July 2018 Interim Report – Brendon Matusch

**Summary**

This project is an effort to optimize discrimination between alpha particles and neutrons, using machine learning, based on various data collected during the PICO-60 experiment. Since I started work on this project in late June, I have developed several deep learning techniques for this task, and compared their effectiveness to the neural network applied in the PICO-60 paper, as well as the Acoustic Parameter (AP) frequency analysis function, which is the main tool used for this task in the PICO-60 project.

**Key Results**

I have tested many different techniques and configurations. On this page, I have highlighted four of the most successful, starting very similar to the neural network analysis in the PICO-60 paper and progressively making use of lower-level data representations to achieve higher performance. The class-wise standard deviation is used as a performance metric; this is defined on page 2.

Based on this metric, **performance was improved 49% relative to the PICO-60 neural network, and 45% relative to AP.** In addition, **performance was improved 40% relative to AP on a data set without any fiducial, pressure, or audio wall cuts.**

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| **Neural network architecture** | **Fiducial/pressure/audio wall cuts applied?** | **Input data format** | **Performance compared to PICO-60 NN** | **Performance compared to AP** |
| 2-layer perceptron with 50% dropout regularization | Yes | Position-corrected 8-band Fourier transform (piezo\_E\_PosCor) | 46% lower class-wise standard deviation | 19% lower class-wise standard deviation |
| 3-layer perceptron with 25% dropout regularization | Yes | Non-corrected 8-band Fourier transform (piezo\_E) with positional input (X, Y, Z) | 46% lower class-wise standard deviation | 26% lower class-wise standard deviation |
| 3-layer perceptron with no regularization | Yes | Non-corrected custom 20-band Fourier transform with positional input (X, Y, Z) | 49% lower class-wise standard deviation | 45% lower class-wise standard deviation |
| 3-layer perceptron with no regularization | No (data set is much larger and has greater acoustic variation) | Full resolution custom Fourier transform (50,001 bands) with positional input (X, Y, Z) | Not applicable (network does not meaningfully function on this data set) | 40% lower class-wise standard deviation |