Reducing Noise in Atrial Fibrillation Electrograms Using Autoencoder Neural Networks

Samuel Ruipérez-Campillo[1,2,3,4], José Millet[2], Francisco Castells[2]

University of California, Berkeley; Universitat Politecnica de Valencia, Stanford University, ETH Zurich.

Introduction: Accurate non-invasive diagnoses in the context of cardiac diseases are problems that hitherto remain unresolved. We propose an unsupervised classification methodology for atrial flutter (AFL) dianosis using dimensional transforms of ECG signals in high dimensional Hilbert spaces.

Methods: We used simulations based on physiological parameters of clinical signals to create 8000 vectorcardiogram (VCG) loops of 8 different AFL types. Dimensional transforms are used to represent each VCG as a vector in an n-dimensional Hilbert Space (n = 579) from the concatenation its channels, later projected in an m-dimensional subspace (m<n). Unsupervised K-means and multivariate Gaussian Mixture Models are used together with agglomerative nesting algorithms such as Ward's Hierarchical Clustering to classify the AFL mechanisms. Self-implemented metrics based on Mahalanobis distance and others are designed to evaluate the accuracy of the analysis.

Results: The first six components of the eigendecomposition express more than 96% of the variance, with the 7th onwards expressing less than 0.01. Closeness metric S (0-1: S=1 close, S=0 far) allows classifying AFL types when reducing up to a 3 dimensional space (S=0.35 for cases with same slow conduction region and direction (clockwise – CW; counterclockwise – CCW); S = 0.93 for same velocity distribution (ignoring conduction direction); S = 0.04 for those with nothing in common). In 2D, only mechanisms are discerned, but not conduction direction (e.g. common AFL from perimetral, but not CW from CCW). Clustering allowed distinguishing groups in a 3D space with a 87% accuracy, while in 2D, the for groups (no CW/CCW) are classified with a 99.7% accuracy.

Conclusions: Classic bio-signal analysis techniques combined with machine learning techniques in dimensional transforms in the context of Hilbert Spaces can provide a novel methodology to non-invasively diagnose and classify cardiac diseases from its surface signals. This is currently being applied to clinical signals.

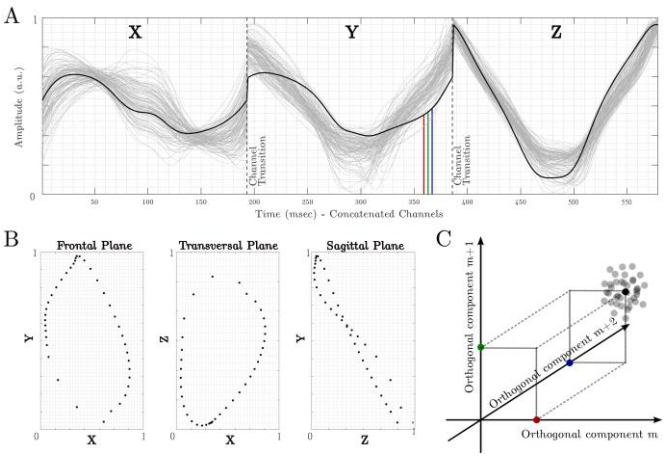

Figure. A: *Concatenation of the three channels for a synthetic type of AFL. Each of this camples is used to provide magnitude to a dimension of the n-dimensional vector space where each wave is represented as a point. An example for thre samples is depicted in blue, green and red (see* **C***). One VCG is marked with a black line for illustration purpses (see* **B***).*