HEARTBIT

Novel Pervasive Technologies for the Prevention and Monitoring of Cardiovascular Diseases

Although cardiovascular diseases are the leading cause of dead worldwide, in general, people only seek assistance whenever symptoms appear or when a major event occurs (e.g. stroke). The HeartBIT project developed low-cost instrumentation and software tools for Electrocardiography (ECG) with sensors embedded in everyday use devices, enabling pervasive health monitoring and identity recognition.

Main Project Team	
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Indicators	
Funding	27k €
Journal papers	3
Conference papers	10
Concluded PhD	2
Concluded MSc	2

Two Main Publications

A. Lourenço, S. Bulo Bulo, C. C. Carreiras, A. L. N. Fred, ECG Analysis Using Consensus Clustering, "European Signal Processing Conf. - EUSIPCO", pp. 511 – 515, 2014

H. Silva, C. C. Carreiras, A. Lourenço, A. L. N. Fred, R. César das Neves, R. Ferreira, Off-the Person Electrocardiography: Performance Assessment and Clinical Correlation, "Health and Technology", Vol. 4, No. 4, pp. 309 - 318, 2015

PROJECT WEBPAGE URL

https://www.it.pt/Projects/Index/2147

Fig. 1 Instrumentation for pervasive Electrocardiography (ECG).

Fig. 2 VitalyType prototype for near-continuous ECG monitoring while using the computer.

GENERAL MOTIVATION AND OBJECTIVES

This project builds upon original work from our group in the scope of which we successfully demonstrated the acquisition of ECG data with clinical quality using what we've called an "off-the-person" approach, that is, with sensors placed on the subjects hand palms or fingers, and without any need for conductive gel or paste. Experimental results showed that this approach has nearly a 100% exact match to the data obtained at Lead I of a hospital-grade Philips PageWriter Trim III device. Nevertheless, several open questions remained concerning: (a)- clinical applicability of the ECG data acquired in an off-the-person mode (e.g. detection of cardiac dysrhythmia); (b)- robust methods for pervasive / continuous monitoring; (c)- robust methods for cloud-based pattern recognition and signal processing; and (d)- identity recognition performance improvements by combining other physiological sources.

CHALLENGE

We addressed that challenge of creating both hardware and software for the prevention and monitoring of cardiovascular diseases, based on physiological data collected in a pervasive manner, with integrated patient / user identity recognition. A core component was to support the system on low- cost instrumentation, integrating an identity recognition layer, and developing pattern recognition algorithms for clinical diagnostics in a continuous or near-continuous data acquisition framework. One particular challenge was related with the domain knowledge required to identify and validate pervasive ECG parameters applicable to health status monitoring, for which we actively worked with leading professionals from the Hospital de Santa Marta.

WORK DESCRIPTION AND ACHIEVEMENTS

The team developed real-time feature extraction and applied pioneering work on evidence accumulation clustering to the problem of continuous or near-continuous health status monitoring. We have also built on previous work in the field of ECG biometrics to incorporate a user recognition layer, and further improve it through the use of multimodal data sources. Several purpose-built hardware prototypes for data acquisition were also created, resulting in a series of demonstrators described further ahead. The involvement of the organic electronics group also enabled research work on inkjet-printed electrodes and novel electrode designs based on cotton, silk, and paper substrates, in an attempt to improve the overall apparatus. Focusing on leisure applications, the BikeYourHeart demonstrator was created in a partnership with JCDecaux, which consisted on measuring the ECG and deriving the heart rate (HR) using the bicycle handgrips. This demonstrator was developed and installed on a Vélib bicycle, encompassing the development of both hardware and software components, as shown in the cover figure. The hardware was composed of two handgrips with stainless steel and a PCB board with an ECG sensor, an AVR Microcontroller and a Bluetooth Low Energy (BLE) module to communicate with a smartphone. Other demonstrators included pervasive monitoring in computers (VitalidiType) and automotive industry (VitalidiDrive). The hardware development was made with a generic design, so that the same board could be applied in multiple scenarios with minor adjustments. Two new boards were designed which are prepared to communicate with the end-platform using multiple protocols (Bluetooth Low Energy, USB, UART, ...) and have different computational performance.