An Experimental Rabbit Torso-tank Setup for Cardiac Rhythms Investigation Using ECGi

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Introduction: Understanding cardiac electrophysiology is vital for diagnosing and treating cardiac diseases, which remain a significant global health concern. While optical and electrical mapping techniques provide valuable insights into cardiac activity, Electrocardiographic Imaging (ECGi) presents a promising non-invasive alternative, enabling estimation of cardiac electrical activity without invasive procedures. This study employs an animal model experimental setup to apply and analyze the ECGi technique.

Methods: The experimental setup comprises of a Langendorff system, epicardial electrical mapping using microelectrode arrays, non-invasive electrical mapping employing a tank to replicate animal torso conditions, and 3D geometry construction. After meticulous data collection and preprocessing, ECGi is performed using tank potentials and geometries of the heart and torso-tank. Tikhonov regularization (order 0) stabilizes the inverse problem inherent in ECGi, while Root Mean Squared Error (RMSE) quantifies the similarity between estimated epicardial and reconstructed eletrograms in sinus rhythm and cardiac arrhytmias. The euclidian distance bettween the earliest activation is obtained. Dominant frequency and phase maps are calculated.

Results: Optical and electrical signal comparison indicates strong correspondence, suggesting efficient signal propagation. Signals collected from the tank exhibit minor delay and amplitude attenuation due to the distance from the heart to the tank walls. 3D potential maps derived from estimated signals during sinus rhythm offer detailed insights into cardiac activity, facilitating identification of activations across different heart regions. RMSE analysis highlights minimal error (6.4) at electrode 66 (left atrium), with an average error of 24.84 across all electrodes and lower error observed in the left atrium region (average of 15.9). Euclidean distance, DF and phase analysis are under progress.

Conclusion: Potential maps from estimated signals provide a comprehensive view of cardiac electrical activity, serving as a powerful tool for heart analysis. While RMSE values suggest reasonable proximity, further accuracy enhancement is feasible.