Title
SYS 2: Acoustic ENSBox A System of Self Calibrating Distributed Acoustic Arrays

Authors
Lewis Girod
Martin Lukac
Vlad Trifa
et al.

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Acoustic ENSBox: A System of Self-Calibrating Distributed Acoustic Arrays

Lewis Girod, Martin Lukac, Vlad Trifa, Deborah Estrin
CENS Systems Lab – http://research.cens.ucla.edu

Introduction: Self-configuring platform for collaborative acoustic monitoring

Passive Acoustic Monitoring Applications

- **Detect, classify, and localize targets using sound**
- **Free of interference to targets and environment**
- **Suitable for animal behavior monitoring**

Wolf Howls

Woodpecker Calls

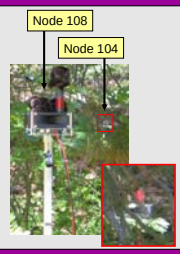
System architecture

- **Network of acoustic arrays distributed in field**
  - Four microphones in a square array
  - PXA255 platform, 2.6 Linux kernel
  - VXPocket 440 PCMCIA 4-channel sound card
  - Arrays are wirelessly connected via 802.11
- **Acoustic monitoring through collaborative processing**
  - Animal vocalization is detected by nearby acoustic arrays
  - Sound is classified and DOA is estimated from phase comparison
  - Animal location is estimated through collaboration of multiple arrays

Problem Description: Challenges in collaborative acoustic monitoring

Collaborative monitoring system

- **Staged signal processing model**
  - Early stages filter out periods where there are no events
  - Later stages detect, classify, and compute DOA
  - Collaborative phase: data association and localization
- **Precise synchronization between sampled channels**
  - Required for accurate direction of arrival (DOA)
  - Need to overcome limitations of VXP hardware



Self-calibration

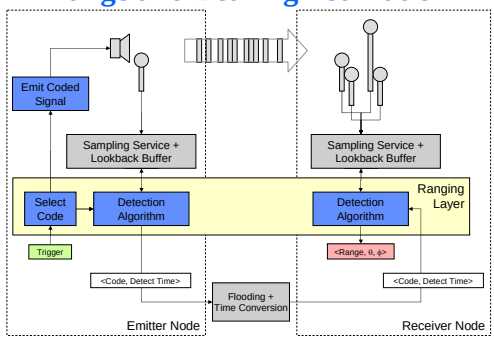
- **3-D location and orientation of microphone arrays**
  - Required for 3-D target localization via bearing-crossing
  - Difficult to obtain manually in dense-foliage environments
  - Localization info must be maintained when system is bumped or moved
- **Acoustic localization system**
  - Based on time of flight (TOF) of acoustic signals
  - Requires precise synchronization between nodes and from sample clock to node CPU clock

System Design: Acoustic ENSBox: a portable acoustic monitoring box

Software System

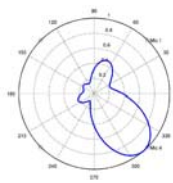
- **Buffered Continuous Sampling Interface**
  - Allows online detection and post-facto processing
  - Abstracts away non-deterministic system delays, e.g. network latency
- **Multihop Time Conversion**
  - Clocks run independent
  - Nodes maintain time conversion parameters
  - Service provides pair wise time base conversion and global event time service
- **Collaborative Network Primitives**
  - Flood service with hop-by-hop time conversion
  - Reliable state dissemination mechanism with publish-subscribe interface
- **Location and Orientation Self-Calibration**
  - 3D location and orientation of sensor array

Range and Bearing Estimation

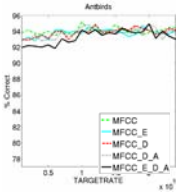


Antbird Detection

- Early results obtained from master's thesis experiments
- Applied AML bearing estimation algorithm to enhance antbird calls and apply HMM recognizer



AML Bearing Estimator



Antbird Species Recognition, for varying HMM parameters