An ECG Compression Scheme Based on Vector Quantisation

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Abstract: An ECG signal compression scheme based on *vector quantisation* (VQ) method is proposed in this paper. The compression is performed by quantising the ECG samples into a reduced set of reference vectors, the codebook. The vector representing elements with a high frequency of occurrence is selected for further coding, while the rest of signal containing all the values occurring with lower probabilities are kept unchanged. The proposed scheme is superior to other available direct compression methods in retaining the most important part of the ECG signal.

Keywords: Biosignal processing, ECG compression, Vector quantisation.

Introduction: The ECG signals are dominated by low frequency or wide-band components but their QRS complexes exhibit strong local variations and narrow-band properties. Fig. 1 illustrates the quantised and sorted form of the ECG segment into 16 bins with a distinctive bin containing elements with a high frequency of occurrence. This bin contains the smoothest part of the ECG signal including the P-wave and ST segment.

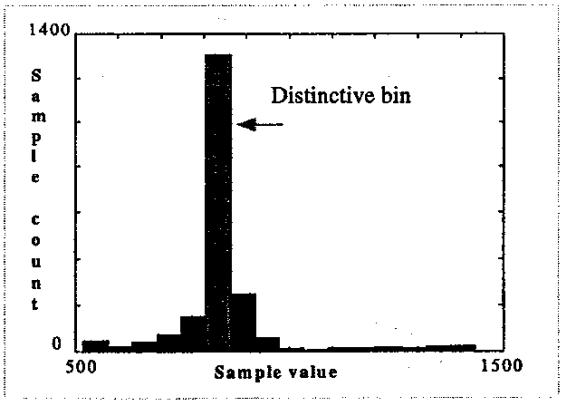

Fig. 1 *Quantised and sorted form of an ECG segment.*

Methods: In most of ECG signal processing applications, precise reconstruction of the smooth part of the signal is not required so it can be selected for further coding by the VQ method. This compression scheme preserves the values with the lower occurring probabilities representing the high-frequency components of the ECG signal. In contrast to other direct ECG compression techniques that detect flat regions and slopes in the signal, this scheme can easily quantise data and then reset the samples within the largest bin to zero. These samples discard during the decoding process. Bins containing lower sample counts represent the important part of the signal (such as QRS in the ECG) and should be kept unchanged.

To reconstruct the signal properly, the portion of discarded samples should be added to the compressed signal with values as close as possible to the original ones. The linear interpolation method can provide reasonable values for the discarded samples.

Results: The proposed method was superior to other available direct methods in retaining the most important part of the ECG signal (i.e. that belonging to the points of inflection). For comparison purposes, a fixed compression ratio (CR) of 2:1 was set for both turning point (TP) algorithm and the proposed method [1]. The TP method performs compression on the whole signal interval and discards every other component. As a result the TP algorithm causes some distortion of the QRS complex, while the proposed method only compresses the least important part of the signal.

Discussion: The principle problem addressed when compressing the signal by the proposed scheme was: the index (location) of the discarded samples has already been destroyed in the decoding process. To overcome this problem only those zeroes that appeared consecutively in a group of pre-set numbers were discarded. This pre-set number can be calculated based on the desired CR. The average value of the samples in distinctive bin was chosen for the discarded pack. The rest of the zeros were substituted with a nearest neighbour value. Now, the interpolation technique can insert the pre-set number of samples with a proper value instead of discarded zeros.

Conclusions: This work shows that the ECG compression scheme based on VQ applies high compression on those values with a high frequency of occurrence which are not critical for diagnostic purposes. The overall CR is related to bin number selection and the pre-set number of discarding zeros. This technique is more applicable in situations where a low CR is satisfactory. A computer based ECG signal compression can be developed by employing the proposed scheme for clinical perspective.

References:

[1] W. Mueller, "Arrhythmia detection for ambulatory ECG monitor," *Biomed Sci Instrument,* vol. 14, pp. 81, 1978.

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