Laboratoire Traitement du Signal et de l'Image LTSI

Inserm

Université de Rennes

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

Context: Heart Failure (HF) stands as a perilous global health concern, exacerbated by the aging population and impacting approximately 15 million individuals in Europe, with a notable medium-term mortality rate. The severity of HF is also marked by repeated unplanned hospitalizations due to Acute Decompensated HF (ADHF). The occurrence of ADHF frequently results in recurrent hospitalizations, presenting significant health and economic challenges. These acute episodes have a poor prognosis resulting in the patient being hospitalized twice and having a 40% risk of death within the next year. To improve the prognosis, an optimal management of hospitalized patients is necessary, but the ambulatory follow-up has also a major impact. The current medical challenge of reducing these recurrent hospitalizations remains in the early detection of ADHF at a pre-hospitalization stage. This will save crucial time and assist in providing the right kind of medical treatment to the patient. Implantable cardiac electronic devices are promising technical solutions to meet the clinical need. These devices allow multiple sensors to be embedded to record multiple biomarkers. In addition, they pave the way for a tele-monitoring of physiological variables of the patient. ElectroCardioGram (ECG) signal includes information on the heart's rhythm and is useful for diagnosis of heart related 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 goal of this internship is to explore the feasibility in characterizing HF events in the framework of Graph Signal Processing (GSP) [1].

Objectives: The goal of this project is the characterization of HF and HF-free episodes through a graph topology that will be identified/learned using the available heart related 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 learning on graph [3].

Profile: We are looking for M2 or 5th year undergraduate engineer student strongly motivated by new techniques for biomedical signal processing. Applicant should demonstrate background in deep learning, machine learning, numerical analysis, optimization and signal processing. Programming proficiency in Python is required.

Internship emplacement: Laboratoire Traitement du Signal et de l'Image (LTSI) – INSERM U1099, Bâtiment 22, Campus de Beaulieu, Université de Rennes, 35042, Rennes, France.

Time period: The internship run in mid-March and last for six months.

Reward: around 570 € per month.

Contact: Applications comprised CV, cover letter and mark transcript are to be submitted to Ahmad Karfoul (ahmad.karfoul@univ-rennes.fr) and Amar Kachenoura (amar.kachenoura@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.