Can Laplacian Eigenmaps be used for differentiation between healthy subjects and patients with corrected Tetralogy of Fallot?

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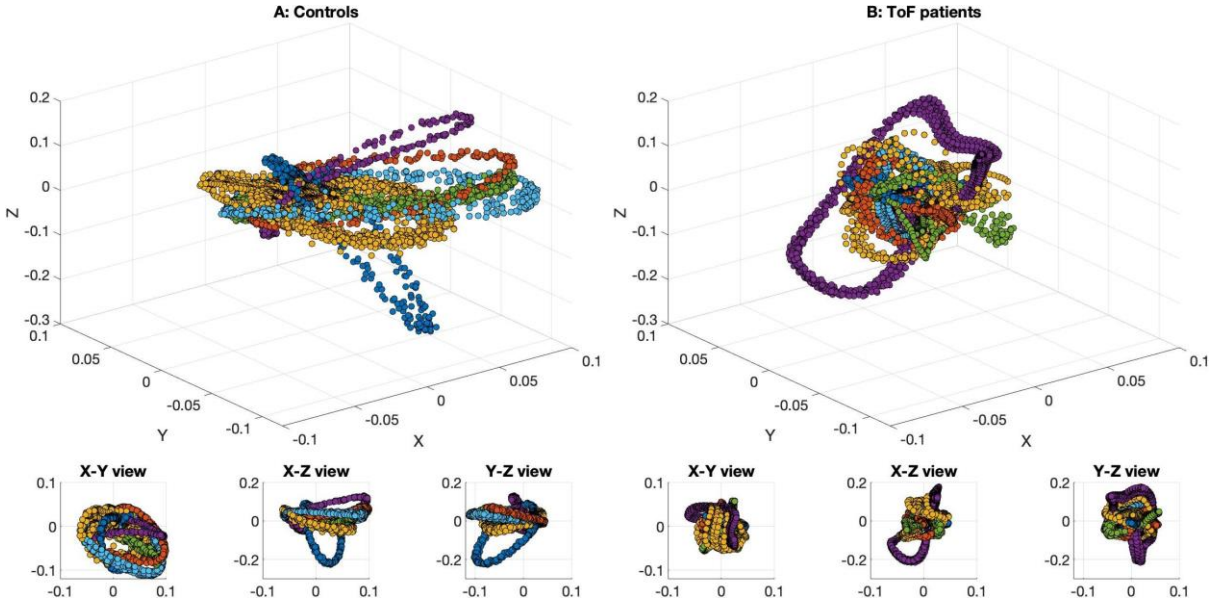

Figure 1: (A) Laplacian Eigenmaps of the 6 controls within the reference space. (B) LEs of the ToF patients. One LE consist of several LE loops. Every LE loop corresponds one heartbeat.

Tetralogy of Fallot (ToF) is a congenital structural heart disease that is present at birth. Early diagnosis and corrective surgery allow most patients to live normal lives. However, some patients slowly deteriorate, develop ventricular tachycardia and heart failure, possibly leading to sudden cardiac death. The current inability to quantify the deterioration and predict these events prompts a data driven approach.

Laplacian Eigenmaps (LEs) is a dimensionality reduction technique that can be used to project multi-lead ECGs onto a lower dimensional space. We hypothesize that it can contribute to characterize the deterioration of ToF patients, and aid in the prediction of life threatening events.

This pilot study aimed to investigate the use of LEs for the differentiation of heartbeats of controls with ToF subjects.

First, we segmented the heartbeats of 20 healthy controls and constructed a reference LE space. Hereafter, we projected all heartbeats of those 20 subjects onto this space and created a reference projection, further called loop, by taking the average. Second, we projected the heartbeats of 6 ToF subjects, who died of a cardiac reason, and 6 healthy controls onto the reference space. To quantify the distance with the reference loop, 4 metrics were used: (1) point-to-point, (2) 3D dynamic time warping (DTW), (3) Eigenshape and (4) Hausdorff distance.

This experiment was repeated 10 times with different control subjects and different reference spaces. Statistically significant differences ($p<0.05$) between the controls and the ToF subjects were observed in 10/10, 10/10, 7/10 and 2/10 cases for the point-to-point, DTW, Eigenshape and Hausdorff distances, respectively.

In conclusion, this LE implementation is able to reliably synthetize the differences between control and ToF subjects with most of the used metrics. In future work, we aim to assess the deterioration by tracking the quantified differences in time with the point-to-point, DTW and Eigenshape distance.