Siamese Neural Networks for Small Dataset Classification of Electrograms

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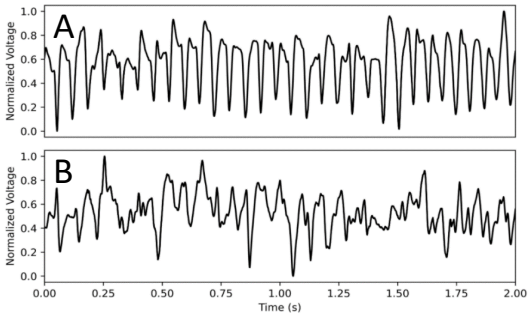
Aims: Conventional algorithms have difficulty classifying signals based on morphological features, a difficulty which is amplified by irregular signals such as those in atrial fibrillation (AF). Deep neural networks can improve on conventional algorithms but often at the expense of requiring extensive datasets. In this work, we aimed to isolate AF electrograms with highly distinguishable activations in a small dataset using Siamese neural networks.

Methods: We examined 1,006 non-contact endocardial unipolar electrograms of 2 seconds from a paced canine model of AF (n=6, female mongrel, 29±2 kg, 4 to 24 wks. pacing) during sustained AF and manually identified 86 electrograms (8.5% of total) as having highly distinguishable activations. Classification criteria included low fractionation and presence of a dominant single-potential morphology. Our Siamese neural networks were two 5-layer convolutional networks with a joint linear layer to produce a binary similarity metric. We utilized a 75%/10%/15% training/validation/testing split with the two classes divided proportionally between datasets. We randomly sampled pairs of electrograms from the training dataset, input the electrograms into the networks to determine similarity and loss, and trained until validation accuracy plateaued after 490,000 samples.

Results: When evaluated on the testing dataset, the Siamese networks achieved an AUC of 0.72 and weighted accuracy of 74% at similarity threshold 0.28. For the optimal comparison electrogram from the testing set, we achieved an AUC of 0.90 with weighted accuracy of 88% at similarity threshold 0.29.

Conclusions: We used Siamese neural networks to achieve clear improvement over a random prediction weighted accuracy of 50% in this learning task. This methodology is promising for future electrogram work where target signals are rare or dataset size is small. This technique can further be used in therapies which target regions based on electrogram features.



Electrograms with (A) highly distinguishable activations and (B) poorly distinguishable activations.