CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

**Name(s)**

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**Project Title**

# MapAF: Deep Learning to Improve Therapy for Complex Human Heart Rhythm Abnormalities

## Abstract

**Objectives**

Atrial fibrillation (AF) is a chaotic and irregular electrical disturbance of human heart rhythm that affects over 33 million individuals worldwide, causing serious fatal health effects, yet for which therapy is poor. Recent studies that have used voltage mapping videos reveal areas of rotational sources in the atria, for which ablation (burning of diseased tissues) at these particular regions terminates AF. Unfortunately, current methods to identify AF sources from these complex mapping videos are solely manual, therefore limited and subjective, with an average of 60-70% accuracy. I developed MapAF, the first computational approach to automatically recognize the location of these AF rotational sources from within chaotic electrical patterns.

**Methods**

Electrical mapping videos from 35 de-identified patients undergoing ablation with persistent AF were collected. Data was pre-processed in MATLAB so that each video was split into 5000 images. Each image was labeled either rotational or non-rotational by an expert. A multi-layered convolutional neural network (CNN) was then implemented and datasets were filtered through 25 different feature extraction and classification layers to classify the output. I used the AlexNet architecture as the base for developing the network. I then trained an unsupervised learning algorithm on the images which contained rotational source (s). Using the principal components of the images as inputs, I clustered the images into K=2, 3, and 4 groups using the k-means clustering algorithm.

**Results**

The sensitivity of the CNN is 97% and the specificity is 93%. Therefore, in blinded testing, the supervised network is 95.0% accurate for potential sources and detected all sites of AF termination, more accurately and efficiently than medical experts. Individual patients can be grouped into K=3 clusters based on their types of images in 3 clusters: Cluster A showed more ambiguous rotations of small domain sizes, Cluster B contained larger rotational patterns, and Cluster C showed unclear rotations.

**Conclusions**

This is the first tool to identify sources for AF and provide insight into its mechanisms. Promising unsupervised data showed that clusters could be linked to an individual patient s history and shed light on which patients may have more advanced AF for tailoring treatment. MapAF may standardize and streamline the treatment procedure by eliminating subjectivity, reducing the expert physician time to detect sources, and being accessible in areas lacking experts, making a potential global impact on AF therapy.

**Summary Statement**

MapAF is the first computational tool using machine learning to automatically pinpoint sources of AF better than medical experts, thus improving AF treatment.

**Help Received**

I conducted my research at Stanford University where the PI of my lab, Dr. Sanjiv Narayan, and two other graduate students assisted me with implementing the machine learning model.