Graph-based characterization of cardiac events for early detection of heart failure

Context: Heart failure (HF) represents a major global health concern, accentuated by the aging population, affecting approximately 15 million individuals in Europe and presenting a significant medium-term mortality rate. The severity of HF is also evidenced by repeated unexpected hospitalizations due to acute decompensated heart failure (ADHF). The frequent occurrence of ADHF leads to recurrent hospitalizations, posing significant healthcare and economic challenges. These acute episodes have a grim prognosis, with a 40% likelihood of death in the following year for patients hospitalized twice. To improve prognosis, optimal care management of hospitalized patients is essential. Intelligent monitoring plays a crucial role for understanding the mechanism of compensation and how to improve it by ensuring proper medical treatment. The integration of data from multiple sensors allows for identifying and tracking new digital biomarkers of HF compensation. Promising solutions for intelligent monitoring of patient physiological variables are thus expected, meeting clinical needs and contributing to hospitalization reduction. The electrocardiogram (ECG) signal, providing information on heart rhythm, proves useful for diagnosing heart diseases. SEPIA team of LTSI has long experience in heart related signal analysis, processing and modelling for early detection of HF. More particularly, multivariate exploration of waves and intervals of the ECG to detect early episodes of the event of interest such as apnea-bradycardia was conducted in SEPIA team based on the analysis of dynamics of temporal multivariate series extracted from ECG using Hidden Markov Models (HMM), Hidden Semi Markov Models (HSMM), coupled HMM (CHMM) and Coupled HSMM (CHSMM). Inspired from previous SEPIA works on heart failure detection and more particularly from the intuition behind the coupling between different temporal dynamics computed from ElectroCardioGram (ECG) recording which includes information on the heart's rhythm and is useful for diagnosis of heart related diseases, the aim in this project is the characterization and the classification of HF and HF-free ECG episodes in the framework of Graph Signal Processing (GSP) [1].

Objectives: The goal of this project is the characterization of HF and HF-free episodes in the framework of GSP under the assumption that ECG signals are living on a graph structure to be identified/learned from the available ECG recordings. Next, differentiating HF from HF-free episodes will be performed through a machine/deep learning model that will be tailored to optimally capture relevant features in the inferred graph topology. A particular attention during this internship will be made on the concept of graph topology learning [2] and machine and deep learning on graph [3].

Profile: Candidate should possess a Master's or equivalent degree in biomedical or electrical/electronic engineering strongly motivated by new techniques for biomedical signal processing. Applicant should demonstrate solid background in numerical optimization, signal processing, machine and deep learning. Programming proficiency in Python is a must-have skill.

Emplacement: Laboratory of signal and image processing (LTSI) – INSERM U1099, Bâtiment 22, Campus de Beaulieu, Université de Rennes, 35042, Rennes, France.

Duration of contract: 3 years
Starting date: 2024-10-01

Contact: Applications comprised CV, cover letter and mark transcript are to be submitted to Ahmad Karfoul (ahmad.karfoul@univ-rennes.fr) and Lotfi Senhadji (lotfi.senhadji@univ-rennes.fr).

References

[1] D. I. Shuman and S. K. Narang and P. Frossard et al., "The emerging field of signal processing on graphs: Extending high-dimensional data analysis to networks and other irregular domains," IEEE Signal Processing Magazine, vol. 30, no. 3, pp. 83-98, DOI: 10.1109/MSP.2012.2235192.
[2] G. Mateos, S. Segarra, A. G. Marques, "Inference of Graph Topology," Chapter 13 – Cooperative and Graph Signal Processing, Editor(s): Petar M. Djurić, Cédric Richard, Academic Press, pp : 349-374, 2018, ISBN 9780128136775, https://doi.org/10.1016/B978-0-12-813677-5.00013-4.
[3] W. Hamilton, R. Ying and J. Leskovec, "Representation learning on graphs: methods and applications," IEEE Data Eng. Bull., vol, 40, no 3, pp: 52-74, 2017.