Computational Method for Modeling Geographic Variation of Animal Vocalizations

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Abstract

For the better part of the past 60 years, researchers have been interested in studying how animal vocalizations vary across the geographic range of a species. To that end , there have been several methods for studying geographic variation of animal vocalizations, some of which have become very common. For most of that time, these methods relied heavily on the use of a spectrogram to decompose the vocalizations into their fundamental frequencies for study. Various methods and statistical techniques were developed in order to better utilize these spectrograms to understand the workings of animal sounds. These methods have since become widely used in the study of animal vocalizations. In this paper, we present a new method for quantitatively analyzing and modeling the geographic variation of animal vocalizations using the mating calls of the Cope's Gray Tree Frog (*Hyla versicolor*). The Cope's Gray Tree Frog was chosen because it is very well studied due to its status as a model organism for studies on polyploidic speciation and mate discrimination and therefore there is a wealth of recordings of its mating call. This study focuses on how the Cope's Gray Tree Frog's mating calls vary over the majority of their geographic range. Samples were selected from all over the southeast from Missouri to Virginia and from Texas to Florida and several states in between.

Introduction

Recently, signal processing has become a very large part of field biology with the advent of techniques such as Spectrographic Cross-Correlation (SPCC) and Principal Coordinates Analysis (PCO) often abbreviated together as SPCC-PCO by Cortopassi and Bradbury (2000). This project attempts a simpler version of this method. Here we cross-correlate the original WAV files, generate a distance matrix from the cross-correlations and then relate that distance matrix to another distance matrix consisting of geographic distance measures.

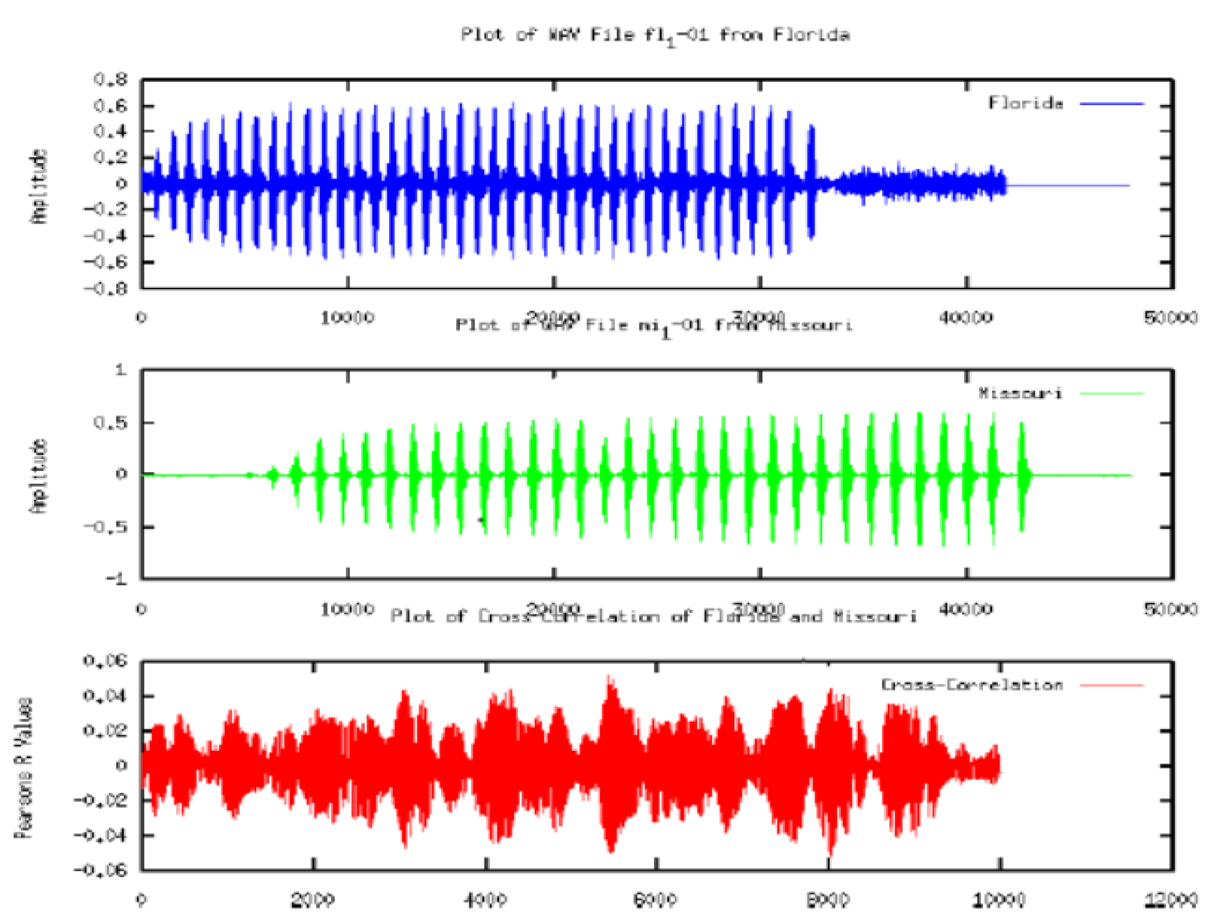


Figure 1 shows three plots of the original,uncorrelated files and their cross-correlation.

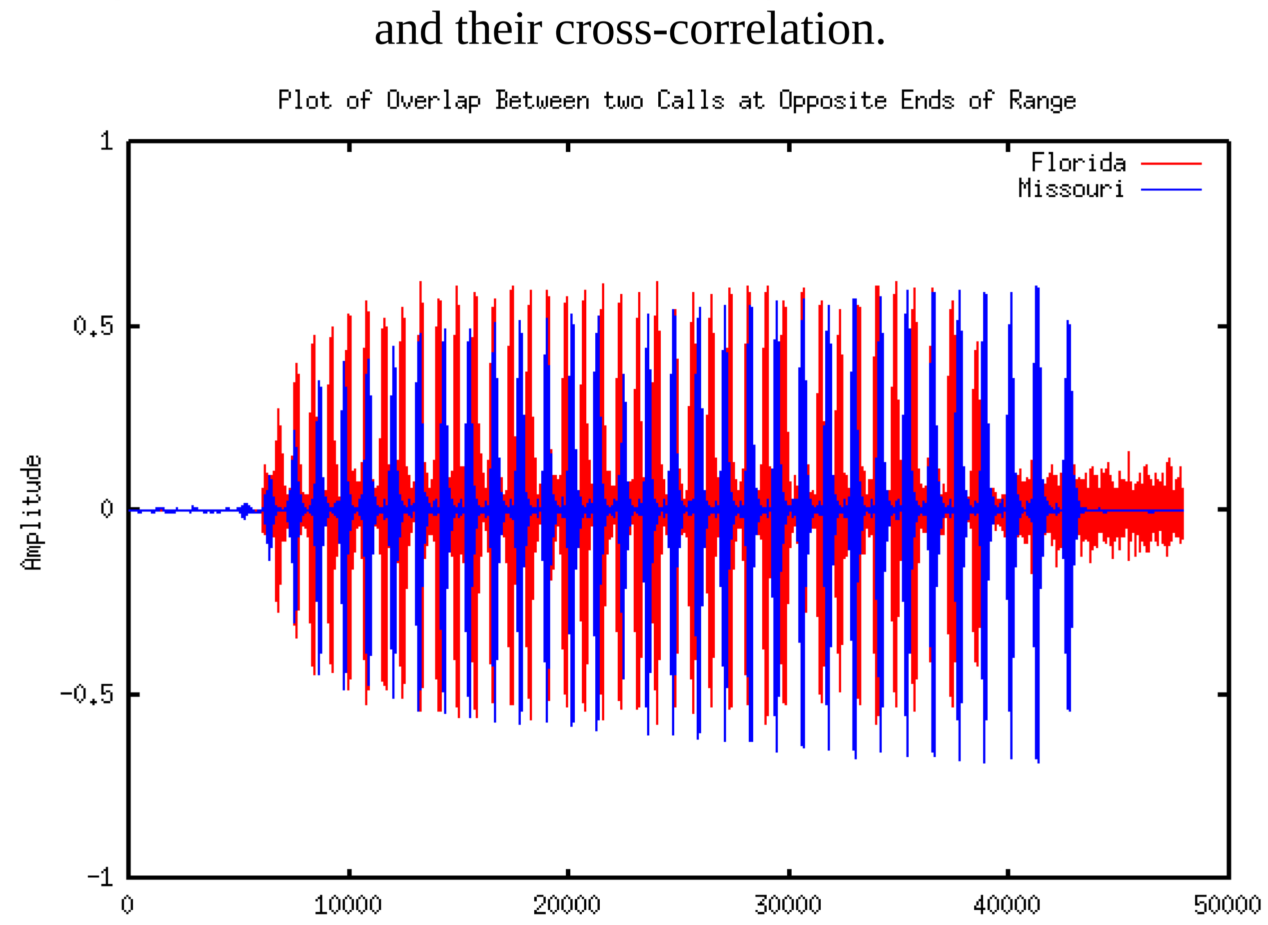
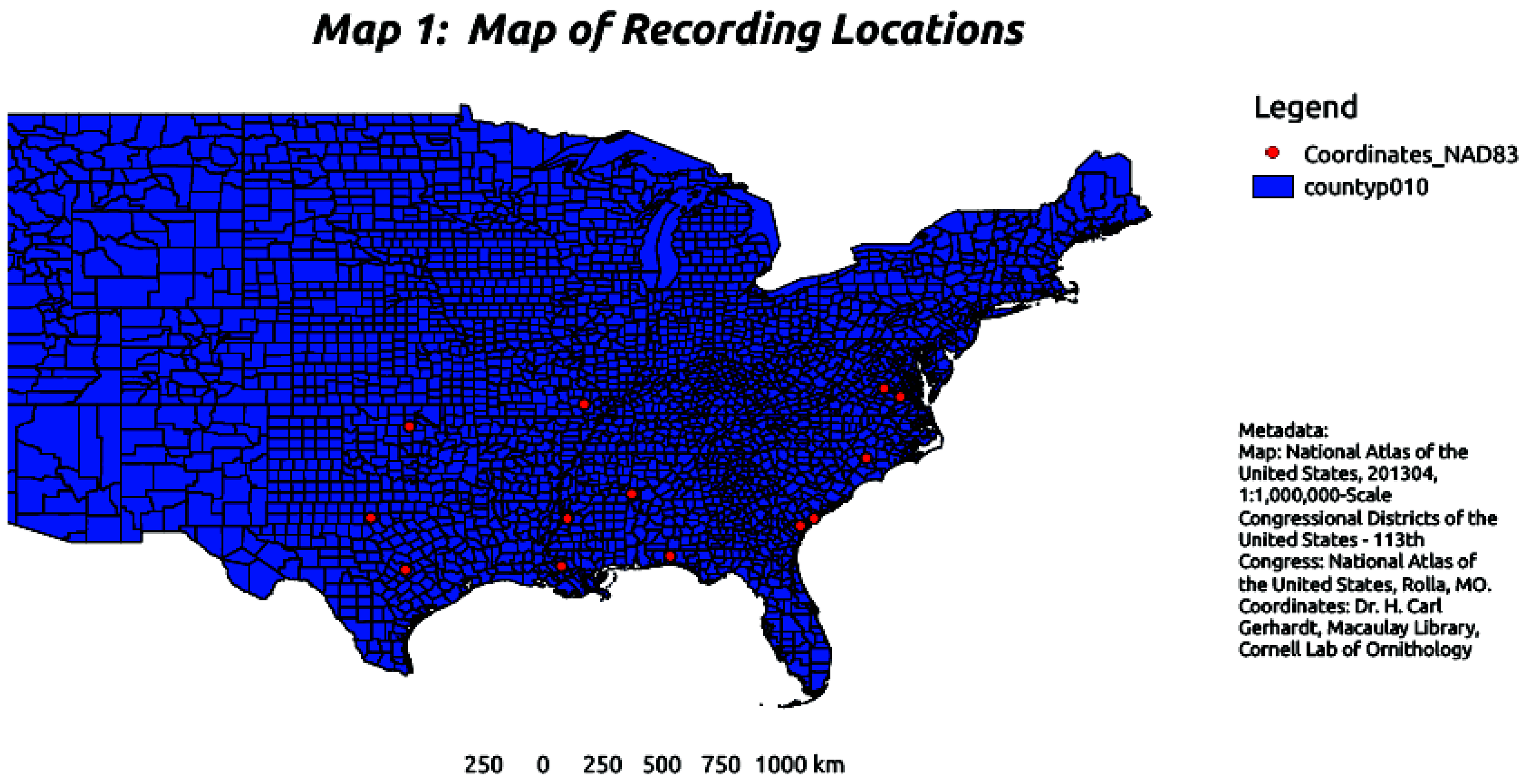


Figure 2 shows the maximum overlap between two frog calls after cross-correlation.

Map 1: Map of Recording Locations



Map 1: This map displays the geographic locations of all of the recording sites from which samples were taken. These samples were collected between 1969 and 1990 by Dr. H. Carl Gerhardt and were licensed to this project and downloaded from the Macaulay Library of the Cornell Lab of Ornithology. The points in red are the coordinate locations while the map itself is from the U.S. National Atlas. It is in the Public Domain as it is a publication of a part of the USDOI.

Hypothesis

It was our hope that this project would reveal quantitative evidence for a relationship between geographic location and mating call features of the Cope's Gray Tree Frog *Hyla versicolor*. The classic work on this species was done by Dr. H. Carl Gerhardt in the 1970s and 1980s.

Methods

For this project, frog call files were licensed from the Macaulay Library which is owned and operated by the Cornell Lab of Ornithology. All of the recordings were done by Dr. Gerhardt over the years 1969 to 1990. The individual calls from each of these files were then extracted for further analysis. In total, 186 individual calls were analyzed. The analysis used a custom program written in MATLAB which read in all 186 files and a csv file with the geographic location at which each call was recorder in North American Datum 1983 (NAD1983) Latitude-Longitude coordinates. The files were then cross-correlated using the built-in xcorr function in MATLAB set to return the Pearson's r coefficients. The maximum correlation was extracted from each of these. The vector of maximum correlations was then used to generate a distance matrix using Mahalanobis distance. The geographic coordinates array was also converted to Universal Transverse Mercator (UTM) coordinates. These UTM coordinates were then used to generate a Euclidean distance matrix. Both distance matrices, one of song compositional distance and one of geographic distance, were then subjected to a Mantel Test (Mantel, 1967) to determine whether or not there was a significant correlation between the two.

Results

Data is still being analyzed, however, the initial results are promising. The results of the Mantel Test were positive showing a similarity value of 0.30076 with a p-value of 0.0001001. To the right is Figure 3 which shows a plot of the geographic distance as a function of the compositional distance between frog calls.

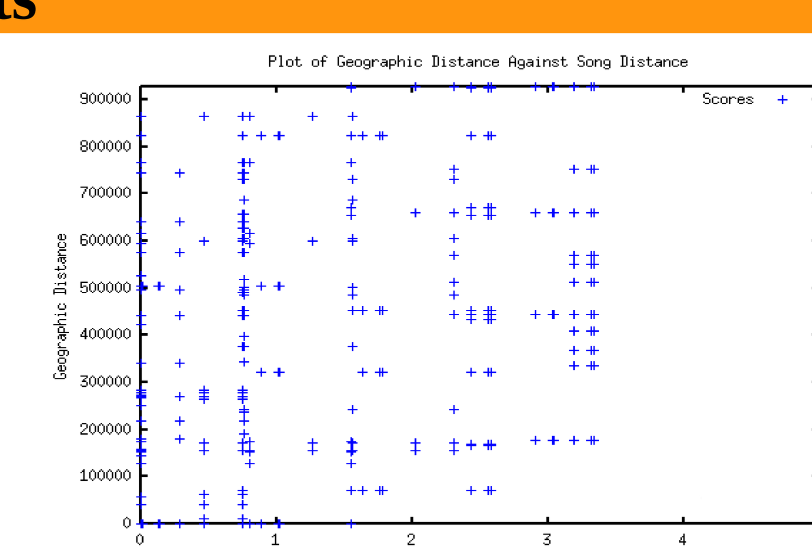


Figure 3 shows a plot of the geographic distance as a function of the compositional distance between frog calls.

Conclusion

Due to the fact that the similarity value is so high and the p-value so small, we may conclude for now that at the alpha=0.01 level, we can reject the null hypothesis that the two matrices are independent and uncorrelated. Therefore there must be a relationship between Geographic distance and compositional distance between frog calls. The nature of this relationship is still under investigation.

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References

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