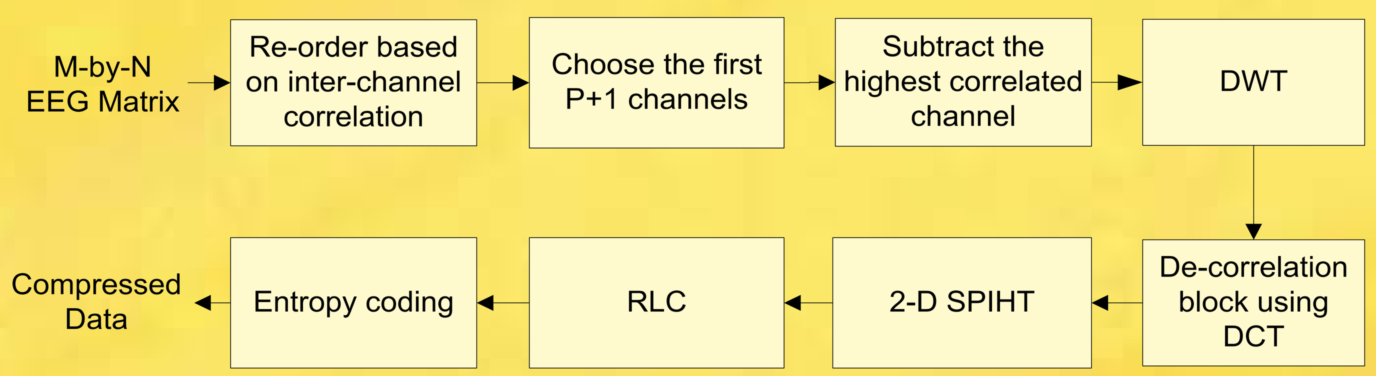

Fig.1 Compression block diagram.

The value P is chosen as the highest value that is smaller than the number of channels in the matrix, M, and divisible by 2k, with k equal to the number of levels used in the DWT. From these P+1 rows or channels, the channel that has the highest correlation coefficient with all other P channels is selected. The values of its samples are subtracted from each channel of the P-by-N matrix, with N being the number of samples of each channel. This results in added smoothness to the matrix. DWT is then applied on this matrix. However, high correlation is still present within the blocks of the DWT coefficients of the same sub-band, which is common when compressing images. To reduce this, a de-correlation block, that involves applying Discrete Cosine Transform (DCT), is added after DWT [2].

Simulation and Discussion

Scalp recordings, with a sampling frequency of 200 Hz, done at the EEG lab at the Montreal Neurological Institute (MNI) are used in the testing. In the testing, M is equal to the number of electrodes used in the recording, 29, resulting in P equal to 24 for a DWT number of levels, k, equal to 3. Biorthogonal 4:4 wavelet is used to compute DWT. The performance parameter used to analyse the results is the percent-root mean square distortion (PRD). Fig. 1 shows the results for different compression ratios of 1-D SPIHT and 2-D SPIHT.

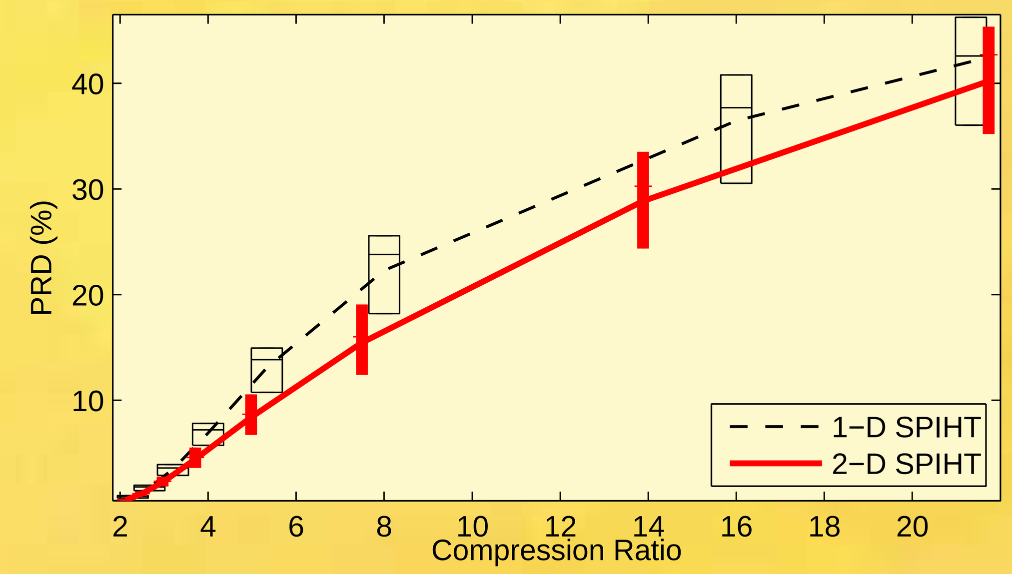

Fig.2 Compression performance comparison between 1D (N=1024) and 2D SPIHT (M=29, N=256). The boxes extend from the 25^{th} percentile to the 75^{th} percentile.

Fig. 2 highlights the fact that 2-D SPIHT is able to achieve higher compression ratios for the same PRD percentage. This is due to the fact that in the 1-D case, the correlation between the channels still exists after compression. The proposed method is compared to Tucker and Parafac tensor decompositions applied on 3-D EEG tensors [3]. The size of the tensor used in these two methods is equal to 29-by-16-by-16. Thus the same EEG segment used in 2-D SPIHT of size N equal to 256 is arranged in 2-D as 16-by-16 [3]. Testing was done on 9 patients over a period of one hour. Fig. 3 shows the PRD results with the 25 and 75 percentiles to highlight how the PRD values are varying between the patients. The proposed method gave better performance results than Tucker and Parafac.

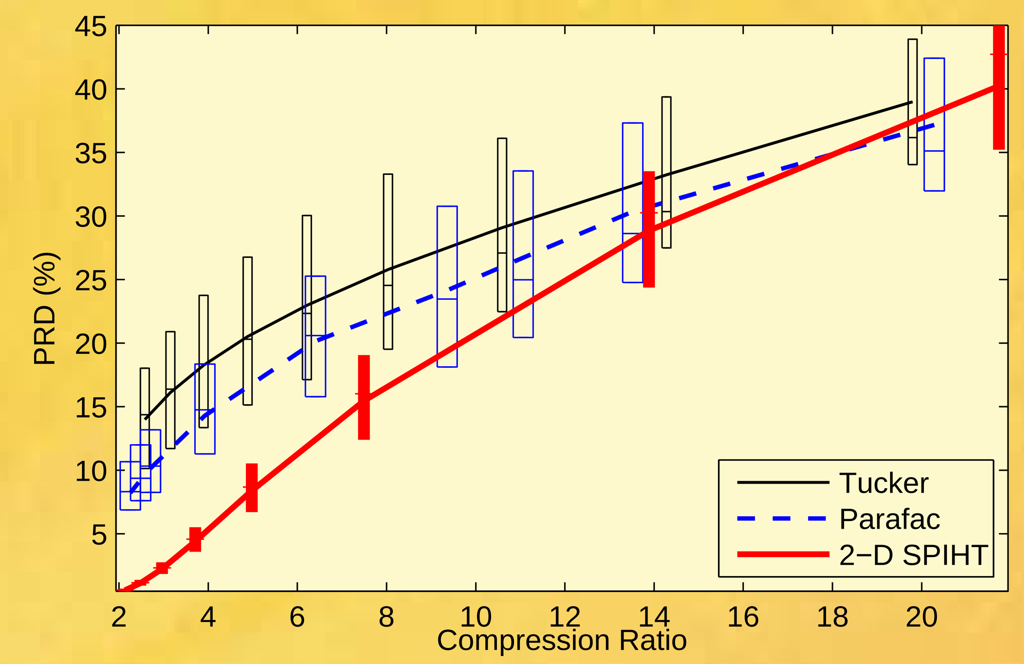

Fig.3 Compression results of 2-D SPIHT (M=29, N=256) compared to Tucker and Parafac (16-by-16-by-29) [3]. The boxes extend from the 25^{th} percentile to the 75^{th} percentile.

Conclusion

Looking at the EEG channels in 2-D enables us to make use of the redundancy found between the channels and between the samples of the same channel. The proposed algorithm is able to achieve low variance between patients and low distortion compared to other compression methods like 1-D SPIHT, Tucker and Parafac. For PRD values lower than 30%, the proposed algorithm achieves higher compression ratios. Above this value, distortion can be regarded as high which is to be avoided when dealing with biomedical signals with important diagnostic information.

Reference

[1] D. Rawat, C. Singh, and M. Sukadev, “A hybrid coding scheme combining SPIHT and SOFM based vector quantization for effectual image compression,” European Journal of Scientific Research, 2009.

[2] K.-L. Kim and S.-W. Ra, “Performance improvement of the SPIHT coder,” Sig. Proc.: Image Comm., vol. 19, no. 1, pp. 29–36, 2004.

[3] J. Dauwels, K. Srinivasan, M. R. Reddy, and A. Cichocki, “Multichannel EEG compression based on matrix and tensor decompositions,” in Proceedings of the 2011 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), July 2011, pp. 629 – 632.