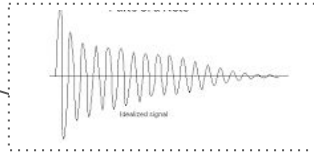# Modeling Electric Guitar Pickup Audio

Aron Connors

How do electric guitars work?

Electric pickups ~pick up~ string vibrations as electric signal

Signal is amplified

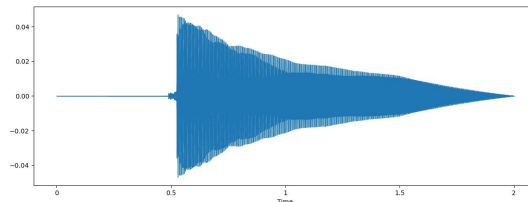# What are electric guitar pickups?

Machine learning?

We can analyze the audio produced by each pickup using machine learning!
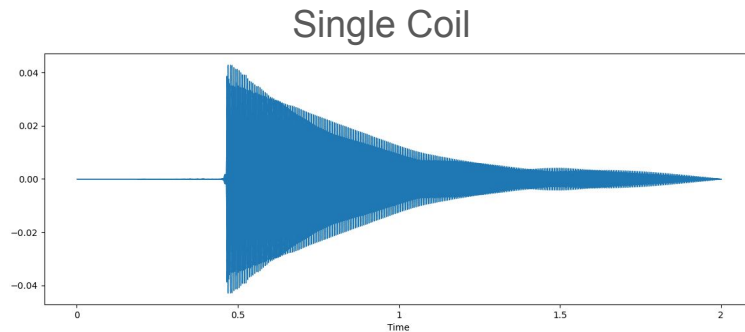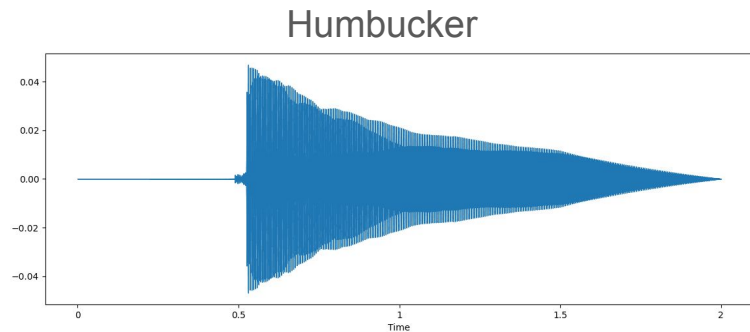
A few audio processing terms:

- Wave form (sound wave): A series of amplitude values over time

- Sample rate: The rate at which we draw samples from the sound wave

- data, sample_rate = librosa.load(sound_wave.wav)
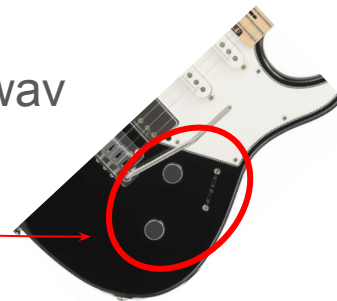
Classifying pickup tones

The note G:

Humbucker	Single Coil

The Dataset:

313 humbucker / 313 single coil - - - Monophonic Notes, 2 seconds, .wav
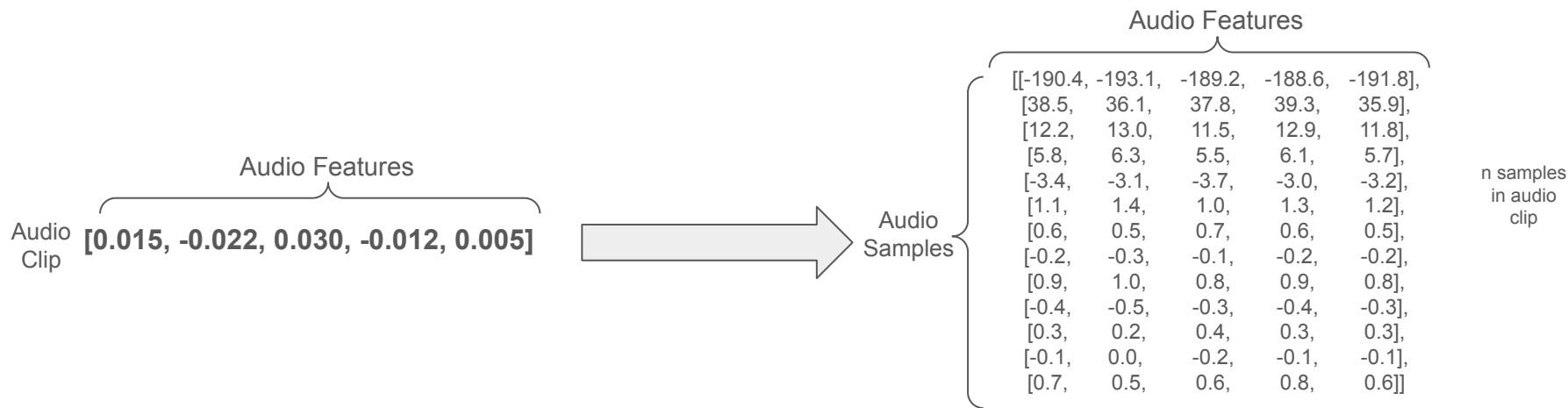
Various pickup, volume and tone settings
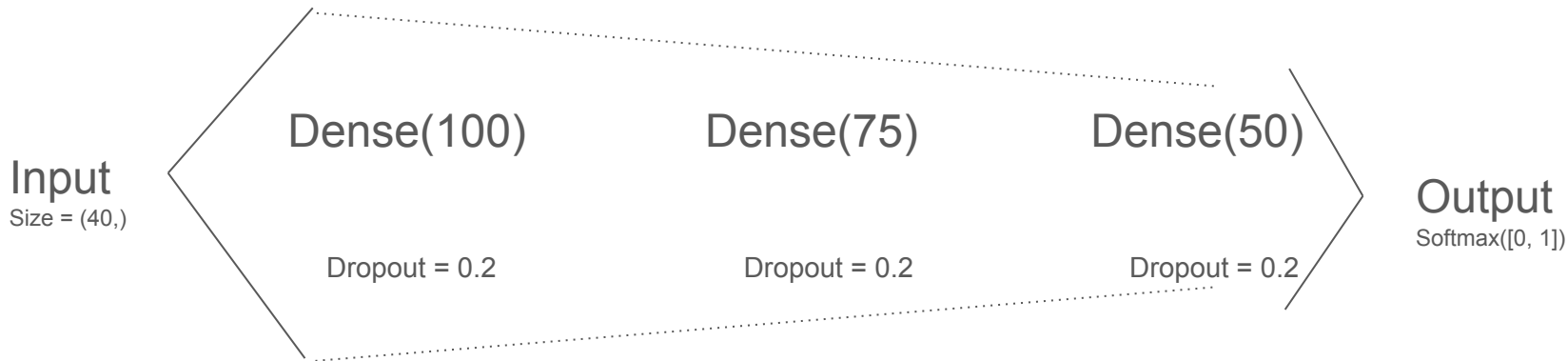
Neural network pickup classifier

Preprocessing:

Convert audio to Mel-Frequency Cepstral Coefficients

Audio Features

Audio Clip

Audio Features
[0.015, -0.022, 0.030, -0.012, 0.005]

Audio Samples

Audio Features

```
[[-190.4, -193.1,  -189.2,  -188.6,  -191.8],
 [38.5,    36.1,    37.8,    39.3,    35.9],
 [12.2,    13.0,    11.5,    12.9,    11.8],
 [5.8,     6.3,     5.5,     6.1,     5.7],
 [-3.4,    -3.1,    -3.7,    -3.0,    -3.2],
 [1.1,     1.4,     1.0,     1.3,     1.2],
 [0.6,     0.5,     0.7,     0.6,     0.5],
 [-0.2,    -0.3,    -0.1,    -0.2,    -0.2],
 [0.9,     1.0,     0.8,     0.9,     0.8],
 [-0.4,    -0.5,    -0.3,    -0.4,    -0.3],
 [0.3,     0.2,     0.4,     0.3,     0.3],
 [-0.1,    0.0,     -0.2,    -0.1,    -0.1],
 [0.7,     0.5,     0.6,     0.8,     0.6]]
```

n samples in audio clip

Neural network pickup classifier

Network: 30 Epochs

Input
Size = (40,)

Dense(100)

Dropout = 0.2

Dense(75)

Dropout = 0.2

Dense(50)

Dropout = 0.2

Output
Softmax([0, 1])

Underwhelming results :(


```
Test Loss: 0.3785
Test Accuracy: 0.8240
4/4 ───────────────────── 0s 7ms/step

Classification Report:
              precision    recall  f1-score   support

           0       0.84      0.81      0.83        64
           1       0.81      0.84      0.82        61

    accuracy                           0.82       125
   macro avg       0.82      0.82      0.82       125
weighted avg       0.82      0.82      0.82       125
```
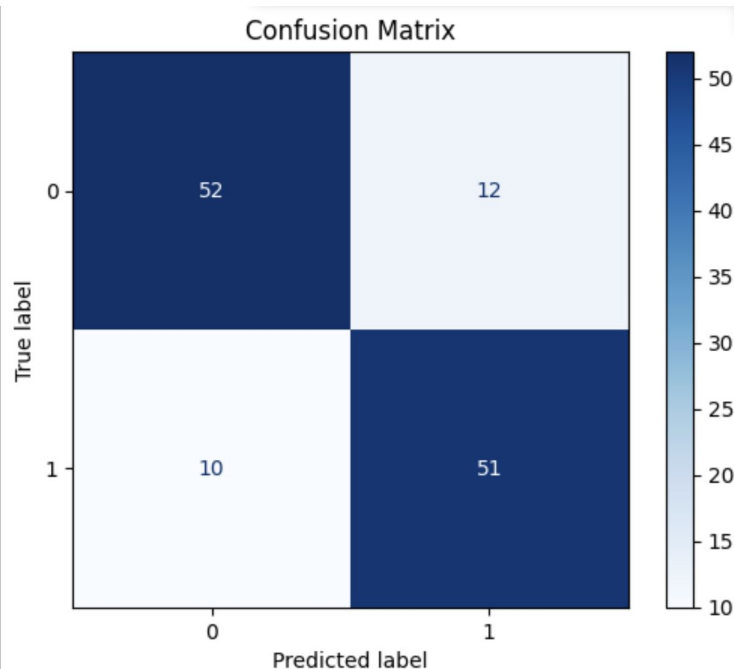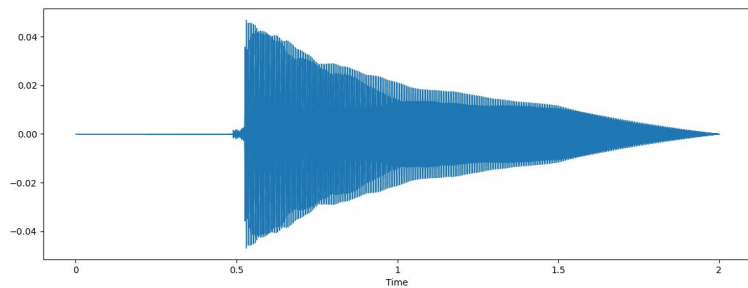
Confusion Matrix
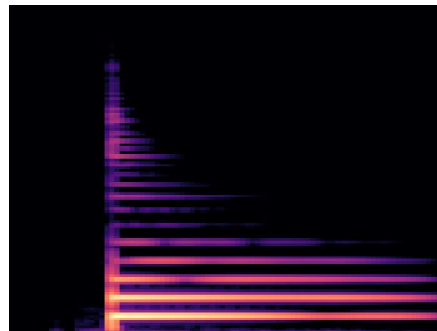
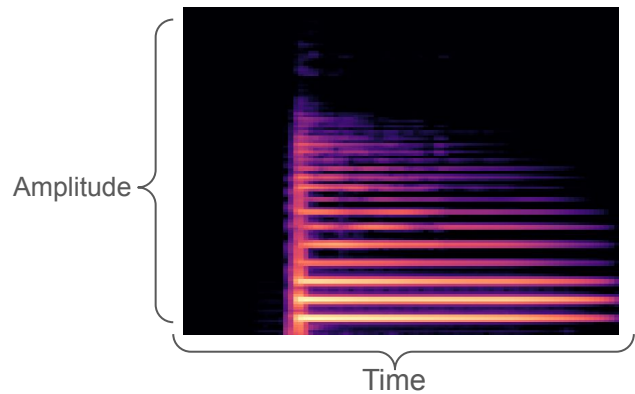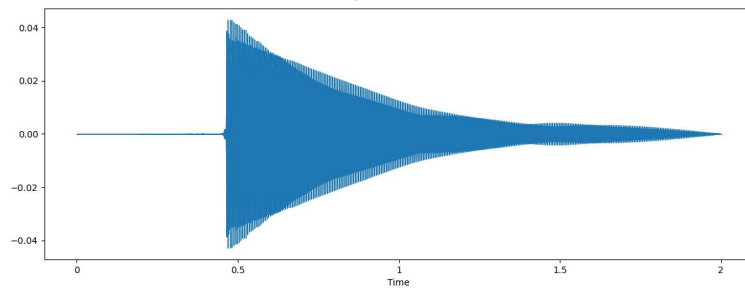Why? Likely because the subtle differences in tone is not captured with MFCC features…

Mel Spectrogram

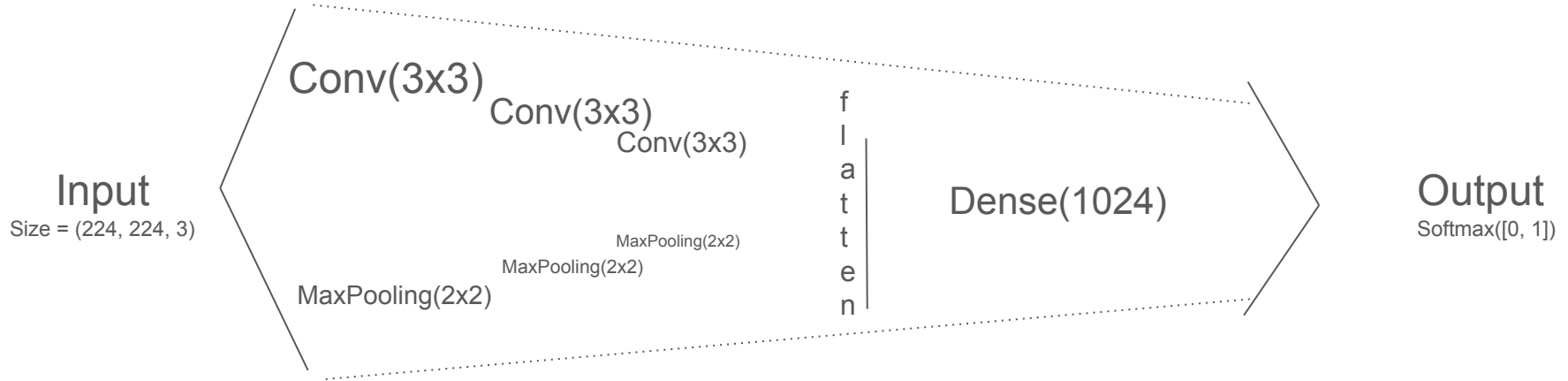Mel spectrograms are a visual representation of the audio.

# Convolutional neural network pickup classifier

Network: 30 Epochs

Input
Size = (224, 224, 3)

Conv(3x3)

Conv(3x3)

Conv(3x3)

MaxPooling(2x2)

MaxPooling(2x2)

MaxPooling(2x2)

flatten

Dense(1024)

Output
Softmax([0, 1])

That's what we like to see :)

```
Test Loss: 0.0590
Test Accuracy: 0.9787
6/6 ──────────────── 3s 403ms/step

Classification Report:
              precision    recall  f1-score   support

           0       0.99      0.97      0.98        94
           1       0.97      0.99      0.98        94

    accuracy                           0.98       188
   macro avg       0.98      0.98      0.98       188
weighted avg       0.98      0.98      0.98       188
```


Confusion Matrix
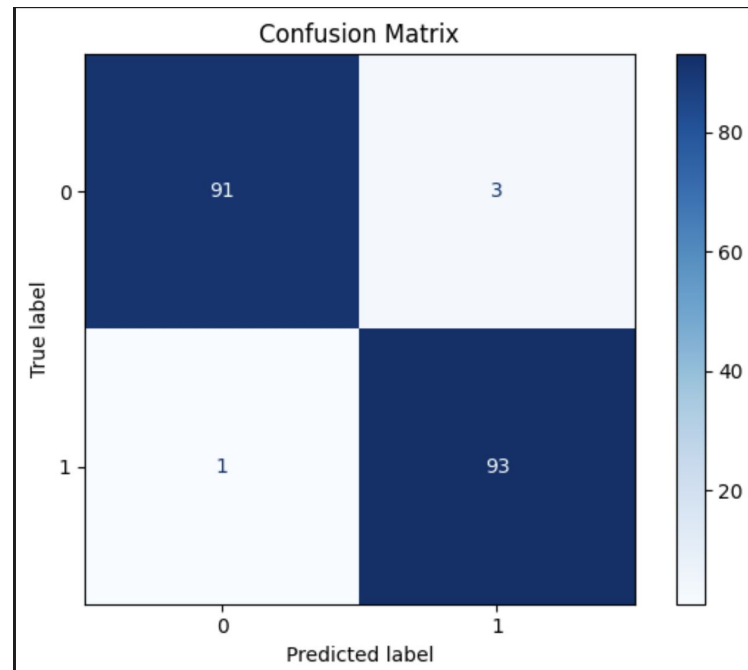
Mel spectrograms better account for subtle details heard by humans