Predictive Modeling of Biomedical Signal based on Spatial Topology Based Feature Space Transformation

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(ABSTRACT)

Biomedical signal classification has been frequently investigated by researchers in the past decades. Various classification systems have been proposed and evaluated by classification metrics. The essence of most methods, is to analyze test signals using reference models constructed based on a collection of healthy and abnormal signals. While system performances in terms of classifying signal samples increased significantly with modern machine learning algorithms such as recurrent neural network, there are one important factor in biomedical signal processing which is rarely studied in recent research. In this work, we go one step beyond the conventional methods and intend to predict potential upcoming abnormalities before their occurrence. The approach is to build a patient-specific model and identify minor deviations (e.g. yellow alarms) from the normal trend, which can be indicative of potential upcoming significant deviations (red alarms).

To facilitate a sound deviation analysis, a controlled spatial transformation is proposed to reshape the signal geometry in the feature space, such that the abnormality classes symmetrically surround the normal class. We applied the developed technique to Electrocardiogram (ECG) signals and the results confirm the utility of the proposed method in predicting upcoming heart abnormalities before their occurrence. For instance, the probability of a red alarm of specific abnormality class increases by 10% after observing a yellow alarm of the same type. This approach is general and has the potential to be applied to a wide range of physiological signals.