Aron Connors ML Project Proposal

Transforming the Tone of Single Coil and Humbucker Electric Guitar Pickups

Introduction and Summary

Electric guitars, first introduced in the mid 1930s, innovated on a centuries old instrument by enabling amplification with the addition of magnetic pickups. Electric guitar pickups are constructed by coiling a thin strand of copper wire around a magnet, creating a magnetic field. Steel guitar strings sit within the magnetic field of the pickup, and their vibrations when played generate an electric signal in the coil which can then be amplified.

Over time, two main form factors have prevailed: the taller, narrower Single Coil pickup and the shorter, wider Humbucker pickup. The dimensions of these pickups create different levels of inductance in the coil, which changes the resonant peak and overall tonality of the instrument. The lower inductance Single Coil pickups have a high resonant peak resulting in a “brighter” tone, while the higher inductance Humbucker pickups have a lower resonant peak resulting in a “darker” tone.

The untrained ear won’t hear much of a difference, but experienced guitar players can immediately detect the tonal nuances of the two pickup classes (and will spend vast sums of money to build a collection of guitars that capture very slight differences in tone).

Anticipated Objective

My goals for this project are to use Google’s *Differentiable Digital Signal Processing* (DDSP) tools to model the sounds of both Single Coil and Humbucker pickups. DDSP reformulates *Digital Signal Processing* (DSP), a set of traditional physics equations used to model sound waves, into a set of differentiable components suitable for training neural networks.

The intended result of the project is to transform the direct input signal from a Single Coil pickup into a synthesized Humbucker tone (a.k.a. a tone transfer) using these methods. I also aim to build a classifier for the audio from the two classes of pickups and will attempt to fool the classifier with audio I’ve transformed.

Tasks and Schedule

I will start constructing a dataset immediately. There is potential to build a comprehensive and clean dataset from public resources, but if access to a suitable dataset limited, I can create my own dataset with my own playing. The dataset requires a large variety of sounds from the instrument played the same on both pickups. I will aim for variation in playing style (strumming/picking/fingerpicking), guitar settings (volume/tone/pickup selection), voicing (monophonic/polyphonic), and certainly tonality (pitch, key, mode).

Training and testing a neural network classifier with this dataset will be my next goal. Once satisfactory classification results have been obtained, I will move on to the more ambitious tone transfer task. The testing process for this task will consist of a simple listening test, a survey from other experienced guitarists, and a test to see if the classifier is fooled by the transformed audio. Unforeseen challenges may arise, I think this timeline is easily adaptable if these results become unattainable in one month.

References

- First and foremost, the DDSP blog, paper and GitHub repository containing tutorials and demos.
- This video was phenomenal in explaining the mechanics of magnetic pickups, how the unique sounds we are modeling are created, and a brief background on the physics behind the data I am modeling.
- Of course, Sundeep Rangan's Neural Networks GitHub repository containing demos, the lab from that unit, and lecture videos.