A Novel Blind Wavelet Base Watermarking of ECG Signals on Medical Images Using EZW Algorithm

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INTRODUCTION: NECESSITIES, METHODS, AND ALGORITHMS CURRENTLY USED

Exchange of databases between hospitals needs efficient and reliable transmission and storage techniques to cut down the cost of health care. This exchange involves a large amount of vital patient information such as biosignals and medical images. Interleaving one form of data such as 1-D signal over digital images can combine the advantages of data security with efficient memory utilization (Norris, Englehart & Lovely, 2001), but nothing prevents the user from manipulating or copying the decrypted data for illegal uses. Embedding vital information of patients inside their scan images will help physicians make a better diagnosis of a disease. In order to solve these issues, watermark algorithms have been proposed as a way to complement the encryption processes and provide some tools to track the retransmission and manipulation of multimedia contents (Barni, Podilchuk, Bartolini & Delp, 2001; Vallabha, 2003). A watermarking system is based on an imperceptible insertion of a watermark (a signal) in an image. This technique is adapted here for interleaving graphical ECG signals within medical images to reduce storage and transmission overheads as well as helping for computer-aided diagnostics system. In this chapter, we present a new wavelet-based watermarking method combined with the EZW coder. The principle is to replace significant wavelet coefficients of ECG signals by the corresponding significant wavelet coefficients belonging to the host image, which is much bigger in size than the mark signal. This chapter presents a brief introduction to watermarking and the EZW coder that acts as a platform for our watermarking algorithm.

EZW

The EZW algorithm was originally developed by Shapiro (1993) to find the best transmission order of the wavelet coefficients, which is the absolute value of decreasing order. This algorithm has already been applied to medical images and the electrocardiogram with good success (Nambakhsh, Ahmadian, Ghavami & Dilmaghani, 2006).

EZW in Image

The wavelet transform is a dyadic decomposition of an image (Nambakhsh et al., 2006) achieved by a pair of quadratic mirror filters (QMF). In two-dimensional separable dyadic discrete wavelet transform (DWT), each level of decomposition produces four bands of data, one corresponding to the low pass band (LL), and the other three corresponding to horizontal (HL), vertical (LH), and diagonal (HH) high pass bands (Figure 1).

Two distinct properties of the EZW algorithm make it an effective means of compression, as compared to traditional approaches. First, the EZW algorithm exploits the hierarchy of the wavelet coefficients and establishes a connection between coefficients from corresponding subbands in different levels of wavelet decomposition, allowing multiple coefficients to be encoded simultaneously. Second, coefficients are encoded in order of importance using bit prioritization (Mallat, 1989). After performing the 2-D DWT on the image, the resulting wavelet coefficients are coded by using a decreasing sequence of thresholds; that is, $T_0, T_1, \ldots, T_{N-1}$, where:

$$T_i = \frac{T_{i-1}}{2}, \qquad T_0 = 2^{\log_2(\max|\gamma(x,y)|)} \tag{1}$$

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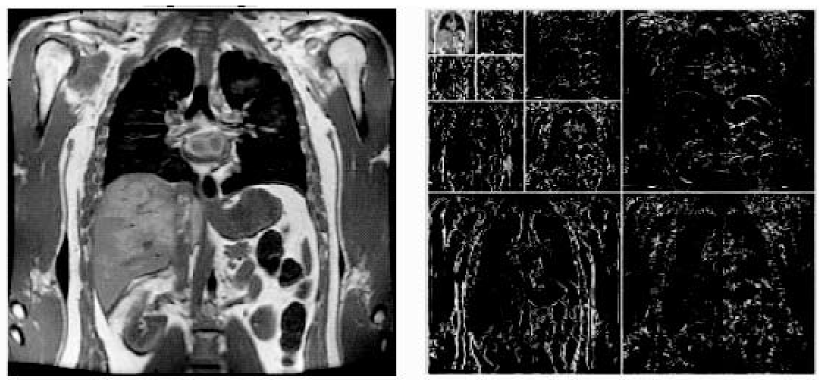
Figure 1. Levels of decomposition



Here $\gamma(x,y)$ is the amplitude of wavelet coefficients and T_0 is the initial threshold value. The algorithm executes recursively two successive passes by considering significant coefficients in each pass related to the current threshold only (i.e., absolute value is higher than current threshold).

In the first pass, called the dominant pass, we look through significant coefficients related to the current threshold according to a scan order given in Figure 2(a) using the hierarchy given in Figure 2(b).

The algorithm then provides positions and signs of the significant coefficients in a predefined path that associates the absolute value of the parent coefficients with respect to their children ones. Two kinds of predefined paths are depicted in Figure 3.

Coefficients according to equation 1 and the way of scan that is illustrated in Figure 3 turn into four different symbols in the every step. In other words, they will be coded to P, N, Z, and IZ by the every pass process. Table 1 shows complete instructions of the coding process.

EZW in Signal

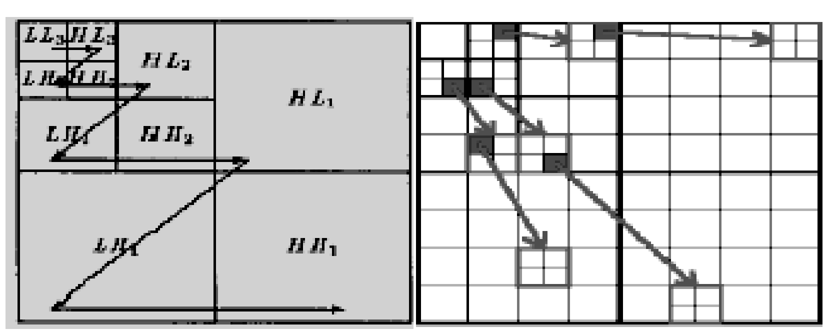
The EZW algorithm can be applied on signals similar to image. In this case, decomposed signal coefficients have dyadic tree instead of quad tree (Barni et al., 2001). This is illustrated in Figure 4.

It is obvious that each coefficient has two correlated coefficients in lower scale and so forth. We will use this similarity between images and signals to embed a signal inside an image, which is the topic of the next section.

PROPOSED WATERMARKING ALGORITHM

The multiresolution watermarking with multi secret key algorithm, which is developed in this chapter, is blind, because during the EZW decoding, only the multiparameter's secret key, which includes the header information and many parameters defined by the user, is used to extract the embedded information. There are

Figure 2(a). Scan order of wavelet coefficients (b) quad-tree relation of coefficients



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