CALIFORNIA STATE SCIENCE FAIR
2006 PROJECT SUMMARY

Name(s)

A. Si-Si Hensley

Project Number

J1512

Project Title

Marco Polo Dolphin Style: How Accurately Can Direction Be Determined by Animals using Echo Location?

Abstract

Objectives/Goals

The objective of my project is to determine how accurately can animals that use echolocation determine the direction to an object and how is the accuracy affected by frequency, separation of the ears and background noise?

I hypothesized that angle estimates using sound waves with a lower frequency will not be as accurate as waves with a higher frequency, that the closer the ears of the animal are together, the less accurate their ability to determine direction and that the more noise the less accurate the direction estimate.

Methods/Materials

Materials used in my project included: Meter stick, protractor, T-square, 2 microphones, 1 Apple I-Pod earphones (used as a speaker), PC and sound card in PC, digital thermometer, Goldwave Software, homemade anechoic chamber made from foam board, thick packaging foam, glue and duct tape.

I conducted my experiment using two different frequencies (7500 Hz and 11000 Hz), two separations of the ears (6 and 10 cm), a number of different angles from -15° to 15° , and three different noise levels (no noise, 1/3 noise amplitude compared to the signal, and equal amplitude of noise and signal). A sound card emitted a sound signal with a wave of a specified frequency plus noise at a specified level. Two microphones were placed the opposite ened of the anechoic chamber (built at home) separated 6 or 10 cm. Using a computer and the sound card I recorded the received signal at the two microphones.

Results

Using the recorded sound signals, I observed the time shift in the received signals that varied with angle. I calculated the estimated angle based on the ratio of the amplitudes of the sum signal (addition of the two signals) and difference signal (subtraction of the signals), the separation distance of the microphones and the wavelength. Six estimates were made for each angle and the mean was my estimated angle and the standard deviation the error estimate.

Conclusions/Discussion

The conclusions of my experiment were: There is maximal angle for making good angle estimates that depends on the wavelength, w, and separation distance between the ears, L, given by (w/2L). The greater the frequency or separation between the ears the more accurate the angle estimate. As the noise increases the angle estimate is under estimated. Dolphins and bats may be able to estimate direction to better than 0.2° for an angle range of about ±4° and ±6° for dolphins and bats respectively.

Summary Statement

This project determined the accuracy for which animals using echolocation can determine direction as a function of separation distance between the ears, sound frequency and noise level using a PC sound card and a homemade anechoic chamber.

Help Received

My dad helped me learn the math needed (basic trigonometry) and the mathematical description of waves. My mother helped me to learn how to use the Goldwave software (for the sound card). My dad helped get the sound card data into Excel. My parents also helped me build the anechoic chamber.