Localizing Crow Vocalizations in Social Aggregations

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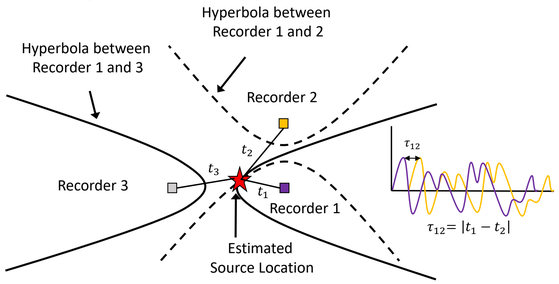
Motivation

To localize simulated and experimental playback of crow vocalizations using an array of remotely activated, time synced microphones. Eventual goals include localizing live calling crows in large social aggregations

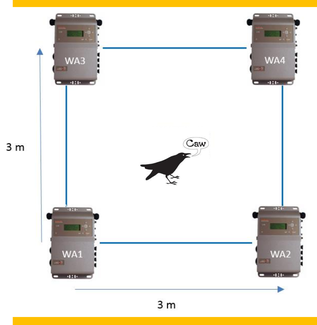
Time Difference of Arrival Method

The Time Difference of Arrival (TDOA) method is used to localize individual callers in a two dimensional space defined by an array of microphones. Through the use of hyperbolas, and with the knowledge of when a signal reaches each microphone, we can locate the origin of the signal within the confines of our array.



Simulation

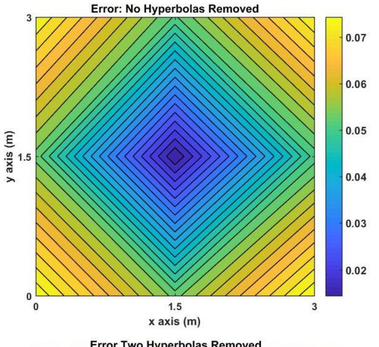
Simulation Setup



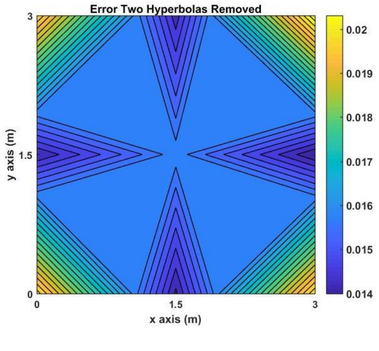
For simulated testing, the following setup and specification were used.

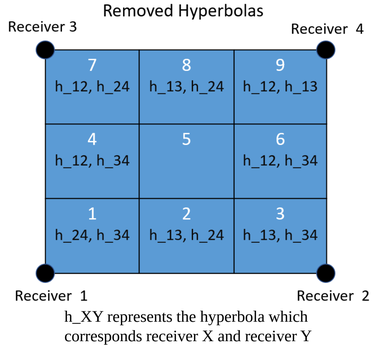
- Sample Frequency: 48000 Hz
- Bandwidth: 500 Hz – 2500 Hz
- Simulating signal: recorded crow caw
- Simulated space size: 3m×3m square

Error Analysis



As only three audio recorders are needed for localization, a fourth recorder allows for the removal of inaccurate hyperbolas from our localization. To further decrease error, we examined the effects of removing certain hyperbolas from sections where they displayed the greatest error. This error was calculated by averaging the errors from 1000 runs of our simulation. Through this analysis, we reduced our greatest error by a factor of three.





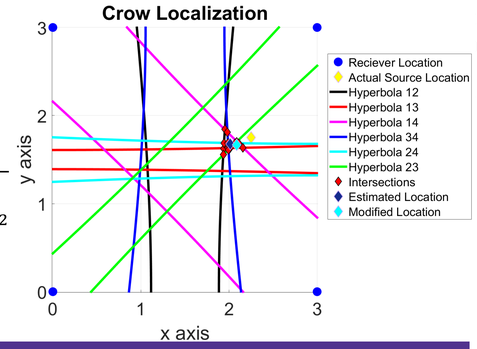
h_XY represents the hyperbola which corresponds receiver X and receiver Y

Simulation Results

Still using simulated data, the origin of the source was calculated through the intersecting hyperbolas and TDOA, where the source's location, in x and y coordinates, is defined by:

$$x_S = \sqrt{\frac{1}{N}\sum_{n=1}^{N}|x_n|^2}\ , y_S = \sqrt{\frac{1}{N}\sum_{n=1}^{N}|y_n|^2}$$

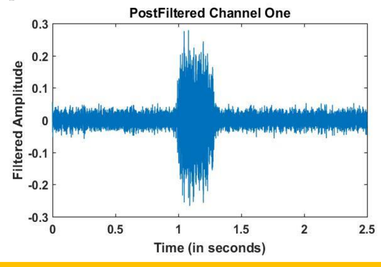
The known location was plotted separately to examine error.

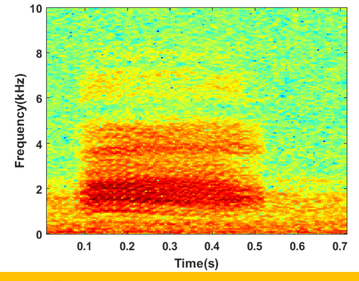


Experiment

Introduction: Caw Call

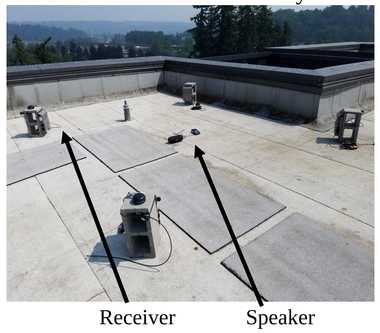
Initial detection methods were tested with a 0.3 second duration crow caw, also referred to as syllables, played on our omnidirectional speaker. Crow calls may be comprised from two to nine caws.





Experimental Setup

For our experimental playback trials, we chose a rooftop location where crows aggregate nightly prior to moving onto their communal roost. Recorders: Song Meter SM3 Bioacoustics Recorder. Playback Device: Omnidirectional Bluetooth speaker

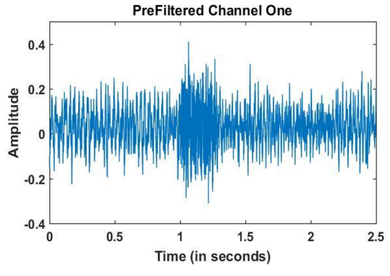


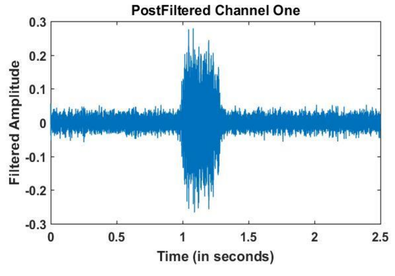
Receiver

Speaker

Noise Filtering: MATLAB Butter Filter

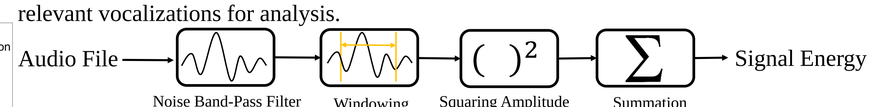
Approximately 7m from our planned recording location, multiple HVAC fans created noise in our audio recordings. By using a band-pass filter between 500 Hz and 2500 Hz, we maximized the information obtained from the crow vocalizations and minimized noise.

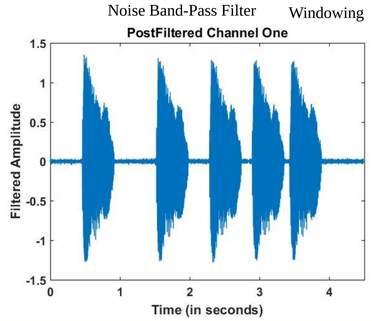


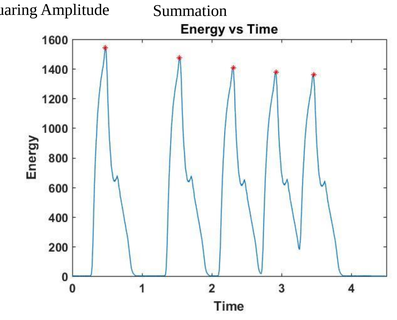


Caw Detection[1]

In anticipation for long wildlife recording sessions, where there will be multiple calls from multiple animals, we hope to automate the process of identification and isolation of relevant vocalizations for analysis.

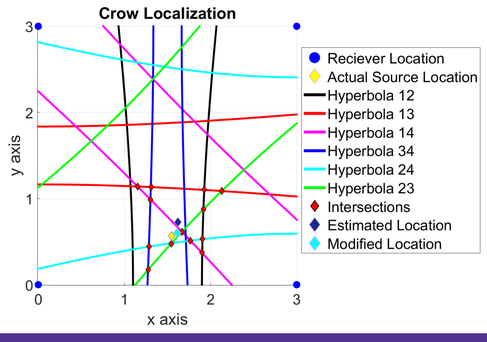






Experimental Localization[2]

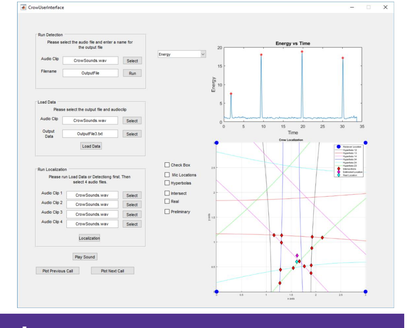
Crow caws were isolated from recordings of real crow calls obtained from xeno-canto, an online repository for recorded bird sounds. Individual caws were played from an omnidirectional speaker at known locations within our grid, giving us enough data to test our localization, data acquisition, analysis methods as well as future detection methods. As methods improve, we will make our playback recordings more complex in anticipation of more realistic recording environments.



Future Work: Graphical User Interface

To tie Call Detection, Localization, and Analysis together, a Graphical User Interface is being developed, through MATLAB, tailored to the needs of Biology researchers at UW, to assist them in remotely identifying individual calling crows in large aggregations and automate the extraction of specific acoustic characteristics of their vocalizations.

At this time we are ready to start recording free-living crows on pre-roost aggregations.



Conclusion

We've been able to isolate individual caw syllables from experimental playbacks within 0.6 and 27 cm of the source location. Based on previous observations of crow behavior, we should be able to adequately resolve individual crows within aggregations using this approach.

References

1. Deng, Z. D. et al (2013) "Design and Implementation of a Marine Animal Alert System to Support Marine Renewable Energy," Marine Technology Society Journal Vol. 47(4).
2. 2. Recording obtained from http://www.xeno-canto.org/.