An Algorithm For Non-invasive Mapping Based On Cardiac Anatomy and 12-lead Electrocardiogram Data

Svyatoslav Khamzin[1], Anastasia Bazhutina[1], Mikhail Chmelevsky[1,2], Stepan Zubarev[1], Margarita Budanova[1], Werner Rainer[1]

[1]XSpline S.p.A, Bolzano, Italy
[2]Division of Cardiology, Fondazione Cardiocentro Ticino, Lugano, Switzerland

In recent years, many efforts have been made to improve the quality of diagnosis and treatment of cardiovascular diseases. The use of medical imaging data, such as computer tomography or magnetic resonance images, in conjunction with electrocardiography data, has the potential to provide an innovative approach to cardiac mapping.The purpose of cardiac mapping is to create a 3D representation of the heart's electrical activity. We are solving a forward ECG problem and then use neural networks to determine the parameters of a mathematical model of cardiac activity that ideally replicates the patient's real ECG and therefore could be used for activation map reconstruction.

As input data for the proposed algorithm, we used 12-lead patient ECG and cardiac meshes with torso and lung geometry. To identify an activation map that corresponds to the patient's ECG, we used the following workflow. First, we identified the possible zone of cardiac activation points based on the patient's ECG. Then we solved 1000 forward ECG problems with varied parameters. For parameter sampling, we used the quasi Monte Carlo method. In the last step, we used neural networks to identify mathematical model parameters for patient ECG and reproduce the appropriate activation map.

Our algorithm shows the mean correlation between the patient's 12-lead ECGs and calculated ECG of $0.89(\pm 0.05)$. In order to validate our algorithm we used retrospective invasive electro-anatomical mapping(EAM) data from five patients with left bundle branch block. The algorithm shows the mean correlation for left ventricular endocardial maps between EAM and non-invasive approach was 0.81, the mean absolute error for local activation time was 16ms and the mean absolute error between late activation zones was 14mm. These remarkable results show the promise of a non-invasive mapping system for estimating the electrical activity of the heart.