Exploring the Impact of the Tikhonov Regularization Parameter on the Inverse Problem in Electrocardiography

Context

Electrocardiographic imaging (ECGI) is a non-invasive technique used to reconstruct heart surface potentials from body surface potentials, along with the geometrical configurations of the torso and heart. This inverse problem is inherently ill-posed, necessitating the use of regularization techniques to achieve stable and accurate solutions. While zero-order Tikhonov regularization is the standard approach, the optimal choice of regularization parameter is scenario-dependent. Current practices often reveal the challenges of over-regularization or under-regularization only through observation of reconstruction results, lacking a deeper understanding of how specific parameter values influence outcomes. Additionally, various estimation methods for the regularization parameter can exhibit limitations in robustness, convergence, and efficacy under certain conditions. This project aims to shift focus to the regularization parameter itself, providing insights into its impact on ECGI reconstructions.

Objectives

- Investigate the influence of the regularization parameter on the accuracy of ECGI reconstructions.
- Assess reconstruction accuracy using high-precision simultaneous heart and torso recordings from both simulated and experimental data.

Project Description

The intern will work within the Signal Processing Team at the Cardiac Rhythm Disease Institute (IHU-Liryc). The project will emphasize understanding the effects of regularization parameter choice rather than merely comparing estimation methods. For this project, we will take the viewpoint that to acquire more insight into the effects of regularization parameter choice, it makes sense to focus on the regularization parameter itself rather than to focus on comparing the performance of methods for choosing it. In line with these observations, the student will (A) investigate the influence of the regularization parameter on reconstruction accuracy in terms of epicardial potentials, activation maps and localization error of pacing sites (by focusing on a sufficiently large range of parameter values), and (B) to analyze the impact of various external factors on this accuracy including noise, geometric error, numerical solution and/or regularization method.

Requirements

- Strong background in signal processing, mathematical modeling, or related areas.
- Familiarity with electrocardiography or biomedical imaging is a plus.
- Proficiency in programming (MATLAB) for data analysis and simulation.

What We Offer

- Opportunity to work on cutting-edge research in the field of electrocardiology.
- Hands-on experience with advanced signal processing techniques and ECGI methodologies.
- Mentorship from experienced researchers in a collaborative environment.

Interested candidates should submit their CV and a cover letter outlining their motivation and relevant experience to Dr Laura Bear (laura.bear@ihu-liryc.fr)