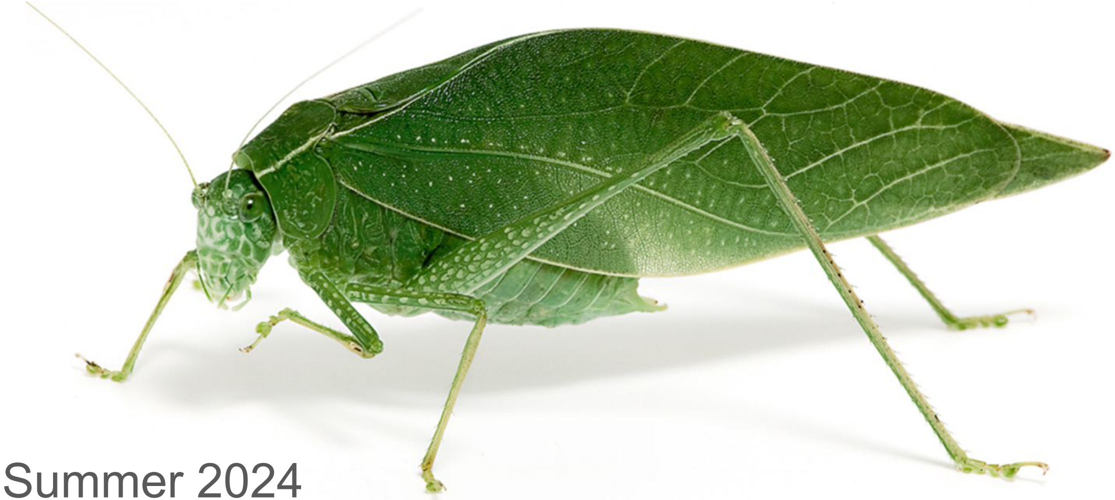
Chirp Checker

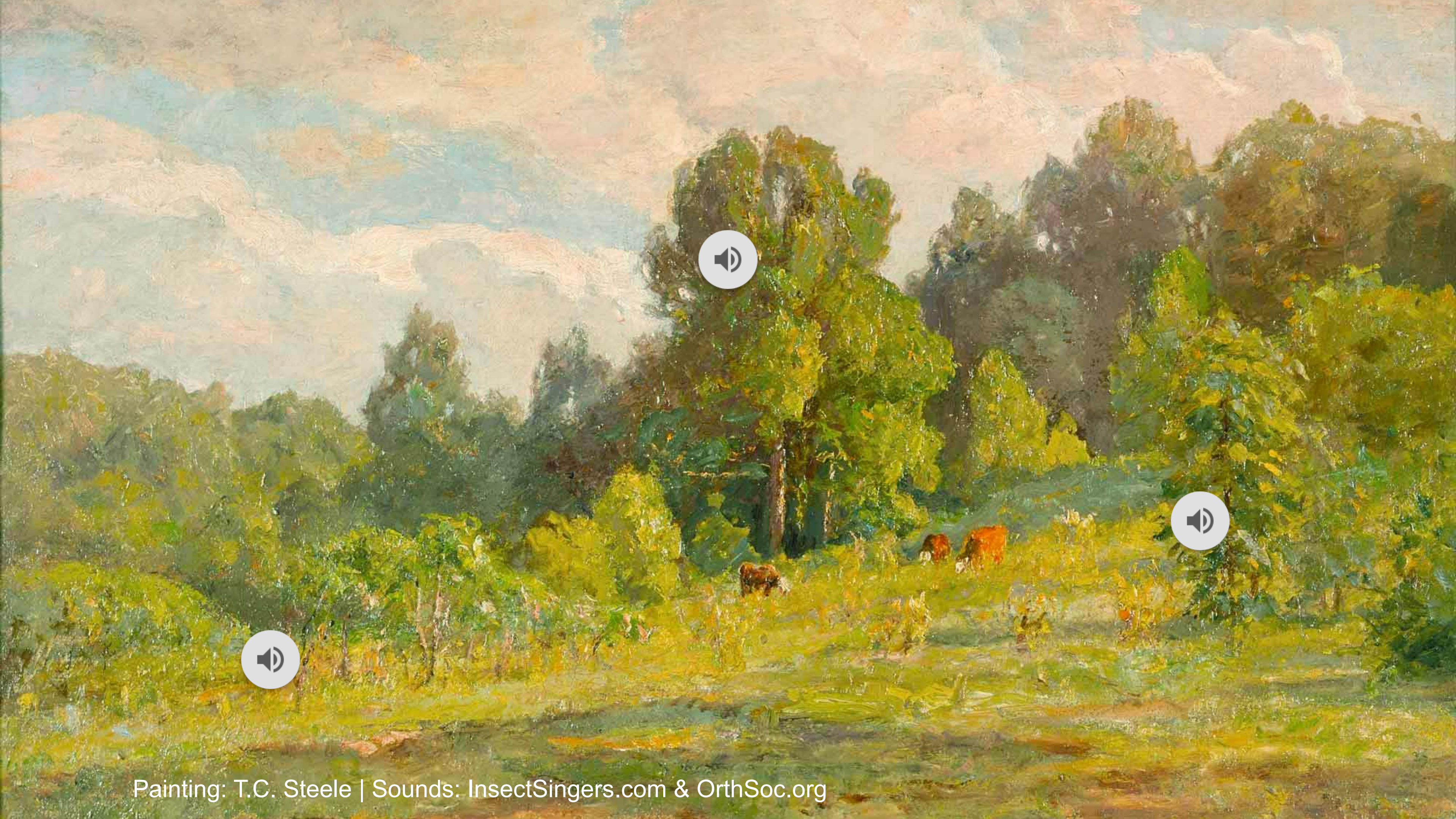
Robert Cass, Caleb Fong, Butovens Médé, Andrew Merwin,
Calvin Yost-Wolff, Yang Yang



THE ERDŐS INSTITUTE

Data Science Bootcamp | Summer 2024

Photo: songsofinsects.com


Painting: T.C. Steele | Sounds: InsectSingers.com & OrthSoc.org

CRITTER NAMES

Crickets

Katydids

Cicadas

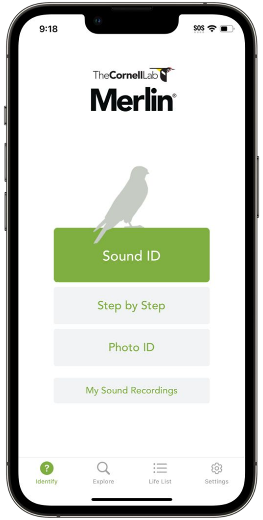
InsectSingers.com

CRITTER NAMES	FAMILY / SUBFAMILY
Crickets	Eneopterinae, Gryllinae, Gryllotalpidae, Hapithinae, Mogoplistinae, Nemobiinae, Oecanthinae, Trigonidiinae
Katydids	Conocephalinae, Listroscelidinae, Phaneropterinae, Phalangopsidae, Pseudophyllinae, Tettigoniinae
Cicadas	Cicadidae

InsectSingers.com

Models for classifying insect sounds could be useful for

Apps



Passive Acoustic Monitoring

Samuel R.P-J. Ross

Objective:

build models that can
coarsely classify insect sounds

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(a) three broad categories

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build models that can coarsely classify insect sounds

(a) three broad categories

(b) families and subfamilies

13,462 files

From the Macaulay Library of Natural Sounds

The Cornell Lab of Ornithology

Macaulay Library

5,899 files

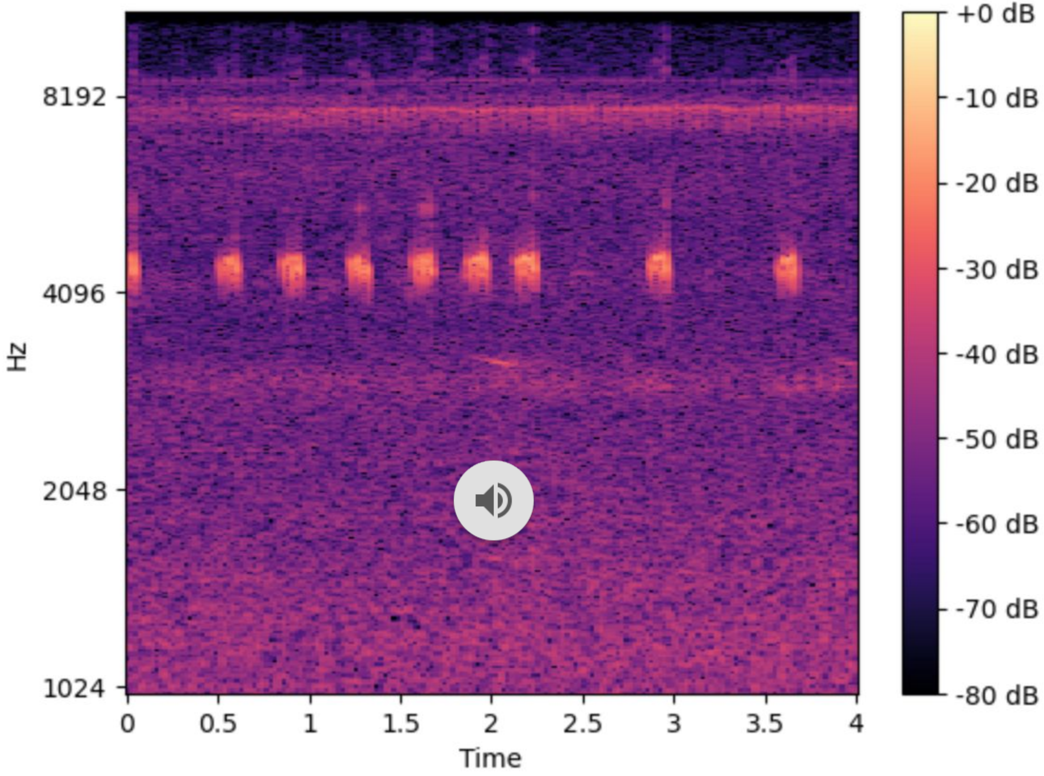
after filtering out human speech

3,949
Crickets

1,895
Katydids

55
Cicadas

Data Visualization: Spectrogram

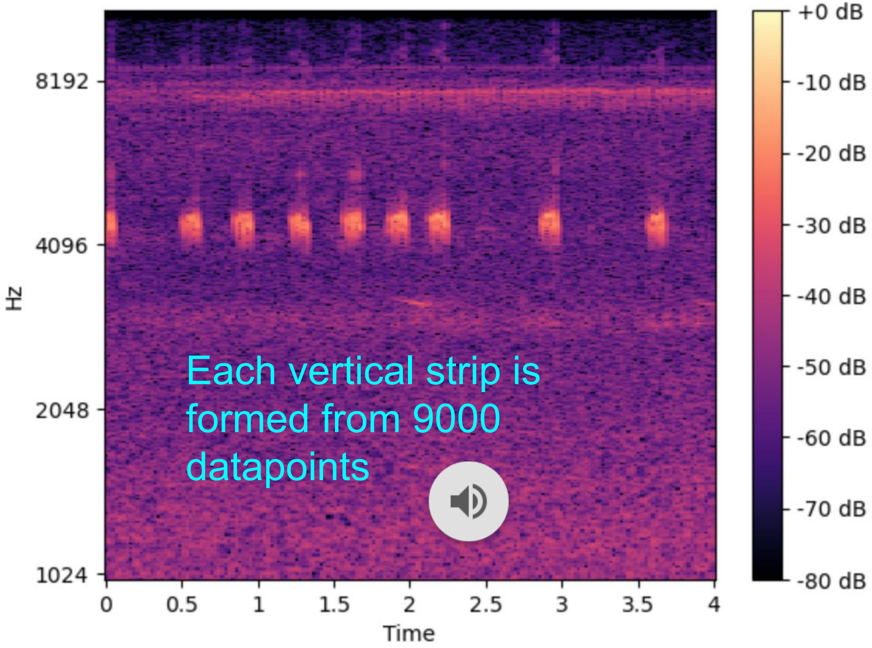


By using the fast fourier transform built in to librosa applied to small time intervals, we get a form a heat map describing which frequencies we are hearing.

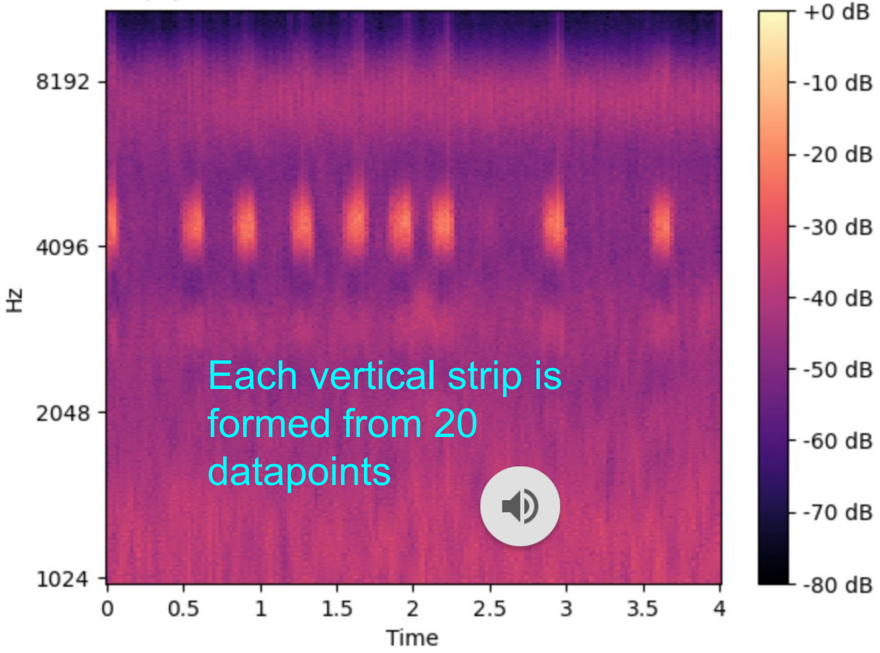
Data Compression: MFCCs

To compress our frequency data, we use Mel-Frequency cepstral coefficients (MFCCs), which represents smoothing each vertical strip in our spectrogram.

Original Spectrogram



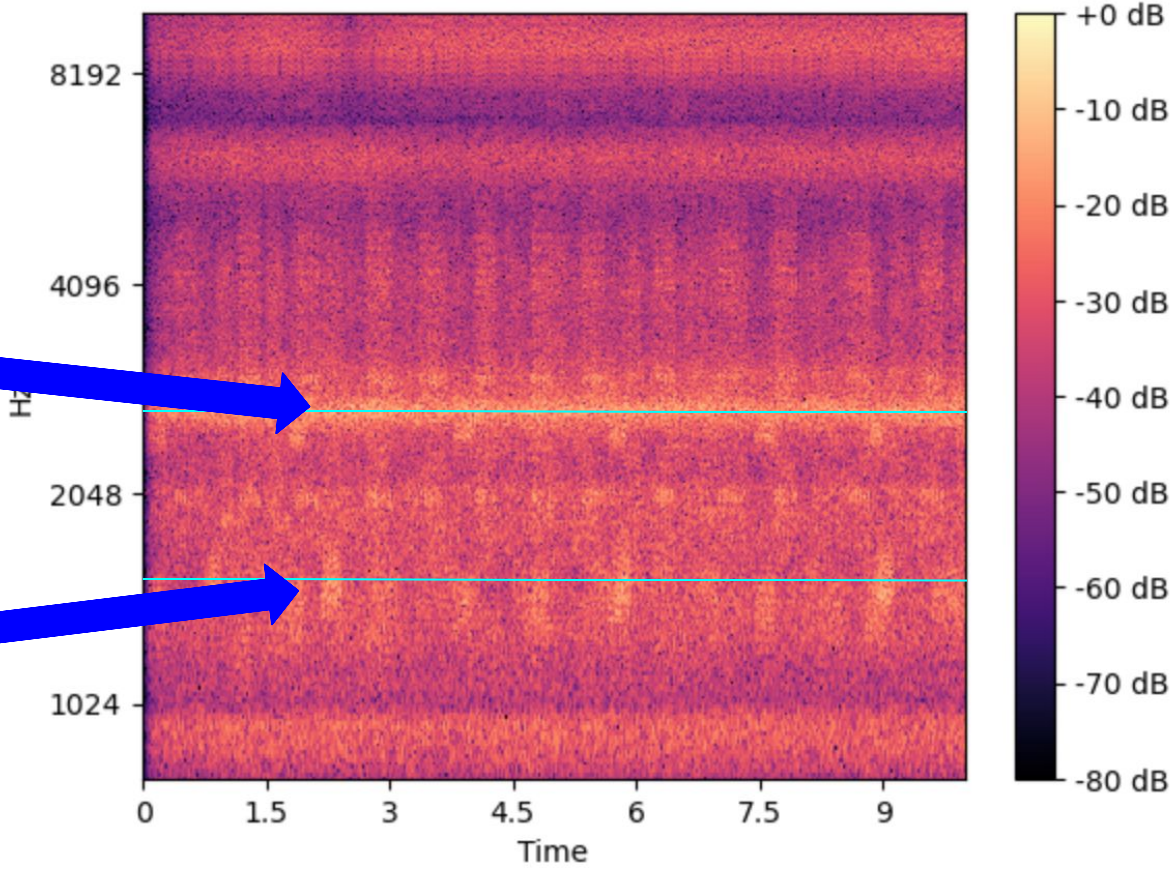
Approximation with 20 MFCCs



What is the main frequency the insect is chirping at?

Loudest Frequency

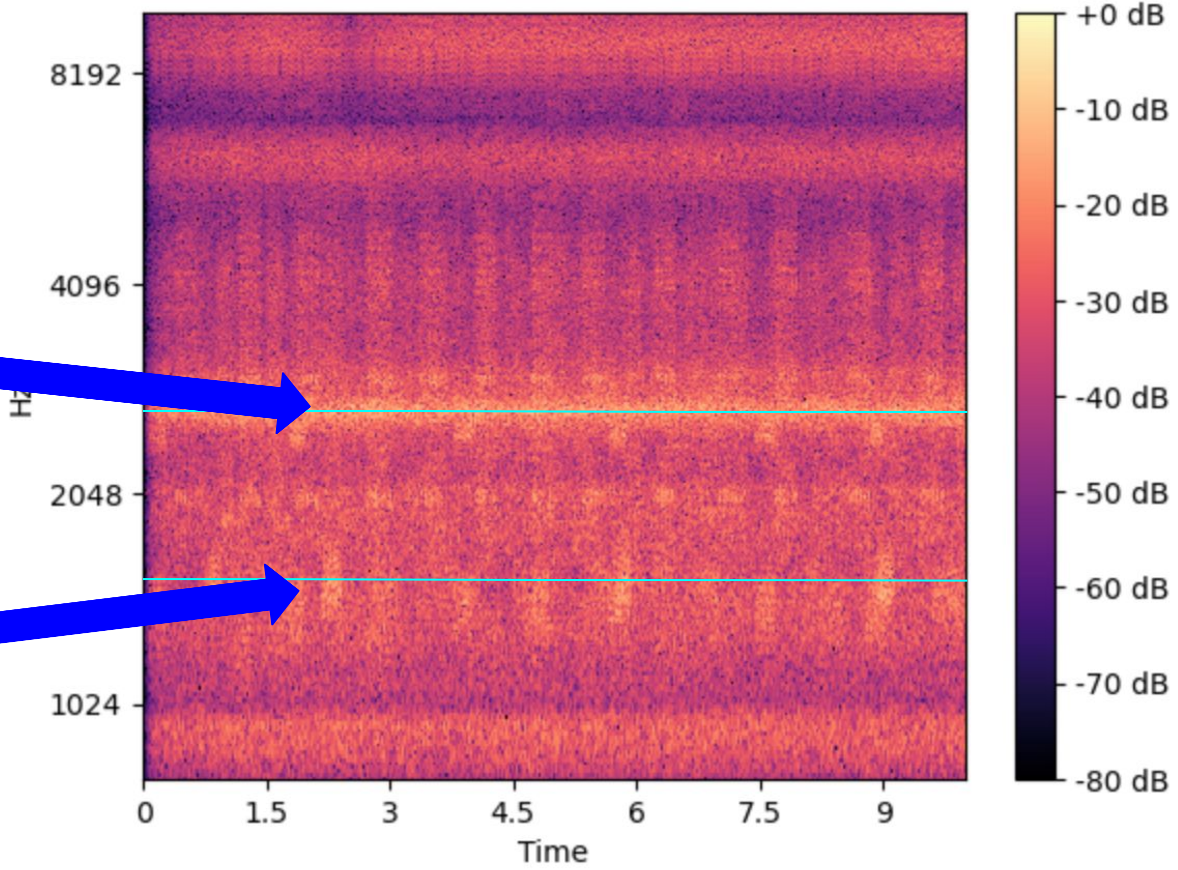
Frequency with the most variance



Two methods to try and extract the predominant frequency: The loudest frequency or the one with the most variance.

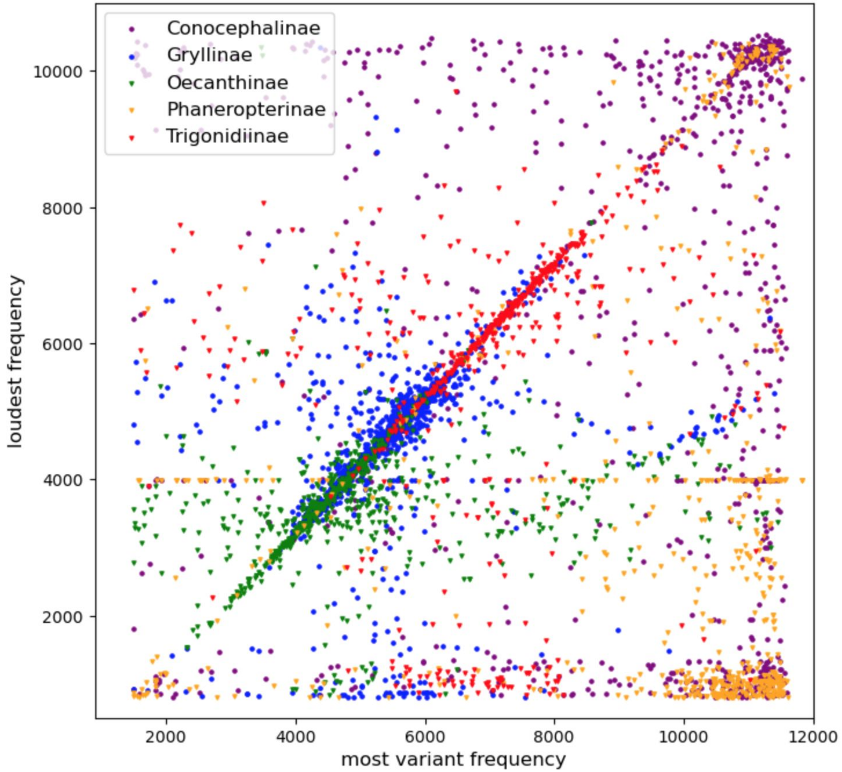
Loudest Frequency

Frequency with the most variance



These two data points are good predictors!

5 most common fam/subfams



An rbf Support Vector Classifier (SVC) with just these two data points gets the fam/subfam correct with 50% accuracy.

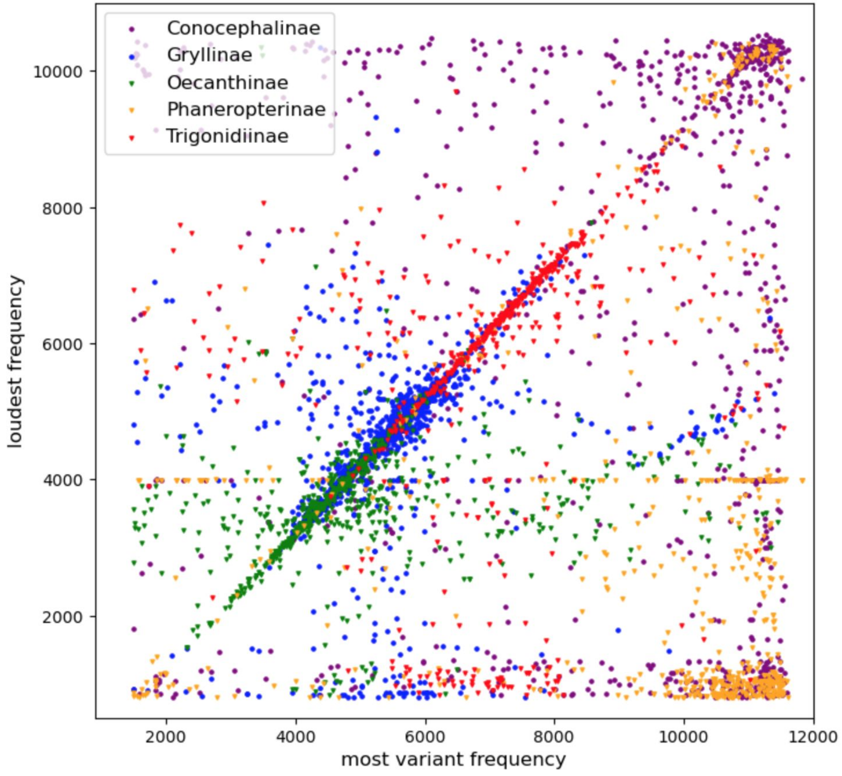
[Baseline guess the most common fam/subfam does 24%].

When mapping our fam/subfam back to its appropriate critter name we get 86.5%!

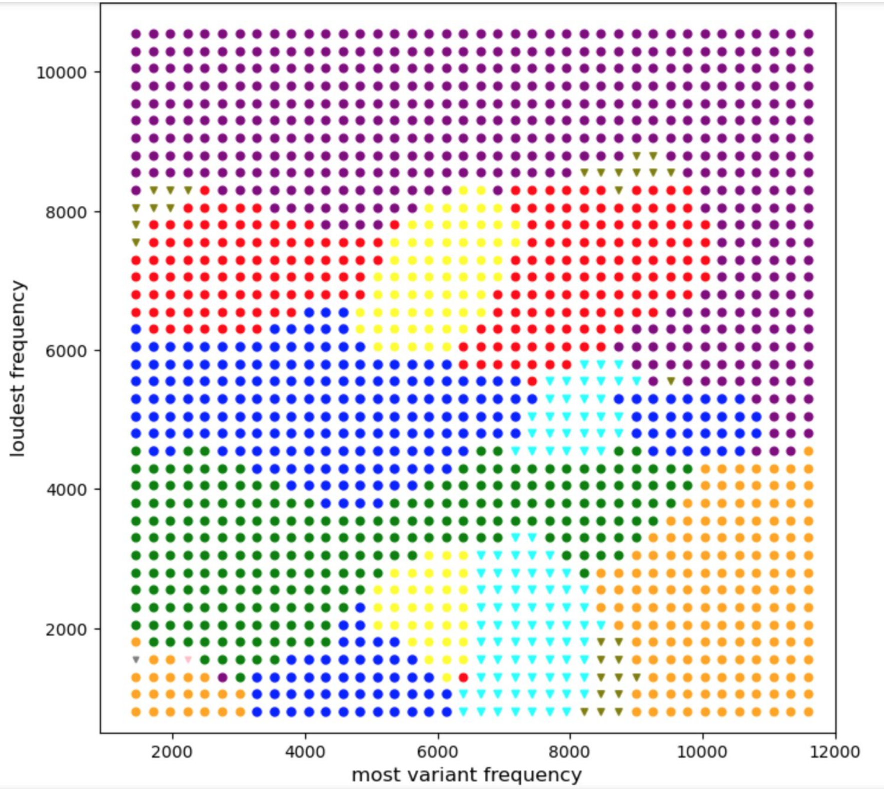
[Baseline guess the most common critter does 57%]

These two data points are good predictors!

5 most common fam/subfams



Decision boundaries for SVC model



Whole recording features

- -loudest and most variant frequency
- -each (of 40) MFCCs mean and variance
- -each (of 40) MFCCs mean and variance during the loudest half-second
- -range of variant frequencies
- -number of chirps per minute

k-Nearest Neighbors, SVC, linear regression

Time dependent features

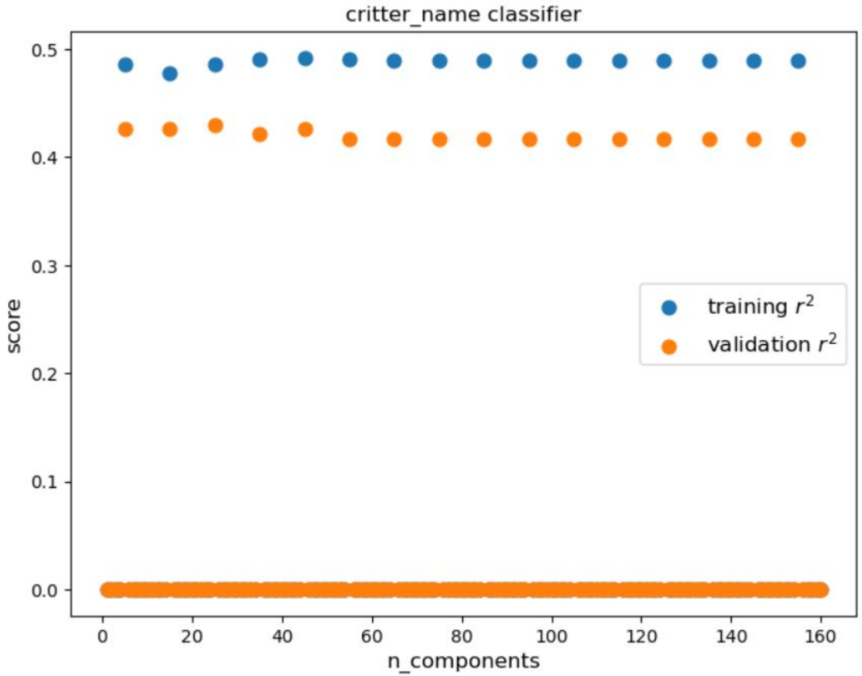
- -spectrogram (a 257x862 matrix)
- -MFCC/LFCC compression of spectrogram (a 40x216 matrix)
- -MFCC compression from loudest half second (a 40x22 matrix)

Convolutional Neural Net

Linear regression does not work

- Horizontal: number of features to be used in linear regression (obtained by PCA)
- Vertical: r^2 value of the linear regression classifier

- The r^2 value never exceeds 0.5 (close to 1.0 is desirable)



k-Nearest Neighbors

Classifying 15 families/subfamilies:

- 62% accuracy vs. 24% baseline
    - k=5

Classifying critter name:

- 87% accuracy vs. 67% baseline
    - k=5, trained on family/subfamily
- 89% accuracy vs. 67% baseline
    - k=4, trained on critter name

Using all whole recording features gave the greatest accuracy

	Predicted cicada	Predicted cricket	Predicted katydid
Actual cicada	1	4	6
Actual cricket	5	684	100
Actual katydid	2	37	341

	Predicted cicada	Predicted cricket	Predicted katydid
Actual cicada	0	6	5
Actual cricket	0	737	52
Actual katydid	0	74	306

RBF Support Vector Classifier

Classifying 15 families/subfamilies:

- 67% accuracy vs. 24% baseline
  - C=1.5

Classifying critter name:

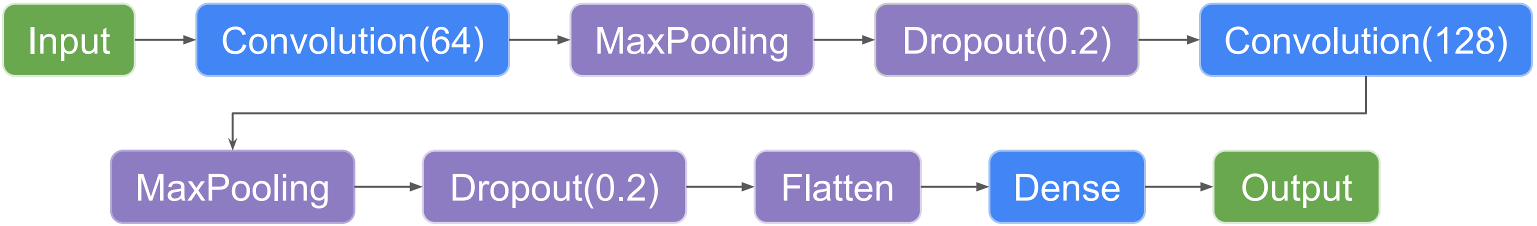
- 91% accuracy vs. 67% baseline
  - C=1.5, trained on family/subfamily
- 91% accuracy vs. 67% baseline
  - C=1.4, trained on critter name

Using all whole recording features gave the greatest accuracy

	Predicted cicada	Predicted cricket	Predicted katydid
Actual cicada	0	9	2
Actual cricket	0	742	47
Actual katydid	0	48	332

	Predicted cicada	Predicted cricket	Predicted katydid
Actual cicada	0	9	2
Actual cricket	0	760	29
Actual katydid	0	61	319

Convolutional Neural Network

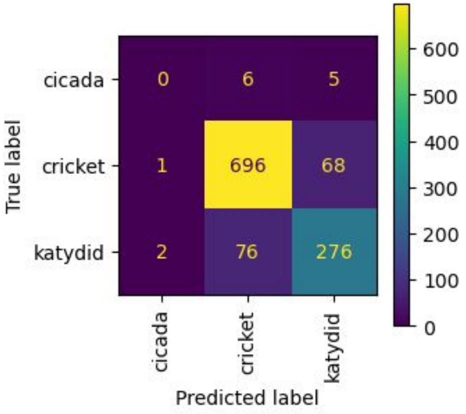


- Feature performance:

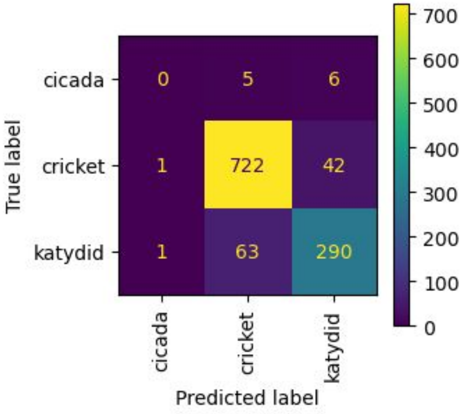
MFCC(5s) ≈ MFCC(0.5s) > MFCC mean/var ≈ Spectrogram > LFCC

- Classifying family/subfamily accuracy: 57%* (86% after converting to critter name)
- Classifying critter name accuracy: 90%*

Classify into fam/subfam then critter



Classify into critter name



*Accuracy of guessing the largest family/subfamily: 25%; guessing the largest critter name: 68%**

**Dataset used for CNN is a subset of the dataset used in other models

Key Takeaways

Model Performance:

KNN, RBF Support Vector Classifier, and CNN significantly improves classification accuracy compared to baseline.

KNN and RBF Support Vector Classifier perform relatively well compared to linear regression.

Future work

Expand Dataset:

Collect additional cicada samples

Increase the number of samples across all insect groups

Quality Comparison:

Compare model performance with clean, high-quality samples

Assess the impact of background noise on classification accuracy

Future work

Noise Reduction:

Develop and integrate noise reduction techniques

Analyze the effectiveness of various noise filtering methods

Real-Time Classification:

Implement real-time sound classification capabilities

Test model performance in live, field conditions

Future work

Broaden Insect Categories:

Include additional insect groups beyond crickets, katydids, and cicadas

Examine and classify different families within these insect groups for more detailed analysis

User Interface:

Develop a user-friendly interface for model deployment

Create visualization tools for classification results