ANURA: Sensor Networks for Classifying and Monitoring Frogs Based on Their Vocalizations

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Main Research Challenges

• Grand aligned challenges
  • Ubiquitous Computing\(^1\)
  • Biological Diversity and Ecosystem Functioning\(^2\)

• We need to understand the Earth’s physical systems
  • Climates, geology, hydrology, ...

• The rainforest is a key environment
  • Let’s start with the Amazon forest

Key Problems

• An environment of extremes
  • Relative humidity: 70-90%
  • Temperature: 64-122 °F
  • Huge area, limited accessibility

• Additional challenges to WSNs

• Ecological issues

• Where should we start?
The Anura Project

- ANURA: Sensor Networks for Classifying and Monitoring Frogs Based on Their Vocalizations as an Early Indicator for Ecological Stress in Rain Forests

- Financial Support
  - LACCIR - Microsoft
  - PRONEX - FAPEAM/CNPq (Brazil)
Motivation

- Amphibians are very sensitive to changes (Carey et al., 2001)
  - Climate changes, deforestation, water contamination...
Motivation

- Anura (Frogs and Toads)
  - Closely related to the ecosystem (Alexander & Eischeid, 2001)
  - Fairly easy to be monitored
Our Approach
First Steps
<table>
<thead>
<tr>
<th>Species</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hylaedactylus</td>
<td>8</td>
</tr>
<tr>
<td>Rhinella granulosa</td>
<td>3</td>
</tr>
<tr>
<td>Adenomera andreae</td>
<td>8</td>
</tr>
<tr>
<td>Ameerega trivittata</td>
<td>5</td>
</tr>
<tr>
<td>Hyla minuta</td>
<td>11</td>
</tr>
<tr>
<td>Hypsiboas cinerascens</td>
<td>2</td>
</tr>
<tr>
<td>Leptodactylus fuscus</td>
<td>4</td>
</tr>
<tr>
<td>Osteocephalus oophagus</td>
<td>4</td>
</tr>
<tr>
<td>Scinax ruber</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49</strong></td>
</tr>
</tbody>
</table>
An Example: *Adenomera Andreae*
Other Species

Rinella granulosa

Ameerega trivittata
Feature Extraction

- Features being used
  - (R) Zero Crossing Rate
  - (S) Spectral Centroid
  - (B) Bandwidth
  - MFCCs (Mel-Fourier Cepstral Coefficients)
<table>
<thead>
<tr>
<th>Features Used for Classification</th>
<th>5-NN</th>
<th></th>
<th></th>
<th>10-NN</th>
<th></th>
<th></th>
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<tr>
<td></td>
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<td>$\alpha = 0.5$</td>
<td>$\alpha = 0.6$</td>
<td>$\alpha = 0.4$</td>
<td>$\alpha = 0.5$</td>
<td>$\alpha = 0.6$</td>
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<tr>
<td>MFCC (human method)</td>
<td>97.07%</td>
<td>97.12%</td>
<td>97.17%</td>
<td>96.45%</td>
<td>97.02%</td>
<td>96.77%</td>
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<tr>
<td>RSB (anura method)</td>
<td>87.98%</td>
<td>89.83%</td>
<td>91.39%</td>
<td>87.93%</td>
<td>90.21%</td>
<td>91.06%</td>
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<tr>
<td>R &amp; MFCC (human, anura methods)</td>
<td>97.27%</td>
<td>97.40%</td>
<td>97.30%</td>
<td>96.79%</td>
<td>97.27%</td>
<td>96.86%</td>
</tr>
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<td>S &amp; MFCC (human, anura methods)</td>
<td>98.10%</td>
<td>98.14%</td>
<td>98.22%</td>
<td>97.59%</td>
<td>97.77%</td>
<td>97.86%</td>
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<tr>
<td>B &amp; MFCC (human, anura methods)</td>
<td>97.75%</td>
<td>97.91%</td>
<td>97.80%</td>
<td>96.99%</td>
<td>97.35%</td>
<td>97.19%</td>
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<td>RSB &amp; MFCC (human, anura methods)</td>
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<td>98.53%</td>
<td>98.43%</td>
<td>97.89%</td>
<td>97.95%</td>
<td>97.89%</td>
</tr>
</tbody>
</table>
A Key Problem: Communication Efficiency
Contributions to CS

- Make it work in the forest
- Counting is too difficult
  - Measure the vocal activity
- Current contribution
  - Event detection and tracking
  - Communication protocols
  - Fault detection
  - Localization
Final Comments: Our Contribution

Solving fundamental issues in WSNs
• Communication, error-prone data
• Spatial and temporal data correlation

Innovating through
• Collaborative (data fusion) algorithms
• Technological solutions

Doing Computer Science
• Help defining the role of WSNs in Ecology
• Multidisciplinary approaches

Involving local communities
• Sustainability
• Formal education
Acknowledgement

• Our Research Network
  • Prof. Eduardo Nakamura (FUCAPI/UFAM, Brazil)
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  • M.Sc. Student Andre Campos (UFAM)
  • M.Sc. Student Antonio Ramos (FUCAPI)
  • M.Sc. Student Afonso Ribas (FUCAPI)
  • ...
Site For “Long-term” Monitoring
Monitoring the Bare-Faced Tamarin
Monitoring Forest Fire

• Amazon
  • Fire of 30cm
  • Fire in line
  • Up to 40% of species are affected

• Satellite
  • Delay
  • Granularity

• Sensor Networks
  • Realtime
  • Cheaper Technology
  • Hard deployment