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Original Research Article

Efficient compression of bio-signals by using Tchebichef moments and Artificial Bee Colony

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ABSTRACT

In this paper, an algorithm is proposed for efficient compression of bio-signals based on discrete Tchebichef moments and Artificial Bee Colony (ABC). The Tchebichef moments are used to extract features of the bio-signals, then, the ABC algorithm is used to select of the optimum features which achieve the best bio-signal quality for a specific compression ratio (CR). The proposed algorithm has been tested by using different datasets of Electrocardiogram (ECG), Electroencephalogram (EEG), and Electromyogram (EMG). The optimum feature selection using ABC significantly improve the quality of the reconstructed bio-signals. Different numerical experiments are performed where to compress different records of ECG, EEG and EMG bio-signals by using the proposed algorithm and the most recent existing methods. The performance of the proposed algorithm and the other existing methods are evaluated using different metrics such as CR, PRD, and peak signal to noise ratio (PSNR). The comparison shown that, at the same CR, the proposed compression algorithm yields the best quality of the reconstructed signals over the other existing methods.

1. Introduction

Bio-signals are physiological signals used by clinicians to monitor the health status of the human body system. These signals are used to measure the electrical activity of different human body organs, such as heart, brain, and skeletal muscles, and help to diagnose many diseases [1]. The most commonly known bio-signals are ECG, EEG, and EMG. Electrocardiography (ECG) is the process of recording the electrical activity of the heart, such that any change in heart beats, which may be indication for heart disease, can be detected [2]. ECG signal is recorded by placing electrodes in particular arrangement on the chest [3]. In the ECG signal, each heart beat produces different deflections, these deflections are represented by series of waves. A normal heart beat is composed of 5 waves represented by 5 symbols P, Q, R, S, and T as shown in Fig. 1.

Electroencephalography (EEG) is the process of monitoring the electrical activity produced by the brain. EEG signal is used

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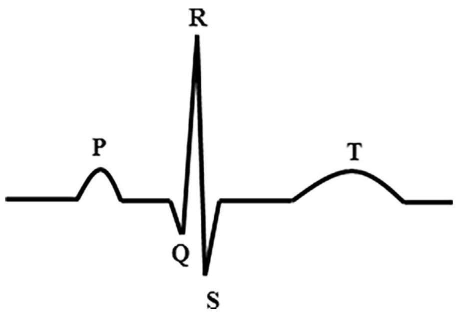

Fig. 1 – Single heart beat in ECG.

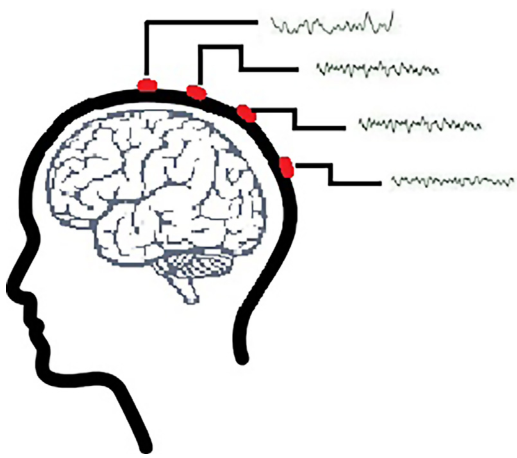

Fig. 2 – EEG recording.

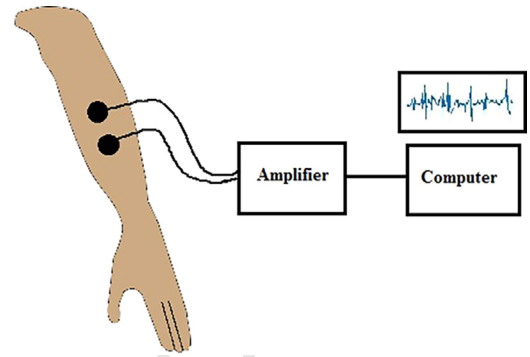

Fig. 3 – EMG recording.

to extract the significant information about the brain status and function that may be helpful to diagnoses brain diseases [4]. Human brain activity can be recorded by placing electrodes at various locations on the scalp. These electrodes generate multi-channel EEG signal for analyzing the activity of the brain from different regions [5] as shown in Fig. 2.

On the other hand, Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles that represents neuromuscular activities [6]. EMG signals are used for diagnoses of neuromuscular diseases or detection of injuries. EMG can be recorded by placing electrodes on the skin of specific muscle as shown in Fig. 3.

Due to the large number of the daily recorded bio-signals in hospitals and medical centers, medical data compression has become a major challenge due to the limited storage capabilities. Transmission of these medical data across networks in telemedicine-based systems entails the need to compress these data efficiently [7]. In general, an efficient and successful compression algorithm should not only achieve high compression ratios, but also it should preserve the visual quality of the compressed data. This issue is very important in bio-signals compression, where losing medical data may led to incorrect medical diagnosis. Our goal is achieving a very high compression ratio, while preserving the quality of the reconstructed bio-signal. In the proposed compression algorithm, the optimization algorithm, ABC, has been employed with block-based discrete Tchebichef transform to choose the optimum moments that are needed for bio-signal reconstruction. The optimum moments are selected by minimizing the objective function. The selected objective function is the Mean Square Error (MSE). The results of the ABC-based compression algorithm reveal that a very high CR can be achieved with excellent reconstruction quality.

The rest of this paper is organized as follows. Section 2 presents a Review of Literature. Concise descriptions of the discrete Tchebichef moments and the ABC algorithm are presented in Sections 3 and 4 respectively. In Section 5, a detailed description of the proposed compression method is presented. The numerical simulation and the obtained results are discussed in Section 6. Finally, Section 7 concludes this paper.

2. Literature review

The compression techniques for bio-signals can be classified into three groups: Lossless, near-lossless, and lossy. Lossless compression techniques involve no loss of information where the reconstructed and the original bio-signals are identical. However, the lossless compression techniques cannot achieve high compression ratios. In near-lossless compression, the information loss is limited and the differences between the original and reconstructed bio-signals are smaller than or equal to given error values [8]. On the other hand, lossy compression techniques involve some loss of information. However, in lossy compression techniques much higher compression ratios could be achieved than the lossless and near-lossless compression techniques.

Lossless ECG compression techniques are presented in [9,10], although these algorithms guarantee no loss of information, they cannot achieve high compression ratios. In recent years, many transform-based lossy compression algorithms have been proposed for compression of bio-signals. Discrete Cosine Transform (DCT) is one of the most known compression algorithms due to its simplicity. DCT has been widely applied in data compression and has achieved appreciable compression results. DCT is applied as compression technique for ECG signals in [11–13]. Based on its compact representation of signals and images, the discrete wavelet transforms (DWT) were applied in many signal and image compression techniques [14–16]. The embedded zero-tree

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