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Data Mining Applied to Acoustic Bird Species Recognition

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Introduction

- Bird Songs
  - ➡ Recorded songs transformed to numerical data through FFT's in order to perform feature extraction.
  - ➡ Species selected: Antbirds, neo-tropical birds that only sing innate songs, which facilitate recognition.
  - ➡ *Great Antshrike (Taraba major), Dusky Antbird (Cercomacra Tyrannina), Barred Antshrike (Thamnophilus Doliatus)*
  - ➡ Location: Montes Azules, Biosphere Reserve in Chiapas Mexico.
- Analysis of acoustic features obtained through feature extraction of bird songs.
- Computational cost
  - ➡ Sensor networks in a noisy environment have power limitations which will benefit from the data mining reduction.
- Exceptional classification results were obtained from reduced dimensionality databases.

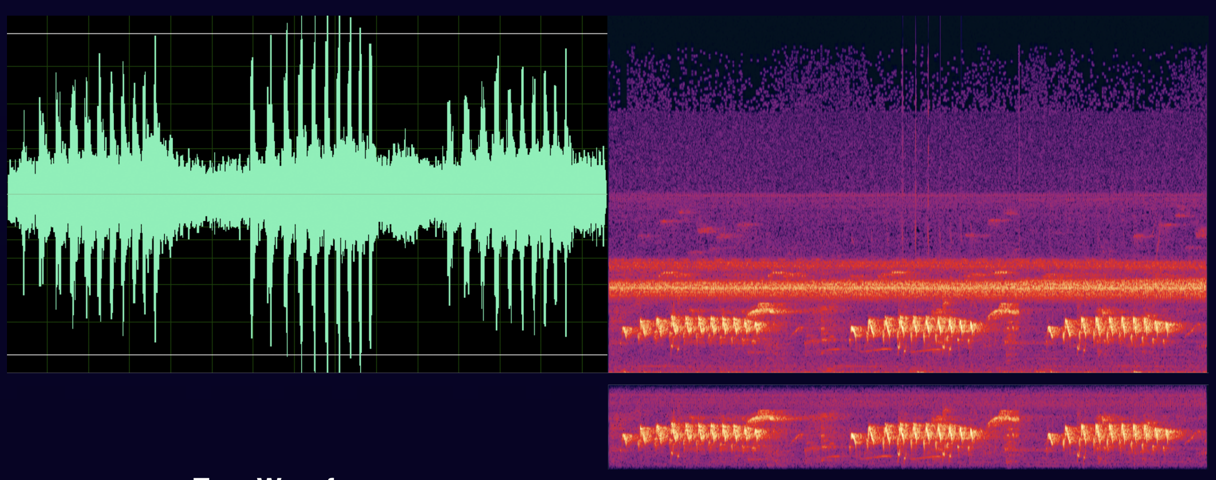
Problem Description

- Performing acoustic analysis and classification in complex environments poses a mayor challenge.
- Objectives:
  - ➡ To improve classifications methods by lowering the complexity of a data sets using data mining.
  - ➡ To obtain the most important sound feature characteristics of a bird's song in order to discern among species.
- We propose automatic bird species and individual recognition by means of acoustic feature extraction to use in conjunction with existing sensor network technologies.

Feature Extraction

- Field recordings are noisy, distinctive features have to be analyzed for each species and filtering is performed at the software level, per species.
- Spectral analysis is performed using Adobe Audition to identify the central frequencies of each species.
- Spectrograms are used by ornithologists to identify phonetic sounds.
- Sound Ruler was used to identify the spectral features of each recording.
- A curated database was constructed with the relevant information to aid future analysis.

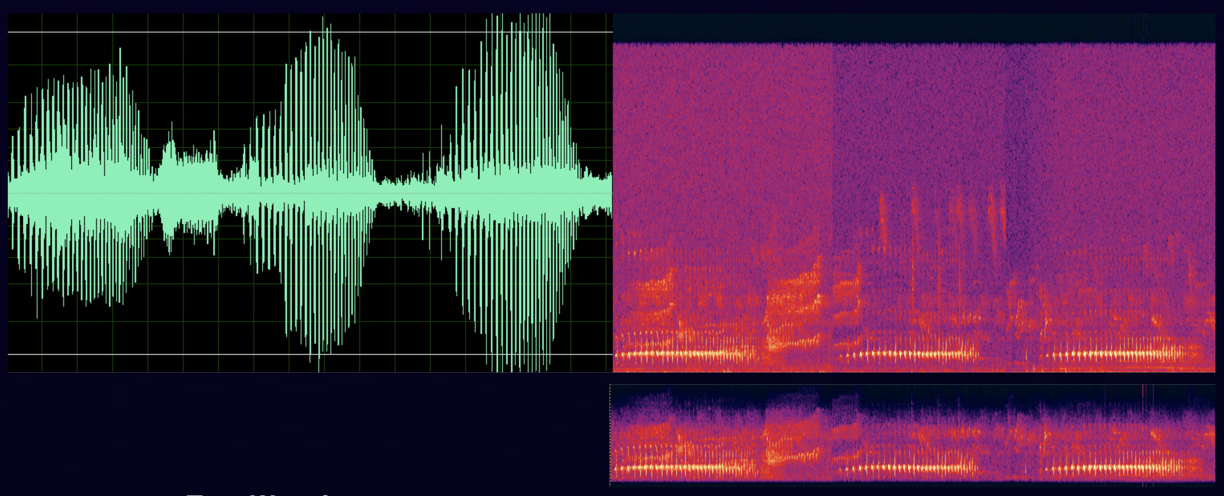
Dusky Antbird



Top: Waveform
Low Pass 4200 Hz
High Pass 920 Hz

Top: Unfiltered Spectrogram
Bottom: Filtered Spectrogram

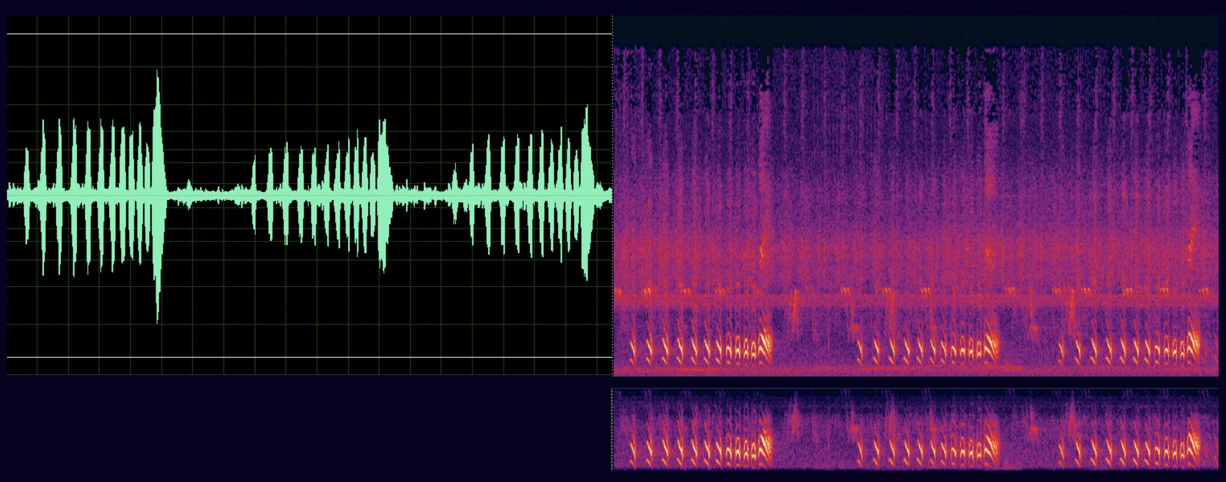
Great Antshrike



Top: Waveform
Low Pass 3597Hz
High Pass 517 Hz

Top: Unfiltered Spectrogram
Bottom: Filtered Spectrogram

Barred Antshrike



Top: Waveform
Low Pass 3597 Hz
High Pass 686 Hz

Top: Unfiltered Spectrogram
Bottom: Filtered Spectrogram

Methods

Data Mining

- Data Mining was used to extract important data obtained from the preprocessing stage.
- Data Mining of acoustic features.
  - ➡ Innovative algorithm combination (J4.8 + Naive-Bayes, ID3 + Naive-Bayes).
- Algorithms:
  - ➡ Decision tree algorithms ID3 and J4.8
  - ➡ Probabilistic classifier of Naive-Bayes
  - ➡ Quantization used to convert numerical into nominal data for ID3.
  - ➡ Classification improvement on the reduced data set due to the removal of cross-attribute dependent information.

Quantization

Quatization - Step by step example

1. vector
   [-1 93.9683 56.1224 -33.7068]
2. initial = min(vector)
   -33.7068
3. end = max(vector)
   93.9683
4. increase = (max(vector) - min(vector)) / (((2^bits) -1) -1)
   21.2792
5. partition = [initial:increase:end], one value smaller than codebook
   [-33.7068 -12.4276 8.8516 30.1307 51.4099 72.6891 93.9683]
6. codebook = codebook = [0:1:(2^bits -1)]
   [0 1 2 3 4 5 6 7]
7. quants = [index,quants] = quantiz(vector,partition,codebook)
   [2 6 5 0]

ID3 and J4.8

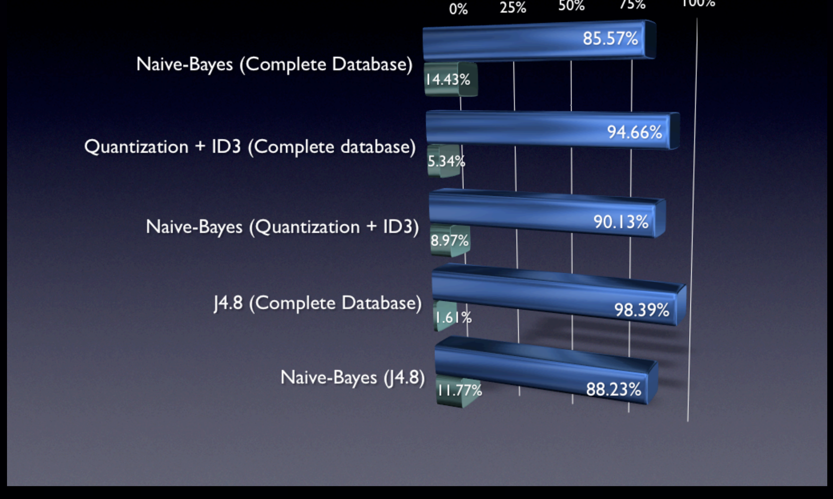
- Low computational cost
  - ➡ ID3 *O(np)* for symbolic data.
  - ➡ J4.8 *O(n²)* for numerical data.
- Unique combination of algorithms, ID3+Naive-Bayes used in order to eliminate the attribute redundancy and to reduce the statistical dependancy.
- ID3 and J4.8 output classification rules which leads to a considerable attribute reduction.
  - ➡ ID3 reduction: 71 to 41
  - ➡ J4.8 reduction: 71 to 47
- J4.8 was chosen for its ability to handle numerical data.

Naive-Bayes

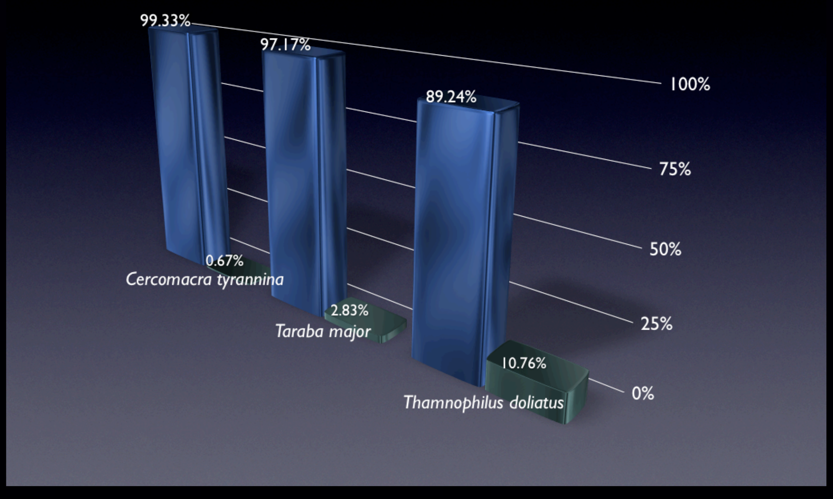
- Chosen because decision tree algorithms are unstable since they depend on the sample data that is selected.
- Naive-Bayes lets us visualize the degree of membership to a class of each test sample.
- This algorithm assumes the statistical independence among the attributes of the data sets.
- High affinity with non-redundant data sets.

Results

- Most significant attributes for classification found:
  - ➡ Pulse dominant frequency, width dominant frequency, number of pulses, dominant frequency at the final 50% of the call.
- Attribute and computational cost reduction.
- J4.8 has a high classification efficiency with a low time and power cost.
- Unique algorithm combination improved the classification percentage of the statistical classifier of Naive-Bayes.



Algorithm Comparison
Results



Species Classification
Results with J4.8

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ITESM-CEM: Computer Science Dept./ UCLA: Dept. of Ecology and Evolutionary Biology