ECGI Periodicity Unraveled: A Deep Learning approach for the Visualization of Periodic Spatiotemporal Patterns in Atrial Fibrillation Patients

Alexander Lacki[1], Ismael Hernández-Romero[2], Maria S Guillem[1], Andreu M Climent[1]

[1]ITACA Institute, Universitat Politècnica de València, Valencia, Spain
[2]Universidad Rey Juan Carlos, Fuenlabrada, Madrid, Spain

Introduction. Atrial Fibrillation (AF) is characterized by an irregular electrical activity. Previous studies show varying degrees of organization in electrophysiological recordings; however, characterization of AF complexity remains a complex process. We propose a novel method of visualizing spatiotemporal patterns in Electrocardiographic Imaging (ECGI) signals and show its ability to identify, quantify, and localize recurring patterns.

Methods. We use ECGI recording from 29 patients in AF. For each personalized atrial geometry, we compute 2-dimensional conformal maps to represent ECGI signals as 2D videos.

Video segments are encoded to a lower-dimensional feature space using a 3D-CNN autoencoder, and further processed with principal component analysis such that principal components (PCs) represent linear combinations of co-occurring spatiotemporal features. Backpropagation-based saliency maps are computed for PCs to identify which atrial regions contribute to the captured patterns. The saliency maps are visualized on 3D atrial models.

Results. The number of PCs necessary to explain 90% of variance varied from 24 to 85 (55.36±20.50) demonstrating varying degrees of complexity in the propagation patterns across patients. The novel parameter proved to be reproducible intra-patient with an inter-segment correlation higher than 85%. Saliency maps show that PCs capture the periodicity of recurring patterns, and dynamically describe periodicity.

Conclusions. We show a novel method to assess the spatiotemporal behaviour of activation patterns in ECGI, that captures different degrees of complexity in AF patients and visualizes the electrophysiological periodicity of activation patterns. Our method captures spatially co-occurring features and visualizes the periodicity as well as localization of said patterns.