Using Machine Learning Classification to Characterize Waves and Signals

Various physical phenomena all around the universe of comprised of signals, often in the form of periodic waves. Using physical characteristics of waves, we have learned to characteristic them by measurements such as frequency, velocity, polarization, amplitude, etc. But some properties of waves and signals are slightly harder to build a concrete mathematical explanation for. In the field of machine learning, and neural networks, classification algorithms have the potential to find patterns in waveforms that humans might not even know to look for.

For signals such as gravitational waves, electromagnetic waves and acoustic waves, machine learning classification has the ability to exceed beyond what has been discovered by humans. By giving sets of labeled training data into a classifier algorithm, various waveforms and signals can be classified based on properties that are not immediately obvious to humans. Using this concept, as a practical demonstration of the signal classification concept, we can classify acoustic signals, and match them to known musical instruments.

In this project, I will construct a set of Python programs that will classify arbitrary waveforms based on their time and frequency spectra and map them to real-world instruments. This will be done by assembling a library of audio waveform files as training data and a selection of labeled chaotically generated waveforms as testing data. Once the accuracy of the classifier has been validated, the program will be able to map any arbitrary waveform to a musical instrument. A completed project will contain the following:

* 1. A set of ‘unknown’ waveforms classified as real world instruments
  2. A program that can map any arbitrary waveform to a real-world instrument
  3. A comprehensive connection as to why machine learning is the valid approach to solving this problem
  4. A comparison between machine learning and standard algorithmic classification methods as well as a comparison to human results.

This study will provide an in-depth analysis into the world of modern signal processing through use of machine learning and neural network algorithms. This project opens the door to a wide range of uses in the professional music and signal processing industry. Small slices of audio information can be classified and mapped to known segments of audio. In the future, related and modified algorithms could be used for electric circuit signal processing, human voice recognition, professional audio editing, and so forth.

In that time, I have amalgamated several physical and digital resources under the topics of machine learning, artificial intelligence, and neural networks. Additionally, I have begun the construction of a digital library of audio wave forms to serve as a training dataset. I similarly have a collection of generated waveforms provided by Dr. Short to serve as a testing data set.

Work will be constructed around an 8 to 12 hour work week schedule. By the end of Spring 2020 I will have constructed the first draft of the program that can read though several categories of musical instruments and classify an arbitrary waveform into one or more of those categories. The results of this project will be summarized and likely be presented at the Spring 2020 URC and/or for a peer review colloquium.