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Atrial Fibrillation detection based on ECG-Features Extraction in WBSN

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Abstract

Wireless Body Sensor Networks (WBSNs) and wearable technology are the new trends in healthcare applications. This technology can provide real-time monitoring of the patient's bio-signals and health condition. In this context, the analysis of ECG signals, reflecting the heart activity, is considered as key tool in diagnosing cardiac disorders such as Atrial Fibrillation (AF) that can lead to strokes and heart failure. Classical approaches for sensor-based AF detection require continuous transmission of ECG signals to a remote server which can rapidly exhaust the sensor energy and shortens the lifetime of the application. In this paper, we propose a new low-power scheme for AF episodes detection in ECG signal that is intended for implementation in WBSN. The paper details the design of this scheme and demonstrates its high accuracy for AF detection.

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Keywords: WBSN, ECG processing , Low energy processing, Atrial Fibrillation

1. Introduction

The use of Wireless Body Sensor Networks (WBSN) can enable real-time automated detection of AF. In depth, this technology of WBSN can be used to capture and transmit a raw ECG signals to a remote server that process the signal, extracts the most relevant ECG features and uses them for classification and AF episodes detection.

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However, applying this approach for full ECG signal transmission using body sensor node faces the problem of limited availably energy in these nodes. Indeed, it has been proved that the transmission of the full recorded signal is highly consuming power at the sensor node questioning the sensor life-time and consequently the validity of the approach [2]. Therefore, the main issue that faces the design sensor-based application for AF detection is to reduce the per-node energy consumption related to ECG data transmission through the wireless link. Radio energy consumption is proportional to the number of transmitted bits. The compression of the ECG signal might be an adequate solution for this issue. However, chae et al.[5] have shown that applying compressive sensing method is not an adequate solution for efficient Low-energy sensing. As an interesting new approach to reduce the volume of transmitted data, we propose an approach of on-sensor extraction of the relevant features from the ECG signal, analysing them for AF detection and then sending adequate notification to the remote server. This approach is intended to reduce the energy consumption related to the wireless data-transmission. Thus, we expect that it will increase the body sensor's life-time and consequently the application of remote ECG monitoring.

The approach of embedded ECG processing for relevant features extraction that helps to detect AF episodes is an active research area that still needs further efforts to bring out an efficient energy solution to be deployed in WBSN. Most of the developed schemes for AF detection use automated arrhythmia classification based on RR irregularity of the ECG segment [11]. A typical heart beat has a waveform composed by P wave followed by QRS complex and then a T as shown in Fig. 1. The extraction of the QRS complex represents the fundamental tasks that allows to determine the R peak in the ECG signal and consequently extracting the duration between two consecutive R peaks called RR intervals. For the AF episodes detection, it requires a combination of two ECG features that are the absence of P-wave and the irregularity in RR intervals. This combination would provide high accuracy of EF detection [15, 16]. However, the The main research challenge at this level is to accurately differentiate between AF episodes and other irregular heart rhythms[13] using an energy-aware and memory-efficient algorithm.

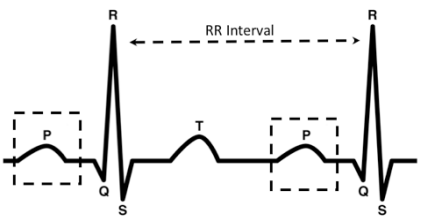

Figure 1 - General relevant ECG features

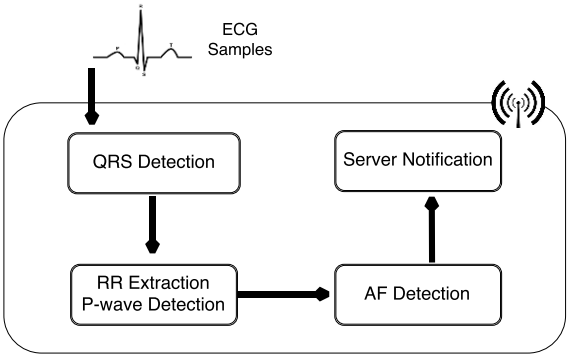

Figure 2 - Proposed AF detection scheme

The main contribution of this paper is to propose a new embedded scheme for the AF episodes detection with low energy consumption intended to be implemented in WBSN. The proposed scheme is based on an enhanced version of Dual Slope algorithm[1] capable to efficiently detect the QRS complex and to extract the measurement of RR interval. It is also extended to detect the P-wave in the ECG signal. The proposed scheme is designed to notify a remote server with the detection of AF symptoms in ECG signals. This papers presents the design of the AF detection scheme in ECG signal. It studies the performance analysis of the ECG sensing scheme to accurately detect the AF episodes in ECG segments and it shows its adequacy for low-power consumption when implemented in wireless sensors.

2. General approach for AF detection in ECG signal

The basic idea, adopted in this paper, is to reduce the amount of transmitted data to the diagnosis-control-point by extracting useful ECG features on the source sensor and analysing them for AF detection. The overall structure of the proposed scheme is summarized in Fig. 2.
AF episode detection is based on the processing of an ECG signal that has a length of 10 seconds. This length is an