INTRODUCTION

Soundscape ecology is an emerging science that researches a variety of global environmental changes. Soundscape composition — defined as the combination of biological (e.g., animal communication), geophysical (e.g., thunder, rain) and anthropogenic (e.g., transportation noise) sounds in a landscape — contains information that can be used to study environmental patterns and processes.

Researchers use automated acoustic recording units (ARUs) to continuously collect sounds, amassing large volumes of recordings. Scientists have developed many indices as an automatic analysis method but are not yet able to describe the structure of a recording using soundscape composition classes.

We propose a new kind of index using spectral timbral features, a type of frequency-domain analysis that summarizes the spectral envelope depending on the feature. Computational musicologists use spectral timbral features to classify musical instruments that are produced by similar mechanisms to terrestrial species (such as by blowing air or scraping a structure).

We hypothesize that spectral timbral features will:
1) distinguish dominant sounds within a soundscape, and
2) classify dominant sounds into soundscape composition groups (biophony, geophony, and anthrophony).

METHODS

TIMBRAL ANALYSIS PROCESS

Records were randomly selected from Pumilio: a library management tool with sound recordings from Costa Rica, Maine, and Arizona and analyzed in two stages: training and testing.

TRAINING STAGE

We determined a model, a spectral timbral feature group, based on SEM and k-means clustering results using a sound bank subset. We compared window lengths for overall feature consistency.

RESULTS

TESTING STAGE

Linear discriminant analysis for Model 3e had 86% of the variance explained on LD1 and LD2 axes. The classification accuracy for the five class model was 73.8%. Above, the testing phase dataset shows correlation patterns between class density per time period, and site density per time period.

DISCUSSION

As an emerging and rapidly developing interdisciplinary science, soundscape ecology embraces new analysis methods that could originate from different disciplines. In this work, we investigated if spectral timbral analysis on real-field soundscape recordings could distinguish dominant sounds within a soundscape and classify dominant sounds into soundscape composition groups.

We first manually labeled recordings using SEM. Then we determined a model based on SEM and k-means clustering results using a subset of the recordings. We tested spectral timbral features in myriad combinations that resulted in varying class clusters. Finally, the model was further validated and evaluated using all the recordings demonstrating that spectral timbral features can distinguish between insects, wind, and manmade noise such as vehicles. Our results suggest that a hierarchical structure that filters results from one feature group combination into another may provide a taxonomic class-specific discrimination method.

Future research will address some of the limitations of this study and include: using a larger sample size; using dimensionality reduction techniques other than NMDS; and further work into features that can classify heavy rain, thunder and bird chorusing.

CONCLUSION

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