The Cross-platform Application for Arrhythmia Detection

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Abstract

The Cross-platform application for arrhythmia detection is an application for monitoring of patient's cardiac abnomalities. If a patient has some kind of arrhythmia, the application provides a connection between the patient and doctor. The application is originally developed and tested for smartphones with Symbian OS, but it designed to be cross-platform. It is used with cardiac monitor Alive Heart Monitor and Activity Monitor. Alive Heart Monitor transmits cardio and auxiliary data by bluetooth to a smartphone. Then the application processes this data and says what happens to the cardiac rhythm.

Index Terms: MHealth, ECG, Arrhythmia.

I. Introduction

Cardiovascular diseases are most significant reason of death in the world. Detection of some types of arrhythmias needs continuous monitoring of heart functions. Holter monitor used in Russian medicine is very uncomfortable since it is a heavy device and it requires skilled doctor's help. Consequently it can't be used for long term monitoring.

Recently, the more convenient solution is a usage of digital monitors. It allows speeding up a processing of cardio data and initial detection of heart problems.

The application requires Alive Heart Monitor and Activity Monitor. This device was developed by Alive Technologies and designed to work via bluetooth.

This paper describes the application of long term monitoring, which is suitable for initial detection of cardiac abnomalities and at the same time is convenient for using in healthcare services.

II. The application architecture

The application consists of six logical modules each one performs a single fearure. The first feature is a connection with Alive Heart Monitor via bluetooth. Then the application extracts Electrocardiogram (ECG) data and searches for abnormalities. If a user wants, he/she can look at his/her ECG. All abnomalities are journalied. And application reports about the most dangerous type of arrhythmia. Figure 1 shows the main idea of the application's archtecture.

Qt Framework was chosen for develepment of cross-platform application. First of all it is made for smartphones with Symbian OS.

A. ECG extraction

The stream data format is used when transmitting ECG and accelerometer data in real time over a Bluetooth SPP connection. Structure of package is simple. First 6 bytes is package header, where is important useful information like the battery charge and the number of data blocks. Data block consists of 5 bytes Electrocardiogram or Accelerometer header and

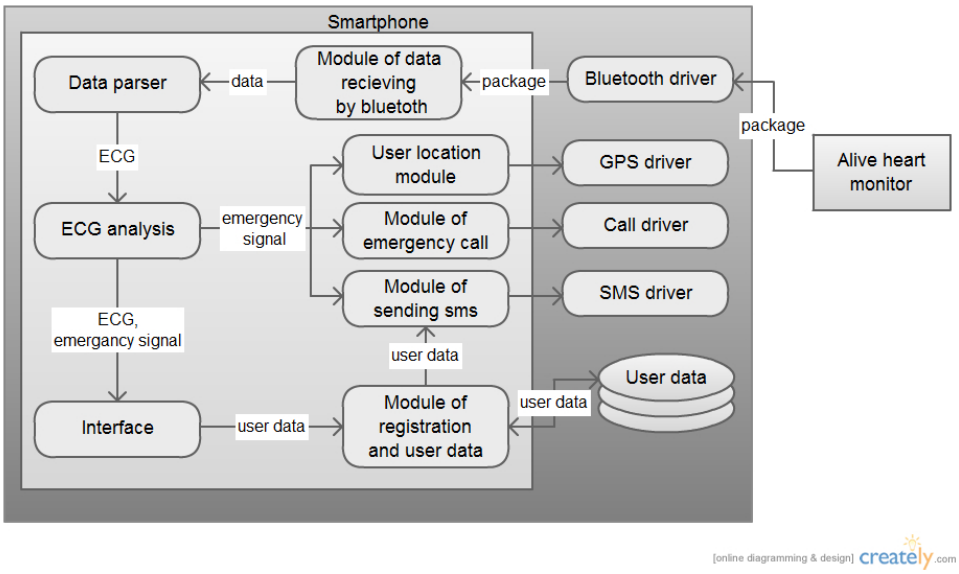

Fig. 1. Architecture of application

Electrocardiogram or Accelerometer Data. Header includes info about length of data and data format, data is just array of bytes.

Bluetooth module provides wireless access to device via bluetooth. Alive Heart and Activity Monitor sends data packages that smartphone recieves (or PC). Written bleutooth module is universal, extensible. It find all bluetooth-available devices in the area, then sends a list of devices names and addresses to GUI (in QML), where a user selects one of them, and bluetooth module connects to it and recieve the data from the chosen device.

1) Technical details of nuances of Qt bluetooth connection.: First of all, it is needed to check availability of bluetooth on a current device, if necessary, turn it on, make it visible to others via QBluetoothLocalDevice. Then search for all bluetooth services on bluetooth-available devices via QBluetoothServiceDiscoveryAgent. Choose a necessary service (QBluetoothServiceInfo) from the result list and connect QBluetoothSocket to it.

But during developing we've faced with a problem of Qt usage for working with bluetooth: QBluetoothServiceDiscoveryManager does not found any services on Alive Heart and Activity Monitor. It was decided to search at first not services, but devices by QBluetoothDeviceDiscoveryAgent, and when it's finished, connect QBluetoothSocket with a service, which expressly wasn't looking for, simply specifying the necessary device address and required bluetooth service class uuid (or type of bluetooth protocol uuid). As for Alive Heart and Activity Monitor, its service provides class serial port via rfcomm protocol.

B. Arrhythmia Detection

The information is presented in waves and time intervals between them. The waves in a normal record are named P, Q, R, S, and T and follow in alphabetical order. Figure 2 shows normal segment of ECG. This waves usually repeate pereodically. Any abnormal change in the shape and variation of time intervals are considered as arrhythmia.

Normal values of ECG features and respective arrhythmia type are detected through ECG feature extraction using Wavelet Analysis [1].

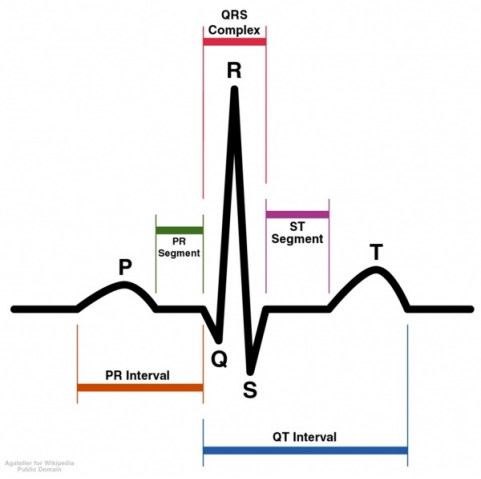

Fig. 2. Electrocardiogram

The main technique of the detection of the QRS, T and P waves is Pan-Tompkins algorithm. The algorithm uses some of the basic techniques that are common in many pattern recognition systems. The ECG signal is first reduced into a set of predefined tokens, which represent certain shapes of the ECG waveform [2].

An algorithm based on first and second derivatives originally developed by Balda et al. (1977) was modified for use in high-speed analysis of recorded Electrocardiograms by Ahlstrom and Tompkins (1983). Friesen et al. (1990) subsequently implemented the algorithm as a part of the study to compare noise sensitivity among certain types of QRS detection algorithms.

The heart rate is counted from duration of RR-interval. In turn RR-interval is counted from time difference between two adjacent R-peaks.

The application implements the detection of Normal beat segment, Tachycardia, Bradycardia, Sinus Arrhythmia, First-Degree Heart Block, Second-Degree Heart block, Ventricular Tachycardia, Ventricular Fibrillation and Ventricular Flutter. Pan-Tompkins algorithm and Wavelet transform allow to identifify ECG parametres. The algorithm consists of two parts: to extract Electrocardiogram's feature, and classify it. Figure 3 shows the procedure followed.

P, Q, R, S, T waves are extracted first. There are four separate algorithms, each of them is designated to extract certaintypes of peaks. First, the peaks of the QRS complexes with their high dominated amplitude are registered. Then Q and S waves are detected. P and T waves along with their onsets and offsets are the last features to be found.

These basic features are used later to evaluate the six final classification related to features: QRS, PR, RR time intervals, heart rate, RR time interval variation, TP and ST interval voltage levels. Then we can classify ECG according to the waves and intervals. it is shown in Table 1.

C. Other functions

User can watch his own cardiogram and some metrics of heart function, e. g. heart rate. In passive mode the application works in background. In the case of arrhythmia detection the user is warned. In emergency case the application can make a call or send a SMS automatically to doctor or relatives [4].

Often patient can't understand his cardiogram, the application should provide the transmission cardio data to hospital database.

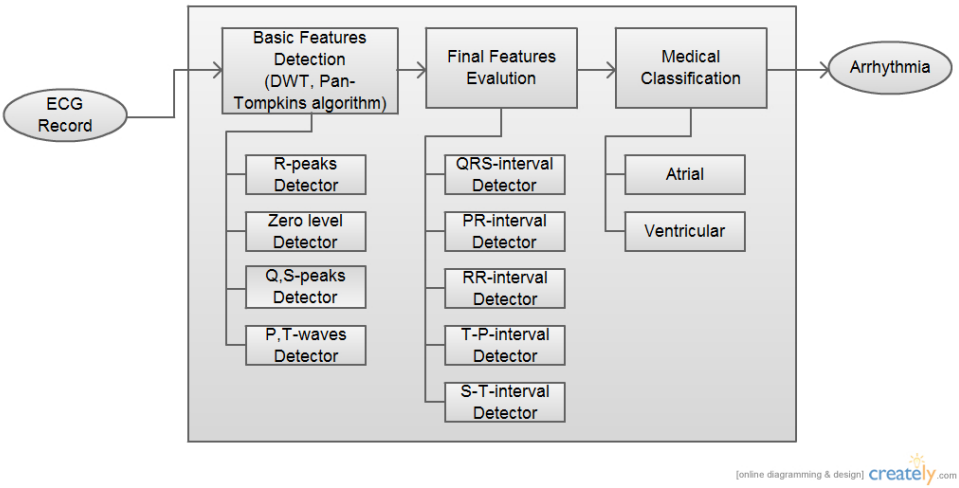

Fig. 3. Main algorithm

TABLE I
ARRHYTHMIA TYPES

Detection	Arrhythmia Type
RR interval longer	Bradycardia
RR interval shorter	Tachycardia
Long RR interval	First degree heart block
More P waves than QRS complex	Second and third degree heart block
Wide QRS	Premature ventricular fibrillation
Absence of P wave	Atrial fibrillation

The long term monitoring leads to a high traffic problem. It can be expensive for a patient. It is needed an effective algorithm of ECG compression, that would be adapted fot using in mobile app. To achieve high compression ratio the following approach is applied. The input signal was transformed with Daubechies Wavelet Transform 9/7 [5]. Then the values of wavelet transform coefficients are compressed with a arithmetic coder.

III. CONCLUSION

Automatic detection of heart arrhythmias could be very important in clinical usage and lead to early detection of a fairly common malady and could help contribute to reduced mortality. Several stages of processing have been used in order to prepare the most appropriate arrhythmia classification.

In this application, the cardiac arrhythmia events can be detected and sent emergency SMS in real-time to cardiologists or relatives. The algorithm is evaluated for records obtained from the MIT-BIH.

Alive Heart Monitor and Activity Monitor has proved as a reliable device. Tests have shown that in a real time transmition packages come every 250 ms and contains 77 bytes of ECG data.

The proposed system, after validation by experts, can serve as a diagnostic tool and aid the physician in the detection and classification of cardiac arrhythmias. The application is developed for smartphones with OS Symbian. And in the future it is going to port to other

mobile platforms (Harmattan, Android, Windows Phone) and desktops (Windows, Linux, Mac).

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