# ANN Seizure Prediction System for Epilepsy


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## Intro

**Background:** Epilepsy is a neurological disorder characterized by random, spontaneous seizures that afflicts 1% of the global population. Current treatments are ineffective for 30% of those effected

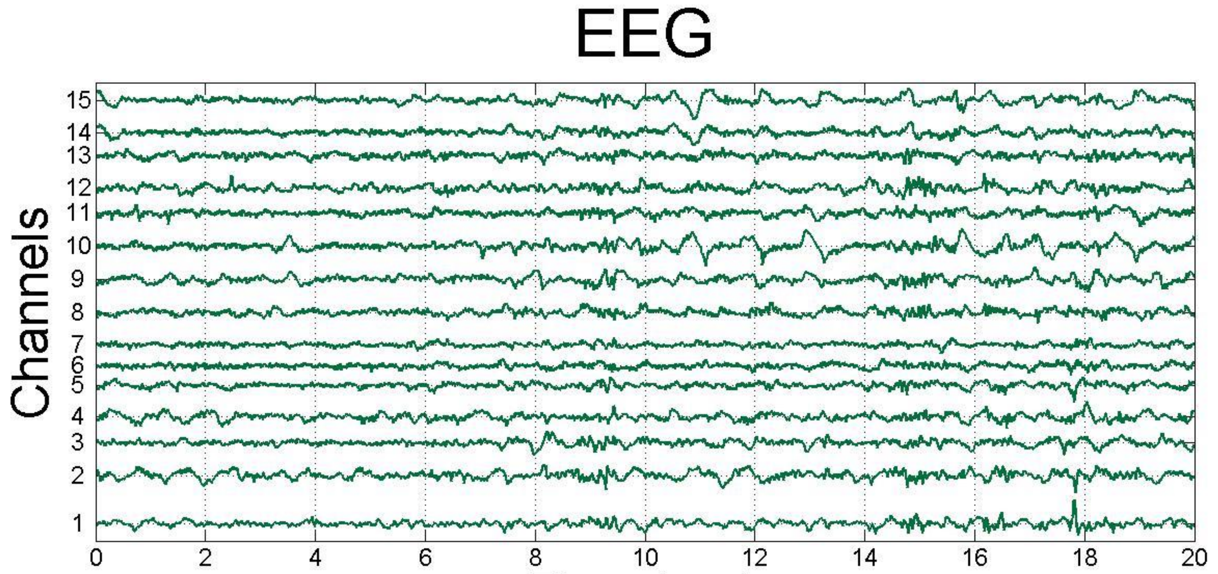
**Computational Problem:** Create an early warning system for seizures by predicting a subjects current ictal state.

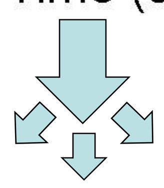
**Data:** EEG data of pre-ictal and inter-ictal states sampled from 5 epileptic dogs, in which there were ~600 examples per dog, each recorded through 16 channels over 240,000 time points.

**Constraints:** The prediction system was implemented keeping in mind that such a system would likely be an implanted device which can make predictions in real time, thus we chose features which are relatively cheap to compute.

**Approach:** Generate frequency based features which are passed to a three layer ANN trained on a per-subject basis.

## Methods



**FFT**

**Spectral Edge** **Average Power**

**Spectral Power**

**Features:** All time-domain EEG data was transformed into frequency-domain using Fast Fourier Transformation (FFT). Power spectra were then generated by normalizing and squaring the frequency-domain data. Spectral Edge represents the frequency (Hz) at which 90% of power falls below. Spectral power and average power are the max and mean values, respectively, of each brain wave region (theta = 0-4Hz, delta = 4-8Hz, alpha = 8-16Hz, beta = 16-32Hz, gamma = 32-100Hz)

## Methods

**ANN:** We implemented a matrix form artificial neural network

**Prediction:** $\hat{y}^l = \varphi(\hat{o}^l + \hat{b}^l)$ *Layer output*

$\hat{o}^l = \hat{y}^{l-1} W^l$ *Net neural input*

$\hat{b}^l$ *Bias term*

$$\varphi(x) = \frac{1}{1+e^{-x}} \quad \textit{Logistic Sigmoid Function}$$

**Backprop:** $\Delta W^l(t) = -\alpha\delta^l\hat{o}^l + \beta\Delta W^l(t-1) - \gamma\Delta W^l(t-1)$ *Weight update*

$\Delta\hat{b}^l(t) = -\alpha\delta^l + \beta\Delta\hat{b}^l(t-1) - \gamma\Delta\hat{b}^l(t-1)$ *Bias update*

$$\delta^l = f(x) = \begin{cases} D^L e, & \textit{Output Layer} \\ D^l W^{l+1}\delta^{l+1}, & \textit{Hidden Layer} \end{cases} \quad \textit{Blame}$$

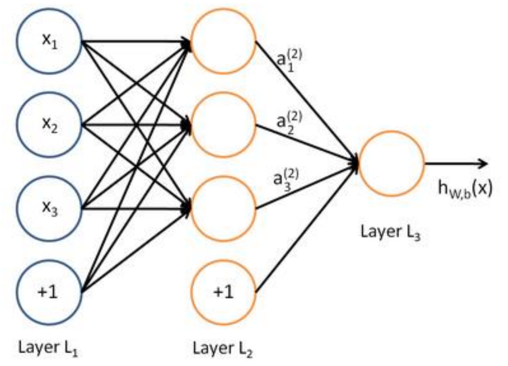
$$D = \begin{bmatrix} \varphi'(\hat{o}_1{}^l) & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \varphi'(\hat{o}_n{}^l) \end{bmatrix} \quad \textit{Diagonal Derivative matrix}$$

$e = (\hat{y} - \hat{t})$ *Error term*

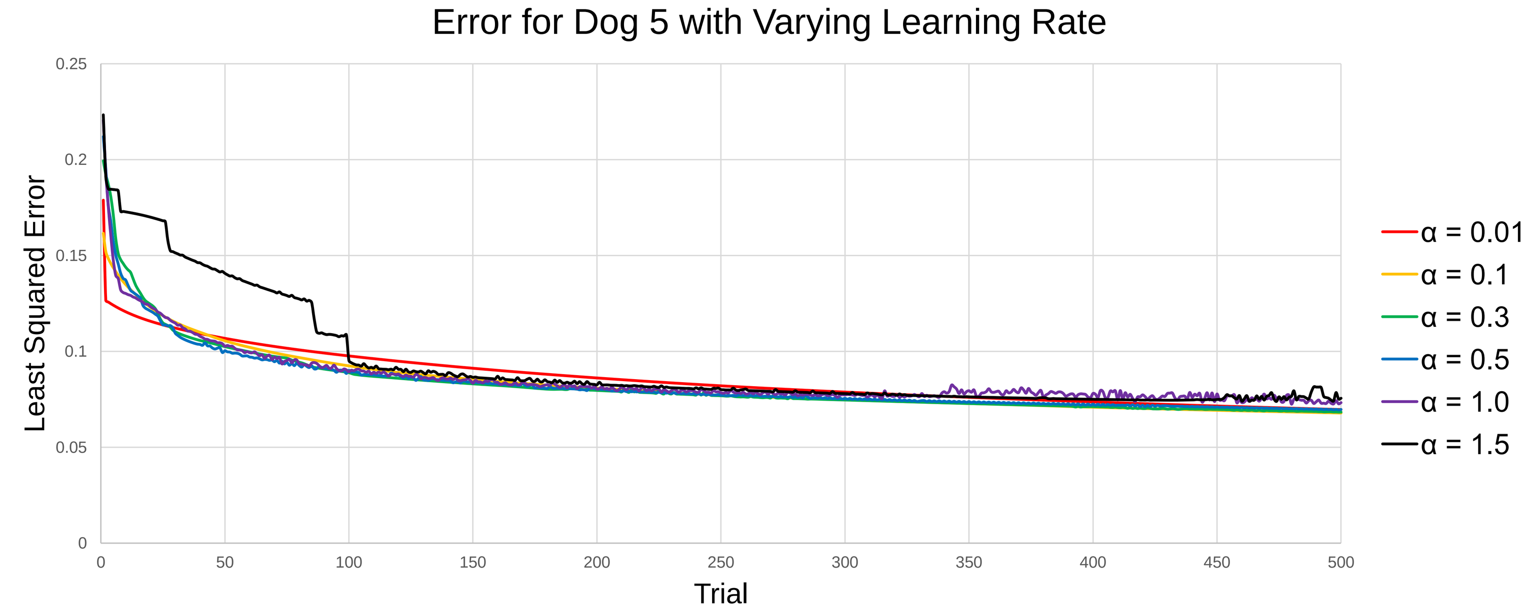
$\alpha = .3$ *Learning rate*

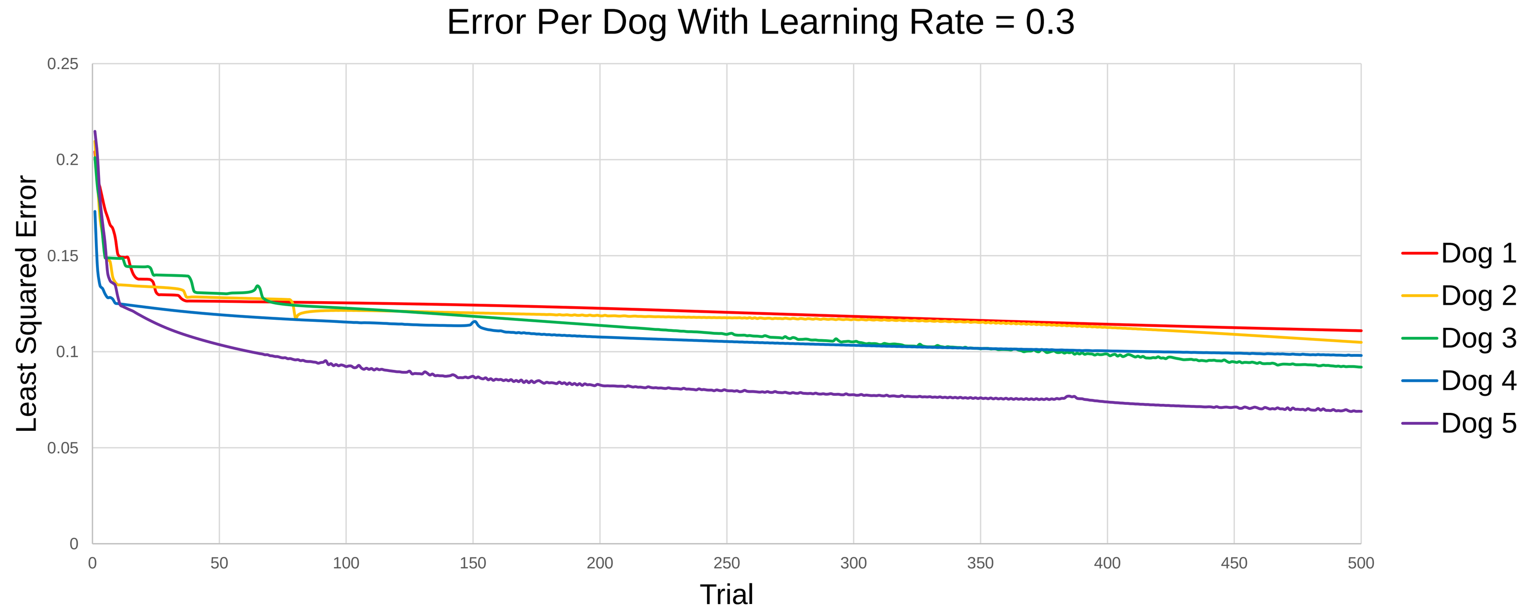
$\beta = .85$ *Momentum*

$\gamma = .05$ *Weight Decay*

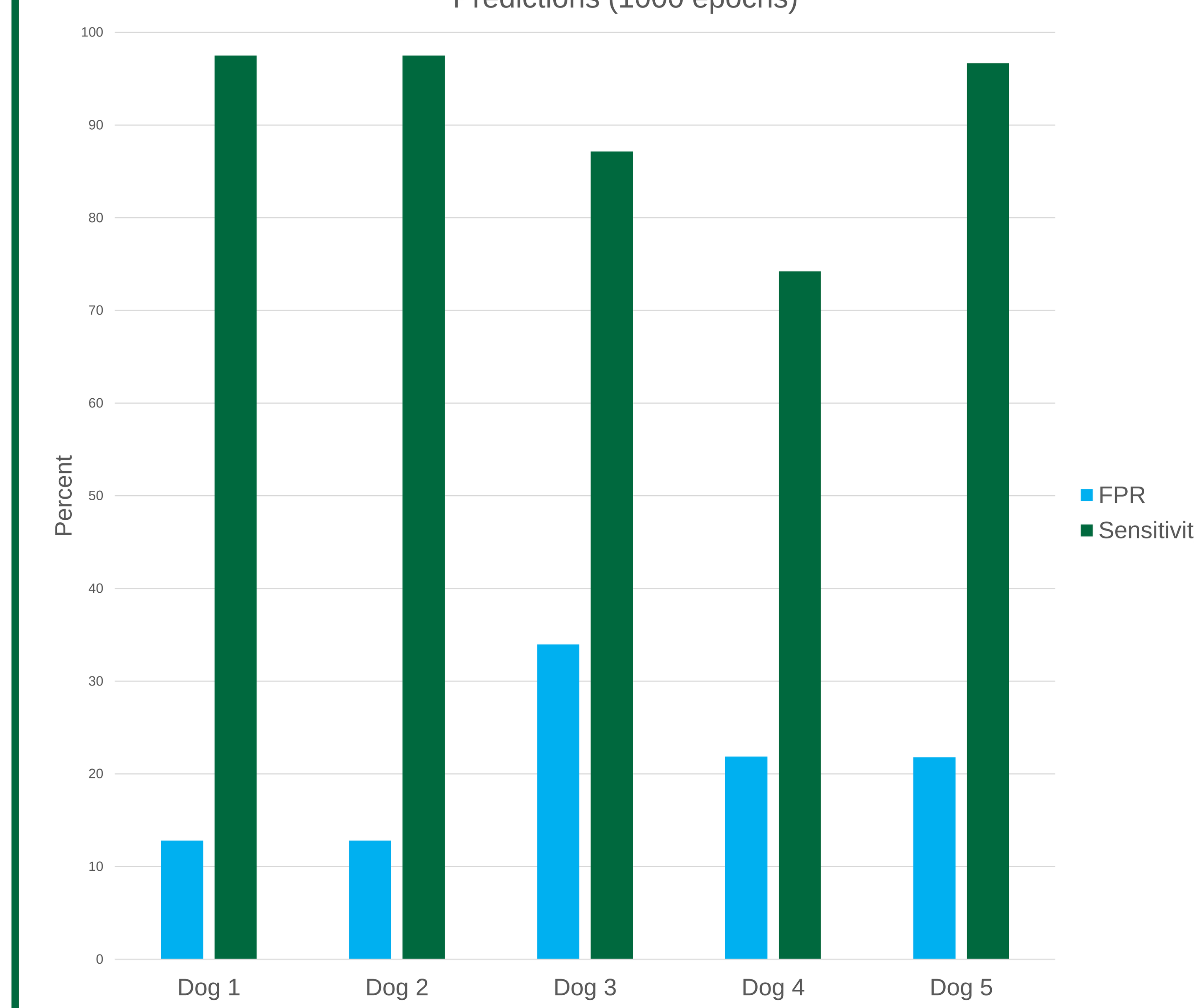



## Results




## Results




## Summary

Using the features generated from raw EEG data, our neural network is capable of learning a system to successfully classify preictal and interictal states.

- Cross validation reveals sensitivity rates above 70% across all dogs, with relatively low false positive rates.
- Conversion from raw data to functional data is quick and requires little computational power while retaining relevant information
- Our neural network is capable of learning each individual quickly over few trials

## References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