Subject: Development and validation of methods to extract cardiac features from sensors within a commercial smartphone

Location: Cardiology Department, Université libre de Bruxelles (Brussels, Belgium)

Context

Nowadays, nearly everyone owns a smartphone—and these devices are increasingly equipped with high-quality sensors that can be used to acquire physiological data non-invasively. Specifically, embedded accelerometers and microphones make it possible to record seismocardiography (SCG) and phonocardiography (PCG) directly from the chest using only a smartphone. This opens the door to accessible, portable, and cost-effective tools for cardiac monitoring outside clinical environments.

SCG measures subtle chest vibrations caused by cardiac activity, while PCG captures the acoustic signals of heart sounds. Both modalities provide valuable, complementary information about cardiac mechanical events such as aortic valve opening (AO) and mitral valve closure (MC)—key markers of cardiac function.

Despite the promise of SCG and PCG as smartphone-based diagnostic tools, challenges remain, especially in accurately detecting AO and MC. These challenges stem from signal noise, physiological variability, and the complex interplay of cardiac events. However, combining SCG with PCG can help improve robustness and timing accuracy in event detection.
This type of mobile cardiac monitoring is particularly suited for remote or extreme environments—such as for astronauts aboard the ISS, or patients in isolated locations like the Concordia station in Antarctica, or those who cannot easily access hospitals due to geographic or economic barriers.

This master thesis will focus on developing advanced signal processing algorithms to improve the detection of AO and MC, and extract other cardiac metrics from smartphone-acquired SCG and PCG. The aim is to create a reliable, efficient, and fully mobile solution for clinical and remote applications, ultimately contributing to personalized and preventive cardiovascular care.

Master thesis project

- Literature Review: The student will begin by exploring current methods for SCG and PCG signal analysis, with a focus on AO and MC detection techniques, fusion strategies, and mobile implementations.
- Signal Processing Development: Design and implement algorithms to preprocess SCG and PCG signals, aiming to reduce noise and enhance key cardiac features. This may include filtering, segmentation, and normalization techniques.
- Feature Engineering and Detection: Extract meaningful features from both SCG and PCG that correspond to the mechanical events of AO and MC. Techniques may involve envelope detection, wavelet transforms, and time-frequency analysis.
- Validation: Apply the developed methods to existing datasets, including recordings from healthy individuals and patients with known cardiac conditions, to ensure generalizability.
- Performance Evaluation: Quantify the method's accuracy, sensitivity, and specificity, and compare it against existing benchmarks. Special attention will be given to evaluating performance across different population groups and recording conditions.

Scientific environment

The student will collaborate with an interdisciplinary team of engineers, cardiologists, and researchers at the Erasme Hospital's Cardiology Department. This vibrant environment offers extensive expertise in cardiac signal processing. The intern will also have access to laboratories located at the Erasme Hospital (LPHYS, Department of Cardiology).

Keywords: Seismocardiography, Phonocardiography, Smartphone, Cardiac Function, Signal Processing, Wearable Devices, Biomedical Engineering.

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