Next-Generation Bioacoustic Analysis Software

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LONG-TERM GOALS

In the past two decades, awareness has grown that acoustic methods are often the best means for studying and monitoring marine mammals. Acoustic methods, for instance, have long been used for detection and study of sperm whales, in part because of the difficulty of visual detection: Visual surveys have been estimated to miss 38% of sperm whales that are on a ship's trackline (Barlow and Rankin 2004), and more at greater distances from the trackline. Other species are similar or worse; for instance, it is estimated that approximately 85% of Cuvier's beaked whales on the trackline are missed with visual scanning (J. Barlow, pers. comm). Acoustic methods, in contrast to visual ones, function well in darkness, fog, high sea states, and other inclement viewing conditions. Via the use of autonomous recorders, acoustic methods can also be used in remote or inhospitable areas (Širović et al. 2004, Mellinger et al. 2008) where visual monitoring would be impracticable or impossible. Software tools are needed for analyzing such data sets, even for such simple tasks as manually scanning spectrograms to find calls of interest. Acoustic localization of calling animals is often performed; whether estimates are in one dimension (bearing), two (X-Y position), or three (X-Y-Z position), analysis software is necessary. Marine mammal acoustic data is often collected in very large data sets, necessitating automated methods for data analysis. For instance, AURAL autonomous recorders (Multi-Électronique, Inc.) operate at a sample rate of 32 kHz, so that a one-year data set is 2 terabytes (TB) in size. Another type of autonomous recorder, the HARP (Wiggins 2003; J. Hildebrand, pers. comm.), operates at even higher sample rates – up to 200 kHz – making a one-year data set 12.6 TB in size. Automation tools are clearly needed for data sets of this scale.

Starting in 2000, ONR funded the development of one such tool, Ishmael (Mellinger 2001). It is a user-friendly bioacoustic analysis package for Windows. It includes displays of sound waveforms and spectrograms, recording capability for real-time input, several methods for acoustic localization, beamforming, several methods for automatic call recognition, and a sound annotation facility. Ishmael is aimed at users wishing to analyze large volumes of data quickly and easily. Ishmael quickly became popular, with thousands of downloads by users; a large proportion those downloads were in active use, and a survey in 2005 showed that 46% of respondents use it regularly. It has also been used in much ONR-funded research:

In this project, we have implemented a number of improvements and updates to Ishmael.

OBJECTIVES

- Hire and train a software engineer to make improvements to Ishmael.
- Implement new audio I/O.
- Implement improved localization.
- Implement improved detection and classification.
- Implement improved acoustical measurements.
- Implement programming interfaces.
- Update Ishmael's documentation for these improvements.
- Create user group / web site for users to share information and tips.

APPROACH

The approach was to hire a software engineer to perform most of that above tasks in collaboration with myself. Research assistants will also perform much of the updating of documentation.

WORK COMPLETED

The software engineer, Jonathan (Jon) Dodge, was hired and started work on Ishmael in early December 2010. Unfortunately, Mr. Dodge, after learning many of the internal details of Ishmael and completing significant work on it, stopped showing up for work in late January 2013, despite repeated unreturned phone messages and emails. (Mr. Dodge had done a similar thing more briefly in August 2012, returning quite apologetic; after he returned, I told him he would terminated if it happened again and he said it would not happen again.) Consequently, his position was terminated in February.

This set the project back significantly, as there are insufficient remaining funds to hire someone new and get them trained enough to finish the required software engineering. As a result, I (Dave Mellinger) am now doing the software engineering for this project. As I do not have time to work on it full time, work is going slower than planned, but is progressing steadily. The following changes have been implemented:

- Implemented a new system for acoustical feature estimation of marine animal calls. Features are estimated after removing background noise from the spectrogram; many of the features are based on the AcouStat system (Fristrup 1992), which has features that are relatively resistant to noise. (Part of this step was started last year, with completion this year.)
- Implemented the Teager-Kaiser energy measure (Kandia and Stylianou 2006) for detection.
- Implemented frequency contour tracking algorithm (Mellinger et al. 2011) for detection of odontocete whistles and baleen whale moans.
- Integrated Ishmael with several systems for plotting and tracking marine mammals in the field. These systems use the Universal Datagram Protocol (UDP) for network communication. Example systems include SPAWAR's *Whale Identification and Logging Display* (WILD; www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA533470) and the *Mysticetus Observation System*

(www.mysticetus.com). Ishmael now uses a standardized UDP packet protocol for communicating with these systems.

- Made Ishmael compatible with another new version of the development environment (Borland/Embarcadero RAD Studio).
- Kept Ishmael operating successfully on new releases of Windows and Mac OS.
- Fixed a number of minor bugs.

RESULTS

Ishmael has several new features, most prominently the improved detection methods and the measurement system.

The new version of Ishmael has been built and made available to users. Work on the software is ongoing.

IMPACT/APPLICATIONS

Ishmael is used for marine mammal acoustic monitoring in many places around the world. Having the new features should make it more useful to researchers everywhere.

RELATED PROJECTS

Advanced Methods for Passive Acoustic Detection, Classification, and Localization of Marine Mammals (award numbers N0001411IP20086 and N0001411WX21401). This ONR-funded effort is developing improved algorithms that will be offered to users in a user-friendly way by implementing them in Ishmael in the future.

REFERENCES

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