Interactive Webtool for Tempospatial Data and Visual Audio Analysis

VAST Challenge 2018: Honorable Mention for Interactive Analytic Tool

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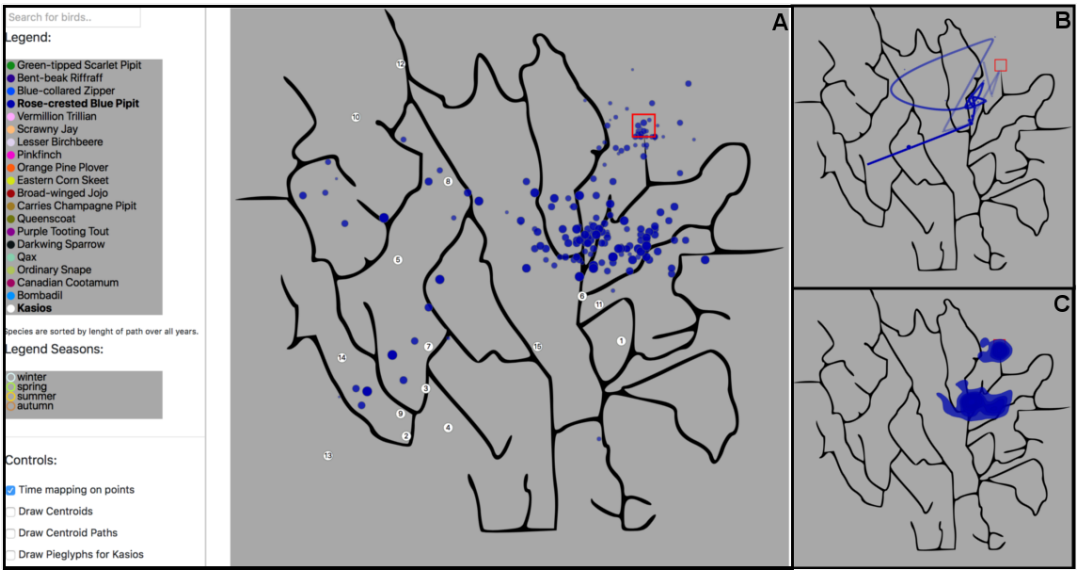

Figure 1: A shows a screen shot from the web tool, showcasing some of the customization and filter options. In this view, each single recording is shown on the map. The point in time is mapped to the size and the opacity of a point (further back in time results in a smaller, less opaque point). Image B shows a shaded path, visualizing the movement of the centroid of the bird population over time. Image C shows a density estimation plot based on the recordings.

Abstract

To solve VAST Mini Challenge 1, we build an interactive visualization tool that allows hypothesis testing and exploratory analysis of the data. The tool contains different visualizations for metadata and audio data analysis. To analyze the recorded bird calls, we trained a Gradient Boosting-classifier to distinguish different bird species. Our tool integrates these results and visualizes them in combination with additional data allowing the user to get context information and confirm the results.

Index Terms: Visual Analytics—Visualization—Visualization techniques

1 Introduction

This paper provides an overview of our submission to the VAST Challenge 2018 Mini Challenge 1 (MC1). The scenario is based on the last year's challenge, where the findings were that a company called Kasios was dumping chemicals in a wildlife preserve. The chemical is suspected to effect the species of the Rose-Crested Blue Pipit, especially the mating behavior. This year, Kasios states that the dumping has no effect on the bird population and that the Rose-Crested Blue Pipit would be living in great condition all over the preserve. The task of MC1 is to analyze patterns of spatial movement of all bird species as well as records of bird calls and songs and to create a hypotheses concerning the state of the Rose-Crested Blue Pipit. As basis for the analysis we analyze 2081 records of bird songs recorded all over the preserve over the course of 35 years together with metadata, containing the location, species, time stamp and the quality of the record. In addition, Kasios provides 15 audio records to prove that their dumping has no effect on the bird species.

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2 Metadata visualization

We provide two visualization approaches for the metadata. Map visualizations for the analysis of geo data and a timeseries for finding temporal patterns and anomalies in the calling behavior.

2.1 Map visualizations

Based on the map of the wildlife preserve and the location data for the audio recording, we build different visualizations. For each representation the species is mapped onto the color.

Location Representation Each data point is plotted onto the map. The size of the points are dynamically adjusted to the time, so smaller circles are further back in time. In addition, the season can be mapped to the outline of the data points. Using this representation we are able to determine migrating birds and birds living in the region of the dumping side. This view can be seen in Image 1.A.

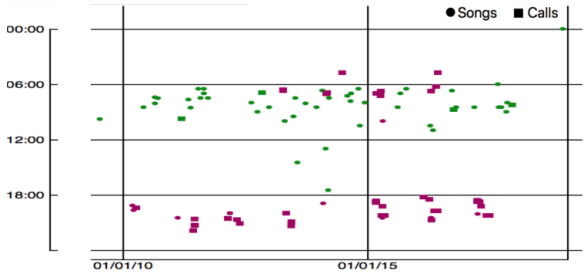


Figure 2: Recordings are mapped to the respective time of the day and differentiated into calls and songs through their shape.

Centroids and Centroid Paths The geometric centroids per year for each species provide information about the habitat and the movements of bird species. The centroids are computed as a discounted sum from previous and the current year to smooth the appearance and outliers. Additionally, a path through all the centroids of one species, where time is mapped onto the opacity, makes it possible to analyze movement patterns over time (Image 1.B). The visualization helps to find bird species that moved away from the dumping site after the dumping took place.

Heat Map The heat map (Image 1.C) provides an overview of the bird's habitats. Popular areas and differences in the distribution of the species can be recognized with this visualization. This view enables us to register the distribution and clustering of bird populations in a quick way compared to just plotting single recordings.

Small Multiples The small multiples represent the map of the wildlife preserve divided in 16 parts for each year, as this view provides a compromise between expressiveness and simple comparison. Each part is colored if the species appears at this location and the share of the whole population for one year is mapped to opacity.

2.2 Timeseries Graph

The timeseries graph (Figure 2) exhibits the calling and singing behavior of the birds. Circular shapes refer to songs, rectangle shapes to calls. The x-axis represents the overall timespan whereas the y-axis displays the time of the day. This helps us to find temporal patterns and anomalies for the species. As an example, the Green Tipped Scarlet Pipit, marked in Figure 2 in green, seems to sing almost exclusively in the morning, while the Canadian Cootamum,in purple, exhibits a calling behavior in the late evening.

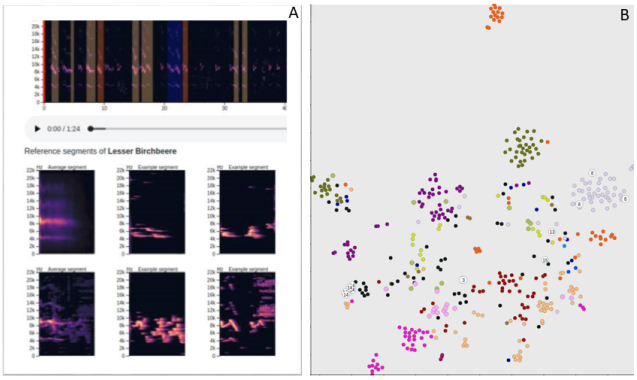
3 Audio Analysis

To preprocess the audio recordings, we use noise reduction, high-pass and low-pass filtering, and segmentation of individual bird sounds to create high-quality files for classification (Figure 3). Furthermore, we bin the segments by length. Based on those files, well-known spectral features and statistics based on fourier-coefficents are generated. We use a sliding window with the length of 1 second. The extracted features are processed by the *lightgbm-classifier* [1] which achieved over 90 percent accuracy at 10-fold cross validation on the training set. For the records provided by Kasios, the results are not sufficient for a correct classification. Reasons for the performance on the Kasios data may include the difference between training and test records, insufficient preprocessing and overfitting to noise in the training data. Therefore, we manually investigated the files further using our spectrogram visualizations.

Figure 4.A shows spectrograms of the Kasios recordings where the classified segments are overlaid. This allows the investigation of the predominant bird species in a recording. Additionally, an audio player is integrated for an audible analysis.

[1] (https://github.com/Microsoft/LightGBM)

Figure 3: The audio preparation pipeline describes the preprocessing of audio data for subsequent classification and analysis.



A: Spectrogram Small Multiples t-SNE projection of spectrograms

Figure 4: The top of Image A displays a Spectrogram with the overlaid classifier results. If one segment is chosen, additional random segments with the same length of the training data are presented for a better comparison. Furthermore, the averaged call and song of the bird species is displayed. In Image B, a subset of the segments from the spectrogram data is projected using t-SNE. The color indicates species and the numbered white dots refer to segments of Kasios's recordings.

Using the t-SNE dimensionality reduction technique as seen in Figure 4.B enables the user to verify the extracted feature metrics using the pre-labeled data. The wide distribution of the Kasios files in the projected space allows the assumption that the files contain many different bird species recordings.

4 Findings

With the help of our web tool we can conclude several findings. Different distribution patterns of bird habitats are recognized and migratory birds detected. Most conspicuous are changed habitats after the dumping. Bird species, for example, the Rose-Crested Blue Pipit or the Green-Tipped Scarled Pipit are no longer located at the dumping site. Additionally, we observe species influencing each other in their habitat. The timeseries graph reveals that the number of songs for the Rose-Crested Blue Pipit is decreasing which supports the hypothesis that the pairing behavior is disturbed by the dumping and subsequent migration of this species. The visual investigation of the audio files shows that three files are manipulated by Kasios. Only four of the files are classified as the Rose-Crested Blue Pipit.

5 Conclusion and Future Work

Our analysis tool provides an useful overview of the metadata. With clustering, filtering, and different visualizations insights in the data can be generated and hypotheses can be tested. Visualizing the spectrograms in combination with the results of the classifier allows us to verify the performance of the classifier in a detailed manner. The t-SNE projection provides insights into the quality of the extracted features and amplifies the verification of the classifier. With the support of our visualizations, we intend to add and refine our preprocessing steps and enhance the feature extraction techniques to improve our automatic classifier.