Novel Metric for Evaluating Ischemic Stress on the Torso Surface Using Laplacian Eigenmaps on Animal and Human Recordings

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Introduction:

The underlying pathophysiology of myocardial ischemia is incompletely understood, resulting in persistent difficulty of diagnosis. This limited understanding of underlying mechanisms encourages a data driven approach, which seeks to identify patterns in the ECG data that can be linked statistically to disease states. Laplacian Eigenmaps (LE) is a dimensionality reduction method popularized in machine learning that we have shown in large animal experiments to identify underlying ischemic stress both earlier in an ischemic episode, and more robustly, than typical clinical markers from signal space. We have now extended this approach to body surface potential mapping (BSPM) recordings acquired during acute, transient ischemia episodes from animal experiments following graded heart rate increase and to human recordings acquired during percutaneous transluminal coronary angioplasty (PTCA).

Methods:

The LE algorithm has been previously described. Here we decompose the entire collection of BSPM's and represent them in a low-order coordinate system as trajectories that represent all leads together, one trajectory for each beat. The shape of the trajectory reflects morphological features in the input signals and changes in shape have been previously reported to reflect injury conditions such as ischemia.

Results:

Our preliminary results suggest that the LE approach is sensitive to the spatiotemporal electrocardiographic consequences of ischemia-induced stress within the heart and on the epicardial surface. In this study, we expand this technique to the body surface of animals and humans. Across 10 episodes of induced ischemia in animals and 200 human recordings during PTCA, the LE algorithm was able to detect ischemic events from BSPM as changes in the morphology of the resulting trajectories.

Discussion:

The sensitivity of this method on BSPM, and its ability to leverage a predefined LE space, suggests that its performance on experimental data may be transferable to the clinical setting and could support novel approaches during, for example, clinical stress testing.