Heartfelt Predictions: Machine Learning to Avoid Cardiac Disasters

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HEARTBEAT BINARY CLASSIFICATION

ECG Data: 14552 datapoints (4046 datapoints normal & labeled 0, and 10506 abnormal & labeled 1). Each datapoint consists of electrode signal values sampled every 8ms over a period of 1488ms.

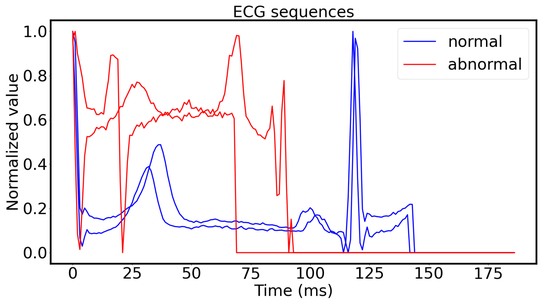
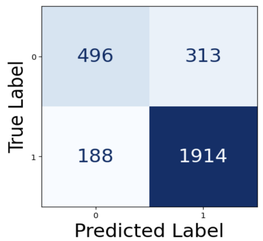


Fig 1

1. Train: Test ratio = 80:20.
2. SubTrain: Validation ratio = 80:20

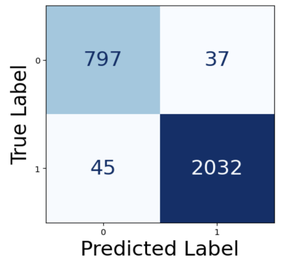


Logistic Regression: Applied a simple logistic regression model with a 5-fold cross-validation in our training set with cutoff = 0.5. Accuracy on test data ~**83%**.

Neural Network: Implemented a simple feed-forward neural network (Fig 2). Applied a ReLU activation function after each hidden layer and a sigmoid activation after the output layer.

Loss function: **Binary Cross Entropy**

Obtained **accuracy of 97%** on test data



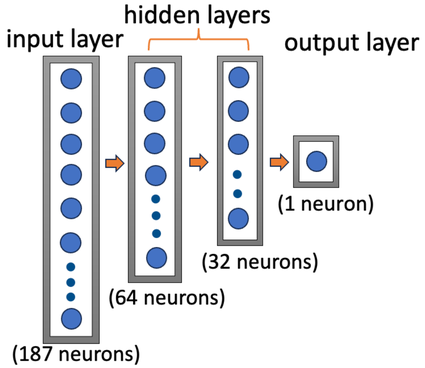
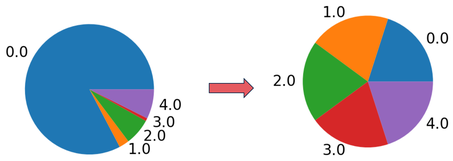


Fig 2: Neural Net Architecture

MULTI-CLASS CLASSIFICATION

ECG sample sequences: 109446, each sample was classified into one of the 5 classes labeled : 0: "Normal", 1: "Atrial Premature", 2: "Premature ventricular contraction", 3: "Fusion of ventricular and normal", 4: "Fusion of paced and normal"



The dataset is highly **imbalanced**. To address this, we used **down-sampling** and **up-sampling** methods to equalize the class distribution

Fig 3: Rebalancing the data

Models	F1 Score
KNN, k = 2	[0.97, 0.64, 0.90, 0.66, 0.98]
Decision Trees, depth = 10	[0.89, 0.34, 0.72, 0.26, 0.87]
CNN	[0.99, 0.99, 0.99, 0.99, 0.99]

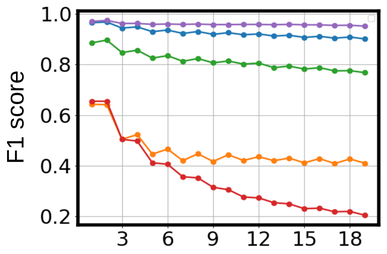
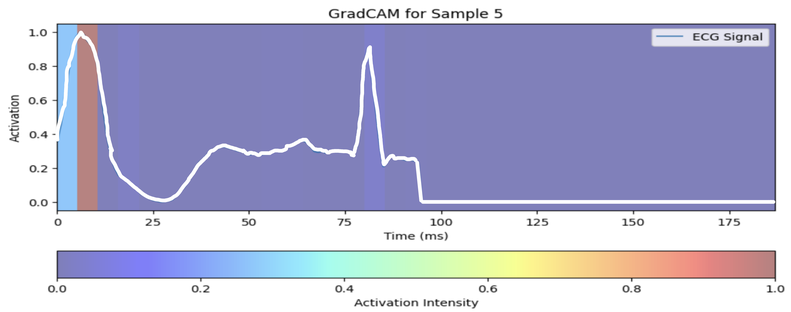


Fig 4: F1 score for each class vs k

Fig 5:
A GradCAM allows us to visualize features that influence a CNN's decision that we otherwise wouldn't be able to visualize.



ACTIVATION MAP RECONSTRUCTION

10-lead ECG (***X***) and activation voltage (***V***) dataset: 16,117. Each 10-lead ECG was converted to a 12-lead ECG (***E***) and derived the peak activation time (***A***) from all Activation maps (***V***)

$$X_{(10\times500)} \rightarrow E_{(12\times500)} \qquad V_{(75\times500)} \rightarrow A_{(75\times1)}$$

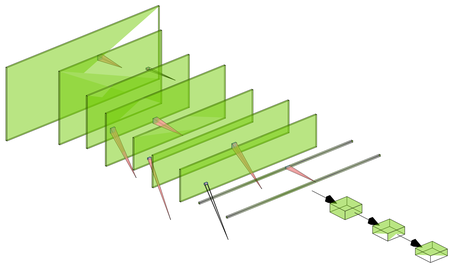


Fig 6: Hybrid Network Architecture

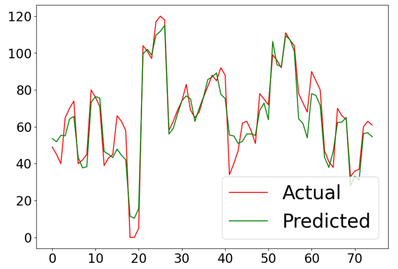
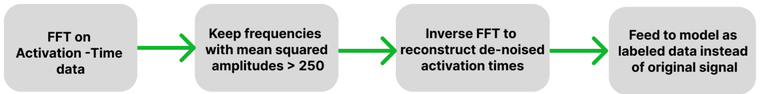


Fig 7: Actual Vs. Predicted Act. Time

Our model (fig 6) resulted in a loss (mean-squared error or MSE) of ***~116 .*** In fig 7, our prediction falls within 5.93 ms of the actual activation time.

Applying Fourier Transform on Activation Time data



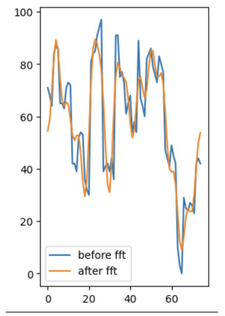


Fig 8: Fourier Transform on activation time sequence

Feeding the de-noised labels into a CNN with 2 convolutional and pooling layers and 3 fully connected layers resulted in a **MSE of 104**.