Analysis of Fourier Transforms Using a Combined Encoder-Decoder and Deep Neural Network Model: A Novel Method for Determining Chromaticity

Kane, Nora (School: Lynbrook Senior High School)

Within a circular particle accelerator, maintaining the stability of the beams in the machine is of utmost importance. To ensure this stability, the chromaticity of the beam, which describes how the beam's motion is affected by its energy, is essential knowledge. Currently, there exist no methods which can determine the chromaticity of high energy beams in a timely manner. To remedy this issue, this project aimed to develop a fast method of determining chromaticity using an encoder-decoder and deep neural network machine learning model. First, beam signals were generated for varied intensities, chromaticities, and tunes. Then, using these signals, Fourier transform plots of these signals were generated and an encoder-decoder model was trained to de-noise these images. Then, the outputs from the trained encoder-decoder, along with each beam's respective tune and intensity, acted as inputs for a deep neural network which predicted the chromaticity of the original beam. After multiple training attempts, the deep neural network had a mean absolute error score of 0.76 units of chromaticity away from the true value of chromaticity, which is within the 1.0 accuracy threshold used for chromaticity predictions. As a result, this research can be applied to real particle accelerator experiments. After completion of model training, a web application was created to make the model accessible to any user, thus allowing international labs to utilize this method and stabilize high energy beams. In the summer of 2024, this method will be used to determine chromaticity during experiments involving the Relativistic Heavy Ion Collider at Brookhaven National Laboratory, and a paper on the method will be published following these tests to allow for more labs to learn about the method.

Awards Won: