New Neural Networks for Plasma Profile Prediction

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We optimize a variational autoencoder (VAE) to remove noise from electron cyclotron emission (ECE) spectrogram data. ECE spectrograms can be used to predict instabilities like Alfvén Eigenmodes (AEs).

To use for training data, we use a denoising pipeline that does the following steps:

Spectrogram Denoising Pipeline:

1. Quantile Filter
2. Gaussian Filter
3. Mean Substitution
4. Morphological Filter
5. Mean Substitution Filter

This greatly reduces the background noise without compromising the features of the AEs. The goal for the VAE is to improve this feature visibility in a faster form that will run faster implemented on FPGAs.

We optimize the validation loss of the VAE while balancing the time to predict a spectrogram since the goal is eventual real time implementation.

Optimized Parameters

1. Number of convolution layers (encoder/decoder layers)
2. Convolutional layer filter size
3. Convolutional layer kernel size

The spectrograms are 256x128 pixels and range from 0-250kHz and are selected from 1,138 shots from DIII-D using the first 20 ECE detector channels.The later channels have lower occurrences of AEs and other spectrogram features.

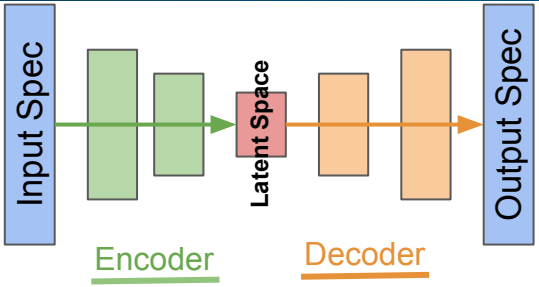
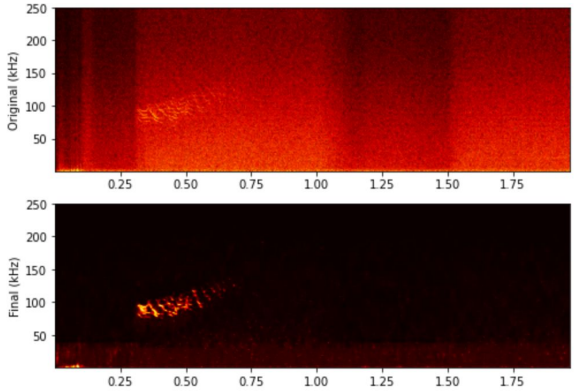


Diagram of optimized variational autoencoder. 3 convolutional layers are used in the encoder and decoder with filter sizes of (16,32,64), respectively. Each convolution in the encoder is followed by a max pooling layer that reduces the data size by a factor of 2.

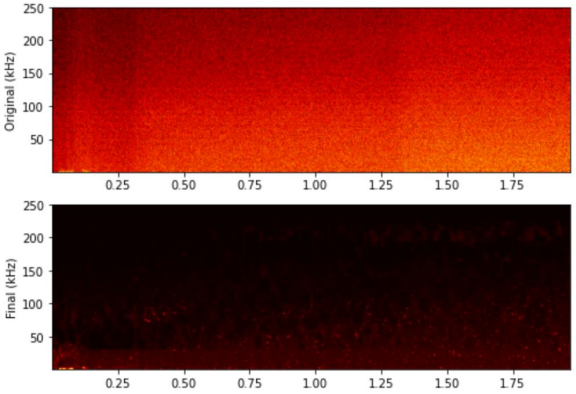
	# of Spectrograms	
Group Type	**Hyperparameter Scan**	**Best Models**
Training Data	36,000	144,000
Validation Data	15,000	60,000
Testing Data	9,000	36,000

Sizes of different data groups. Smaller data sizes were used to scan the parameters to increase speed of the search.

Changing the hyperparameters did not have a significant effect on the prediction time. All changes in the prediction time were under 0.05ms when run on a NVIDIA V100 GPU. So when implemented real time, this should not burden the instability prediction time.



The top spectrogram is the raw ECE data with the bottom being our denoised prediction from the optimized VAE. We see the enhancement of the feature while noise is removed.



Top spectrogram: raw ECE data. Bottom spectrogram: denoised prediction from VAE. We see there are no falsely predicted features from just the noisy data.