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MARINE OPTION PROGRAM

Introductory Workshop to Raven: Interactive Sound Analysis Software

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Abstract

Raven is a user friendly interactive research software program and a teaching asset for scientists working with acoustic signals. In recent years, acoustic studies have been a major area of interest within the marine sciences community. This technology has opened the doors to understanding the complex social and ecological communities that reside under the sea. The objective of this MOP project was to create a workshop introducing students to the field of bioacoustics and how to use Raven, the interactive sound analysis software commonly being utilized in a variety of scientific disciplines today. The workshop began with a 50-minute lecture discussing the role bioacoustics plays in the marine science field, coupled with a PowerPoint that served as a step by step manual on how to navigate Raven's user interface. Once students were given a brief introduction to some of the fundamental tools needed to navigate the program, the workshop continued in the Listening Observatory for Hawaiian Ecosystems (LOHE) Laboratory at the University of Hawai'i at Hilo with an activity worksheet. This gave students the opportunity to experiment with the program in a structured research setting. The PowerPoint presentation was designed in such a way as to allow students to learn how to use Raven on their own time. This visual aid served as an easy-to-understand manual that could be distributed amongst students or taught by other mentors familiar with Raven. There is a need within the Marine Sciences Department to increase awareness about the importance of studying bioacoustics, so by exposing students to this particular discipline, students now have access to areas of research they might not have otherwise been aware of. This workshop provided an invaluable opportunity for students to learn about alternative career paths within, or related to, their field of interest post-graduation and develop a skill that may prove useful in future endeavors.

Introduction

Raven is a user friendly interactive research software and teaching asset for scientists working with acoustic signals. Originally, Raven was created for the purpose of studying bird songs and vocalizations, but quickly grew into a multidisciplinary tool that can be configured for analyzing all sorts of acoustical data (Charif et al. 2010). In recent years, acoustic studies have been a major area of interest within the marine sciences community. This technology has opened the doors to understanding the complex social and ecological communities that reside under the sea.

Hearing is the universal alerting sense in all vertebrates on the planet. Animals can hear events occurring all around them, despite where their attention may be focused. Sounds allow animals to gather information about their environment and communicate at great distances from all directions. Marine life relies on acoustic signals to sense their surroundings, communicate with others, to locate food, and to protect themselves (Scowcroft et al. 2015). For example, dolphins are capable of cross-sensory transfer: an evolutionary ability to visually interpret matter using sound. This type of sensory integration, "echolocation", allows the dolphin to identify objects, obstacles, prey and conspecifics in their habitat where various physicochemical parameters inhibit visibility. Many fish species produce grunts, croaks, clicks, and snaps to ward off predators and attract mates, often playing an important role in complex courtship rituals. All animals rely on sound for survival, making it the most important sense they possess. It is this fact that makes the study of sound such a crucial discipline in the biological sciences.

In a study conducted by Dr. Denise Herzing (1996), under water video footage of various inter-species interactions between Atlantic Spotted dolphins (*Stenella frontalis*) and Bottlenose dolphins (*Tursiops truncatus*) was collected and catalogued for further analysis over the course of 10+ years. Researchers then sifted through these recordings and analyzed the dolphin vocalizations present across an assortment of behaviors. They were able to identify 10 types of vocalizations associated with specific behaviors, and in some cases, individual dolphins. Finding these patterns further supports claims that dolphin have remarkably contextual and complex communication systems. Through the use of this bioacoustics tool, scientists now know that dolphins have names – signature whistles unique to each individual. Analyzing the rhythm, sequence, and social context of these discrete and graded multi-modal signals may play a crucial role in the interpretation of social interactions of many animals, not limited to just dolphins (Herzing 1996).

Raven has also proven useful in the development of species conservation, which relies on understanding seasonal habits and migration routes of the species of interest. Atlantic Right whales (*Eubalaena glacialis*) are listed as endangered and were thought to migrate from the southern US coast to Cape Cod, Massachusetts between the months of February and May. They traverse through dense shipping and fishing activity where there are virtually no regulations for their protection or habitat management. In a study conducted by Moreno et al. (2012), scientists collected passive acoustic recordings on buoys, using a hydrophone, all year round. Using Raven, researchers were able to determine annual spatial and temporal distribution of whales based on their calling activity. This information proved to be much more accurate than visual surveys, and it was discovered that the population of whales were not just seasonal visitors but frequented the bay all year round. This data helped solidify a management plan for the area to reduce the probability of collisions with ships and entanglement in shipping gear (Moreno et al. 2012).

In another long-term study conducted in Hawaiʻi by Dr. Adam Pack and colleagues (2003), Humpback whale (*Megaptera novaeangliae*) songs were recorded and analyzed using Raven software. Humpback whales aggregate to subtropical waters during winter months to mate. Males are famously known for "singing" sequences of sounds composed of various structured patterns to (hypothetically) convey information about the vocalizing whale. Whales continuously modify these sequences over time, and the functional role of the individual patterns within the song is currently unbeknownst to scientists. By collecting these whale songs over a period of 30+ years, researchers were able to create a linear model depicting the evolution of the song using Raven. This was done with the hope that the resulting data could elucidate scientists on the reasoning behind such song modifications in Humpback whales. In past literature, songs were hypothesized to serve as inter / intra – sexual advertisement, serving to inform females about the male's location and reproductive fitness, while also serving to inform other males of their location to possibly determine territories (Pack et al. 2003). Thanks to the long-term song analysis made possible through the utilization of Raven, current hypotheses suggest that varying features of song pattern is the result of a few possibilities, such as: runaway sexual selection for song complexity, a reflection of the age and / or status of the singer, and serves to increase the likelihood that information broadcasted is reliably received by the intended parties (males or females). This information is crucial in the fundamental understanding of mating habits amongst Humpback whales and can be applied to many other species that are known for exhibiting complex courtship rituals. Scientific discoveries such as these would not be possible without the aid of a sound analysis tool such as Raven.

For my Marine Options Program project, I lead an introductory workshop on how to use Raven, the interactive sound analysis software commonly being used in a variety of scientific disciplines today. Once students had been given a brief introduction to some of the fundamental tools needed to navigate the program, we relocated into the Listening Observatory for Hawaiian Ecosystems (LOHE) Laboratory at the University of Hawai'i at Hilo and I provided them with worksheets I personally designed. This gave students the opportunity to experiment with the program in a structured research setting. The PowerPoint presentation was designed in such a way as to allow students to learn how to use Raven on their own time. This visual aid served as an easy-to-understand manual that could be distributed amongst students or taught by other mentors familiar with Raven. There is a need within the Marine Sciences Department to increase awareness about the importance of studying bioacoustics, so by exposing students to this particular discipline, students now have access to areas of research they might not have otherwise been aware of. This workshop provided an invaluable opportunity for students to learn about alternative career paths within, or related to, their field of interest post-graduation and develop a skill that may prove useful in future endeavors.

Materials & Methods

The materials required for this project included access to Raven Sound Analysis Software, which was provided by Dr. Patrick Hart of the Listening Observatory for Hawaiian Ecosystems (LOHE) Bioacoustics Laboratory at the University of Hawaiʻi, using his license through Cornell University.

First, I went through the Raven Manual that is provided with the program in order to successfully master various features that Raven has to offer when analyzing bioacoustics. I enlisted the help of the graduate students, who currently use Raven for their research, to create a list of features they use on a daily basis. Since Raven is a multidisciplinary tool with many uses, I mainly focused on the features that the authors in my cited literature relied on in order to progress with their studies.

Once I mastered this, I put together a step-by-step visual guide in the form of a PowerPoint presentation in order to make it easier for students to navigate the program without needing any prior knowledge of this software. Within the presentation, digital footnotes accompanied each slide, so that students who are interested in learning how to use Raven can do so without the need for a class or mentor to be present. Clear and concise photos and definitions were be provided for novel terms or jargon that students might not have otherwise encountered in their current field.

The Marine Sciences Building (MSB) room 103 was reserved for the lecture portion of the workshop, where the 50-minute presentation took place. Then, students were guided to the Listening Observatory for Hawaiian Ecosystems (LOHE) Bioacoustics Laboratory where they were paired up in teams to experiment with Raven.

Students were provided with a worksheet and two sample sound files to analyze using Raven. Students needed to utilize the skills reviewed in the lecture portion in order to get to the right answer. The questions were organized in such a way that they needed the answer to the first question in order to find the answer to the second question, which was needed to find the answer to the third question, etc.

Once the students completed the worksheet, they were collected and compared with the master answer key to confirm if the students were able to successfully navigate the program and analyze the sound files. Students were asked to provide feedback on their experience, if they felt they learned a valuable skill, and if they think workshops like this would benefit the Marine Sciences Department at the University of Hawaiʻi at Hilo in the future.

Results & Discussion

Introductory Lecture

The lecture portion of the workshop consisted of about an hour and a half of discussing pertinent information related to the bioacoustics field. Important components of how to read a sound file, units associated with measurements, as well as applications in current research, were explained in detail. Information explained in depth included: what sound is and how it is measured in units of pressure (pascals; Pa, kPa), the amplitude of sound and the two ways it is measured – either as energy (decibels; dB) or as voltage (units; U, kU), the frequency of a sound (hertz; Hz, kHz), as well as the wavelength of a sound and how to calculate it (meters per second; m/s).

The various ways sound is analyzed in the field was also briefly covered. This consisted mostly of explaining how marine scientists use hydrophones, underwater microphones, to convert acoustical energy, produced in the form of sound waves, into electrical signals that can be graphically depicted in the form of a spectrogram within Raven. Classic examples of how scientists are using this acoustic information to interpret data and draw conclusions in their current research were also elaborated on in order to show students how they could utilize this software most effectively.

For the final portion of the lecture, various tools used within Raven were explained with the aid of graphics depicting how to find the tool in question, the steps needed to properly collect data, as well as how to organize and export sound files.

Workshop Activity

The activity portion of the workshop took place in the Listening Observatory for Hawaiian Ecosystems (LOHE) Bioacoustics Laboratory located in Wentworth Hall on the University of Hawaiʻi at Hilo campus. Since there were only four computers available for use, students paired up into teams of two. Each computer had two sound files loaded onto the desktop before the workshop took place. The students were asked to follow the instructions on the activity worksheet in order to complete the assignment. This included opening the Raven program, loading the sound files from the desktop onto Raven, and following the necessary steps needed to analyze and compile data that would normally be used when inspecting sound in the field.

Once the students completed the activity, their worksheets were collected and graded based on the master answer key. The average grade was a 94%, based on an 11-point scale. From this, it was concluded that the workshop was a success and the students were able to develop a new skill and properly analyze and identify sounds using Raven software. This workshop was given again the following year to a group of interested students involved with the American Cetacean Society club at the University of Hawaiʻi at Hilo.

MOP Symposium

A 15-minute presentation was given at the 2017 Marine Options Program Annual Symposium. A brief overview of the workshop, as well as how this subject is relevant to current research in marine sciences, was discussed. A few videos and sound files were included in the presentation. Despite some technical difficulties, the presentation attracted the attention of some of the attendees. The interested participants wrote down their contact information, and were sent the tutorial PowerPoint at a later time.

Conclusion

The process of creating a tutorial using the Raven Manual was very time consuming. It was difficult determining what was important to include and what could be left out. Fortunately, with the aid of graduate students proficient in using the program, I was able to successfully include the key important features that a novice bioacoustician would need to navigate the program for research in the field.

The workshop portion went smoothly, and students expressed that they felt they had learned some valuable skills and information about bioacoustics throughout the process. Since the workshop coincided with many of the participant's actual class time, of the 18 students that attended the lecture portion, only 6 students stayed for the activity in the lab.

The symposium went relatively smoothly, although there were a few technical difficulties that ended up effecting my overall presentation. Some of my video and sound files did not work, which could be attributed to the fact I made my PowerPoint using the 2017 MAC version and it was presented on a PC with an older version. Another obstacle was the fact that there were no external speakers available for the presentations, so in order for the audience to hear any sound, I had to actively move the microphone towards the laptop during the presentation. I already have an aversion to public speaking and get very nervous when presenting, so these added stressors definitely effected my ability to convey information about my project successfully. After the presentation, many students representing other schools approached me and seemed interested in learning about bioacoustics and receiving a copy of my tutorial PowerPoint. They wrote down their contact information and were sent copies via email a few days later.

Overall, it seemed as though many individuals were interested in learning more about bioacoustics and it became unquestionably clear that there needs to be more information regarding this subject available for students. The tutorial I created is now available for anyone who requests it online via the Marine Options Program Google Drive.

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