Real-Time Cardiovascular Diseases Detection on a Smartphone

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SPECIFIC TOPIC AREA

III) Point of Care Diagnostics and Remote Patient Monitoring; II) Remote Data Collection and Surveillance.

MOTIVATION

Cardiovascular Diseases (CVD), such as heart attacks, hypertension, strokes, and arrhythmia, are the single leading cause of global mortality and is projected to remain so. According to the World Health Organization (WHO), approximately 17.5 million people died from CVD in 2005, representing 30% of deaths worldwide [1]. According to the American Heart Association, 80,000,000 people were estimated to have one or more forms of CVD in the United States alone in 2006 [2]. If appropriate action is not taken, by 2015, an estimated 20 million people will die from CVD every year, especially in low-income and underserved regions. The Electrocardiogram (ECG) is the most widely adopted clinical tool to diagnose and assess the risk of CVD. ECGs measure and display the electrical activity of the heart from the body surface. Patients with CVD are required to visit a hospital to receive an ECG, which can be time-consuming, expensive, and difficult to obtain especially in rural or under-served regions where the facilities and medical experts are scarce. Moreover, during patients' hospital visits, critical CVD signs may not be detected on standard resting ECG machines since the condition may not be present at that moment in time. While Holter-based portable monitoring solutions offer 24 to 48-hour ECG recording, they lack the capability of providing real-time feedback for the thousands of heart beats they record, which must be tediously analyzed offline and the diagnostic yield can be low.

PROPOSED SOLUTION AND OUTCOMES

In this research, we seek to unite the mobility of Holter monitors and the real-time processing capability of state-of-the-art resting ECG machines to provide assistive CVD diagnosis for under-served regions. To this end, we present ***HeartToGo*** - a smartphone-based mobile that can automatically detect abnormal CVD conditions and classifying them at any place and anytime [3-6]. Specifically, we will demonstrate our smartphone prototypes capable of performing real-time ECG acquisition and display, feature extraction, and beat classification via novel machine learning technique that combines both patient-specific information and medical database data to train the phone to learn to adapt to its user's physiological conditions. Moreover, the same statistical summaries available on resting ECG machines are also provided; thus, combining with the built-in video-out support available in our prototypes, one can easily turn a regular TV or a computer display into an instant ECG machine. In addition to supplying assistive diagnostic data, ***HeartToGo*** can change the way emergency situations are handled to further increase the sudden heart attack survival rate by automatically contact 911 and the doctor via pre-recorded messages and providing the user's precise location through an integrated geographical positioning system (GPS).

ACKNOWLEDGEMENT

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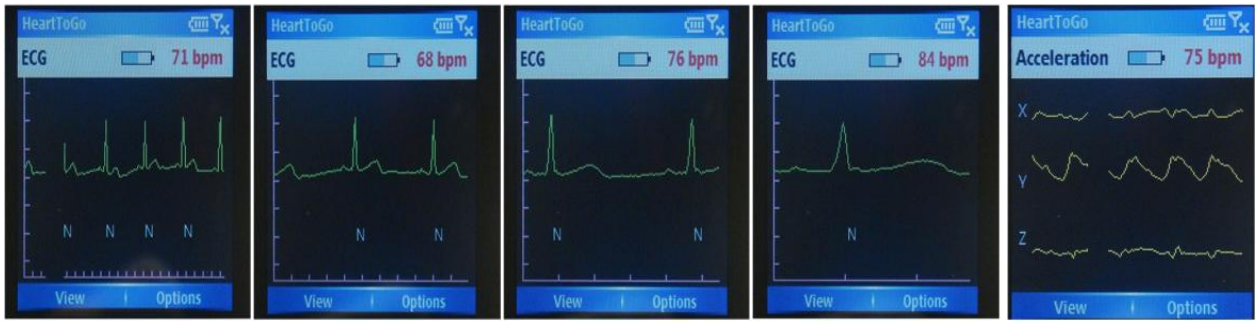
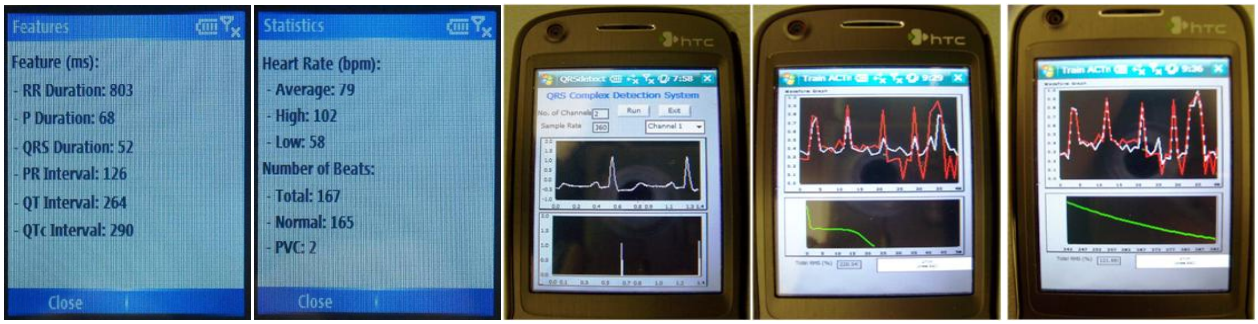
Figure 1. ***HeartToGo*** Prototype 1, including a HTC TyTn II Microsoft Mobile PDA phone with Microsoft Windows Mobile 6 OS and an integrated 400MHz processor and the Bluetooth Alive Heart Monitor.

Figure 2. ***HeartToGo*** Prototype 2, including an AMOI A85 with Fone+ Base Windows Mobile phone that provides TV-out with Microsoft Windows Mobile 5 OS and the Bluetooth Alive Heart Monitor.



(a) (b) (c) (d) (e)

Figure 3. ***HeartToGo*** real-time ECG processing and display at different magnifications: (a) 1x (b) 2x (c) 4x (d) 8x; (e) ***HeartToGo*** Real-time display of the user's 3-axis acceleration data.



(a) (b) (c) (d) (e)

Figure 4. (a) ECG feature summary report, (b) CVD detection summary report, (c) real-time QRS complex wave form detection; and on-phone real-time machine learning: Red Line–the target results, White Line–the predicted results; Green Line–the Root Mean Square (RMS) error, which decreased as the training progressed from the initial training phase (d) to near-complete phase (e).