Title
VoxNet : An End-to-End System to Support On-line, Real-time Bioacoustics Research

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VoxNet - an end-to-end system to support on-line, real-time bioacoustics research

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Introduction: Processing challenges in bioacoustics research

Studying acoustic communication
- **Dynamics of acoustic communication**: Bioacoustics research field has interest in understanding behavior of animals/birds through vocalizations; e.g. marmots, au birds and wolves
- **Three important challenges**: Census, classification and localization are three important aspects of studying animal or bird behavior from vocalizations
- **Data processing**: Typically these observations are made manually or using suitably configured automated event detectors which pick out events of interest for further processing

Data gathering/processing approaches
- **Data gathering**: Scientists would traditionally use manual observation or an array of wired microphones to record acoustic data over area of interest
- **Data processing**: Also, Acoustic ENSBox network (IPSN 2007) allows wireless, time synced data gathering, OR on-line automated event detection

Problem: Using a purely off-line or on-line approach can be problematic

Off-line processing
- **Scientist cannot interact with data processing/gathering in the field**
- **Potentially can miss useful interactions based on feedback of system (i.e. take a photo based on localization results)**
- **Current off-line processing tools vary in generality and complexity**
- **Using more powerful recording tools creates very large datasets – for instance, 8 hours continuous recording @ 48KHz = 10GB/Node (typically 8 Acoustic ENSBoxes/deployment)**

On-line processing
- **Potentially huge data sets can be reduced as data is recorded to make processing more manageable, using on-line event detectors**
- **However, reducing data set may reduce its usability – badly configured detectors may yield bad results (missed detections for example, which is problematic for census)**
- **The data lost may have been useful for another purpose, for example to identify other animals/birds present in recordings**

VoxNet: A system to support bioacoustics research both on-line and off-line

Overview of proposed architecture

Hardware for distributed acoustic sensing
- **Existing Acoustic ENSBox**: 2x400 MHz PXA processors, 64 MB RAM, 16GB CF
- **802.11 wireless, 4x48KHz audio channels**
- **20.8 x 14.4 x 9.2 cm, 2.3 kg, 7.5W consumption**
- **Supports time sync, self-localization**
- **Proposal for new h/w platform (VoxBox)**
  - **1x600 MHz PXA processor, 128 MB RAM, 16GB CF**
  - **10x increase in energy efficiency, 20x comms. Range**
  - **19 x 14.5 x 5.4 cm, 0.75 kg, 0.75 W consumption**

Queries as Applications
- **Nodes have a set of 'core' functionality – self-localization, time sync, routing, archiving**
- **Actual 'applications' are queries, which are programmed using Wavescript (MIT)**
- **Wavescript takes macro-programming approach, abstracting out networking issues for the programmer**
- **Queries can be run over offline data also**

Dynamic reconfigurability
- **Queries can be dynamically replaced during system run-time, to allow most flexibility**
- **Queries are compiled at the Control console, and disseminated over reliable publish/subscribe streams to all nodes simultaneously**
- **Performance is comparable to manually copying binary files to each node in turn**

An example Query

1. **Nodes detect event of interest, send audio data back to sink over wireless channel**
2. **Streams of detections flow to control console where they are processed and fused to create estimate of position estimate map**
3. **Scientist uses position estimate from map displayed on PDA to direct observation in field**

End to end latency

- **Using PDA in-field, scientist can ‘subscribe’ to streams which run in the network (node, sink, network), and visualize the data that is coming from them (see example Query above)**
- **Visualizers can be dynamically plugged into data streams – for example, a time domain visualizer for audio data, or a polar plot visualiser for DoAs**

Visualization of data

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