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Design, Simulation and Testing of Biomimetic Directional Acoustic Sensors

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Abstract

The Ormia Ochracea, a species of parasitic fly, has become the focal point in sound localization research because of its finely tuned hearing abilities. The female of this species uses its super highly directional hearing to pinpoint the call of a host cricket, with hypersensitivity of frequency and phase difference, to reach and dispose of its eggs on the host. The goal of this study was to further the research of a previous Project in Professor Guvench's group which implemented MEMS (Micro Electro-Mechanical System) technology on a chip to replicate these abilities. In this iteration, however, some commercially available large piezo-electric guitar microphones were shaped to implement and test an upscaled version of the previous designs. Because MEMS are costly and fragile, this project required us to build and test a more affordable and durable representation of the Ochracea's hearing and make highly directional microphones and create a test platform for directional response. The upscaled designs have been tested using a sound treated container, shaped as a cube, to reduce ambient noise and interference, as well as reduce reflection of the acoustic waves. Testing was performed with a frequency sweep to test frequency selectivity, with the sound source at different angles of incidence to the microphone. This characterizes its directional sensitivity.

Overview

This project is designed to isolate the microphone and rotate it to test the response at different angles of incidence. The device is a scaled-up version of the original MEMS design. Testing is being performed synchronously with Colby Damren, another EE student with a similar project.

The microphone has two modes, known as tilting and flying. In tilting mode, the device is stimulated on one side, forcing the other side to lift. In flying mode, both sides of the device are engaged to produce maximum output. Hence, device response depends on the angle of the sound being applied.

Figure 1 – Shaped Piezo Mic

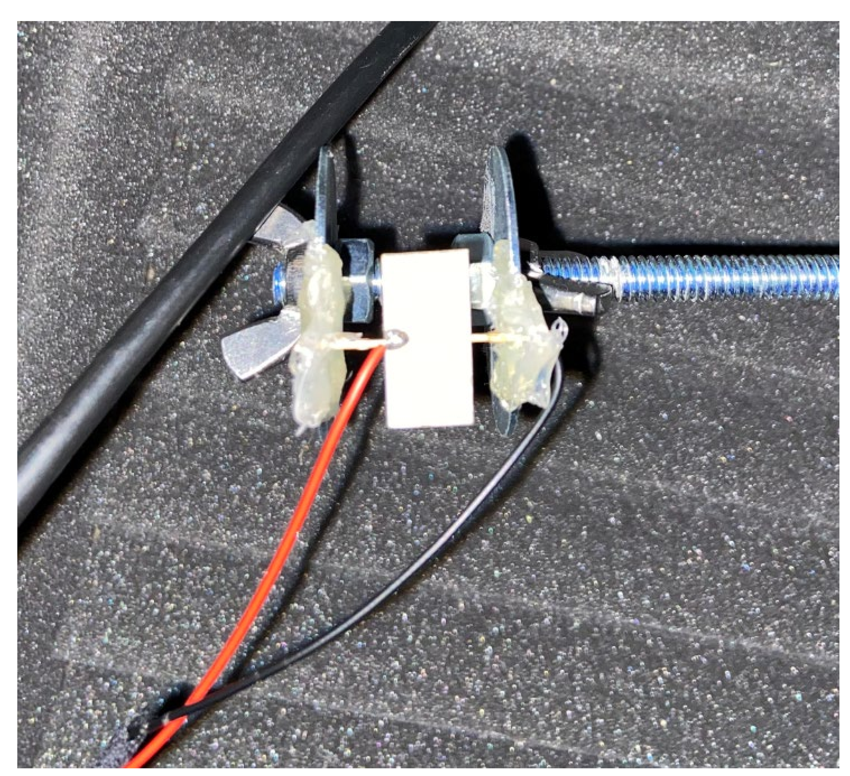


Figure 2 – Test Apparatus (speaker and amplifiers shown)

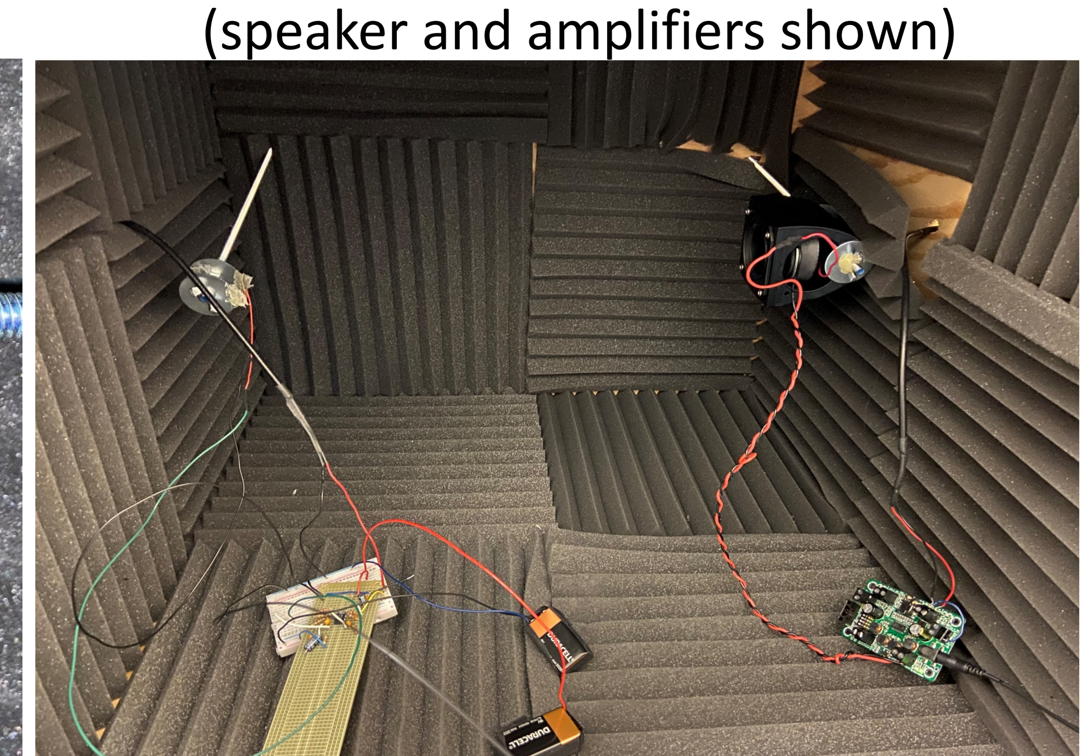


Figure 3 – Tilting Mode

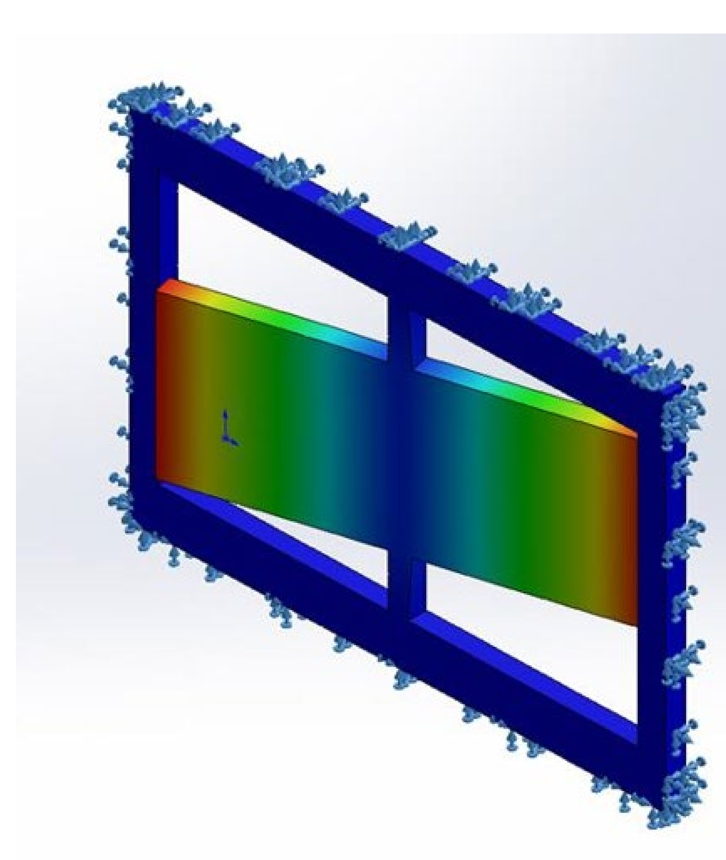
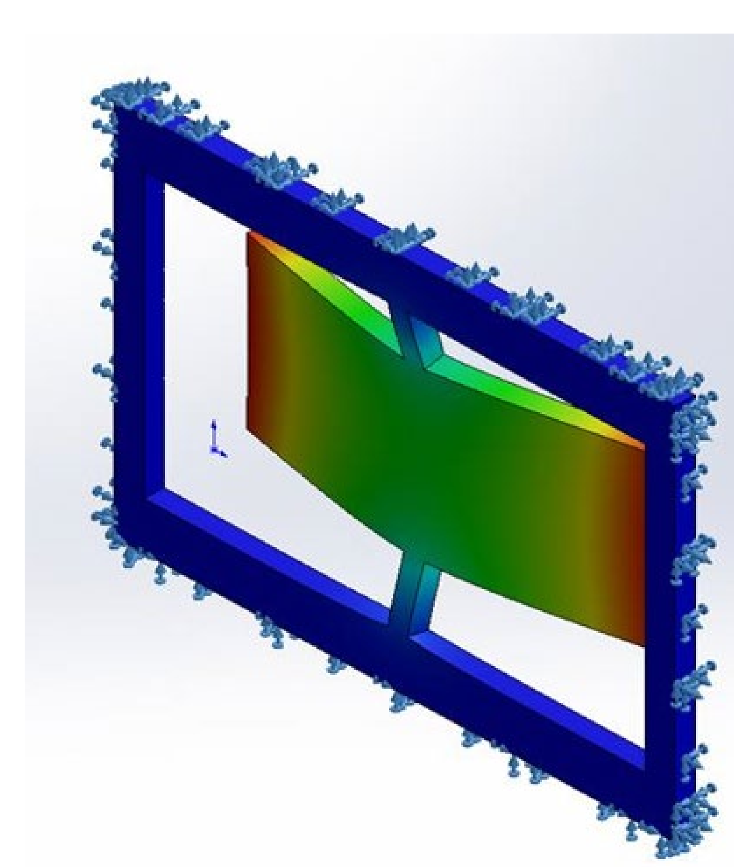


Figure 4 - Flying Mode



Methods

An acoustic isolation chamber was constructed to assist in reducing outside interference. The chamber is equipped with two threaded rods from which to hang the speaker and microphone.
Once the box is closed, the angle of the microphone can be adjusted by turning the rods from outside the chamber. This is meant to prevent the necessity of opening the chamber to change the angles for every test. Mounts have been 3D printed to host the microphone in a stable manner.
Using the USM CIE lab's Bode program, the devices response to a frequency sweep can then be recorded. Once the data is acquired, Excel is used to plot the response data at each angle and compared to the other angles of incidence to determine directionality.

Conclusions & Next Steps

Preliminary data suggests that the microphone does demonstrate directionality, however, at some angles the results were not what was expected. This design will continue to be tested with better quality representations of the device. This requires a more precise shaping of the piezo devices, and better support (spine) for the device.
Furthermore, the testing apparatus is slightly crude and needs some updating, such as better securing of the acoustic tiles, and better routing for the wiring.

Acknowledgements
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