

Assessing Heart Function for Unsupervised Homecare Applications through Multi-Channel Auscultation

The main scientific goal of HeartSafe was to research algorithms applicable in long-term home monitoring contexts for the assessment of cardiac function, the key variable in cardiovascular disease management, using a multi-channel heart sound auscultation approach. The consortium involved three clinical partners in both Portugal and Brazil.



PROJECT WEBPAGE URL
<https://www.it.pt/Projects/Index/1855>

Main Project Team	
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Funding Agencies	
FCT - Fundação para a Ciência e a Tecnologia	57,914€
Start Date	01/07/2013
Ending Date	30/09/2015
Indicators	
Journal Papers	5
Conference papers	18
Concluded PhD	2
Concluded MSc:	4
Two Main Publications	
A. Castro, T. Vinhoza, S. Mattos, M. Coimbra, Heart Sound Segmentation of Pediatric Auscultations Using Wavelet Analysis , IEEE Engineering in Medicine and Biology Conference - EMBC 2013, Osaka, Japan, Jul 2013	
A. Castro, S.S. Mattos, M. Coimbra, Noninvasive Blood Pressure and the Second Heart Sound Analysis , IEEE EMBC 2014, Chicago, USA, August, 2014	



Fig. 1 PowerLab Cardiac Microphones (red circles) and ECG electrodes (blue circles) during an acquisition session



Fig. 2 Auscultation technology deployed in Paraíba, Brazil, during the Heart Caravan 2014 event in which 1000 children and pregnant women were screened for cardiac pathologies during 13 days in 13 different cities.

GENERAL MOTIVATION AND OBJECTIVES

CVD are the leading cause of death (45%) in developed and developing countries and one of the major causes of hospitalization. CVD are highly constraining diseases, tightly associated to aging. In Europe, the proportion of the population aged >65 years is projected to increase to 20% in 2025. These two factors are inducing major pressures on Europe's health care systems. At the other extreme of life, neonates often have prolonged intensive care stays due to cardiovascular decompensation caused by a persistent arterial duct or pulmonary hypertension of the newborn. Effective preventive healthcare strategies based on home care approaches require robust and inexpensive solutions for early detection of HF decompensation episodes for long-term patient follow-up. In this context, heart sound is a very valuable vital sign, since it directly encodes the mechanical status of the heart.

The main scientific goal of this project was to research algorithms applicable in long-term home monitoring contexts for the assessment of cardiac function, the key variable in cardiovascular disease (CVD) management, using a multi-channel heart sound auscultation approach. The consortium involved two proficient research institutes in R&D of biosignal processing and analysis methods (Universidade de Coimbra, Instituto de Telecomunicações) and three clinical partners: two portuguese cardiology (DCCHC-CHUC) and cardiothoracic (CCT-CHUC) units and one brazilian pediatric hospital (Real Hospital Português, Recife).

CHALLENGE

Heart sound processing was applied to extract three different key diagnostic measures to characterize the cardiovascular system status and to prognosis heart failure:

- The systolic time intervals (STIs) – This time interval is altered for unhealthy hearts, providing clues on the myocardial relaxation and contraction mechanism. This diagnosis tool was the gold standard prior to the introduction of echocardiography and is very hard to characterize with human listening alone. (Research by Universidade de Coimbra)

- The presence of extra heart sounds (S3) – The third heart sound (S3) is considered pathological in a population over 40 years old. Its occurrence has been related by several clinical studies as a highly relevant diagnostic and prognostic marker for left ventricle heart failure. (Research by Universidade de Coimbra)

- The characterization of the splitting of the second heart sound (S2) – The second heart sound (S2) is mostly a mixture of two quasi-simultaneous sounds: the closing of the aortic (A2) and the pulmonary (P2) heart valves. While A2 is a reasonably stable sound, P2 depends on the respiration cycle and is slightly delayed during inspiration, creating a window of opportunity in which these sounds are split and can be heard individually. P2 is typically hyper-phonetic in individuals with pulmonary hypertension, making us believe that it might be possible to use signal processing to segment these heart sounds and possibly detect pulmonary hypertension situations. (Research by Instituto de Telecomunicações)

WORK DESCRIPTION AND ACHIEVEMENTS

Scientific challenges were all addressed successfully, resulting in a very high number of scientific indicators. These included 5 journal publications, 18 conference publications and 2 concluded PhD theses. Although the Instituto de Telecomunicações team addressed only one of the three challenges, it provided a very strong contribution to these indicators, totalling 15 publications and one PhD thesis.

Besides scientific achievements, the project produced a few technical achievements namely the crafting of a sophisticated data collection system for multi-channel auscultation and ECG signal recording, as well as several produced databases, both in Portugal and Brazil, and which were the foundation of the scientific research performed.