

The beam aim of echolocating bats tracking moving and stationary prey

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Introduction

- Bats use **echolocation** to forage for food
- They emit ultrasonic chirps and listen to the echoes from their surroundings
- The positions of the echoes and their spectral characteristics help the bat to orient towards and to identify various objects in the environment

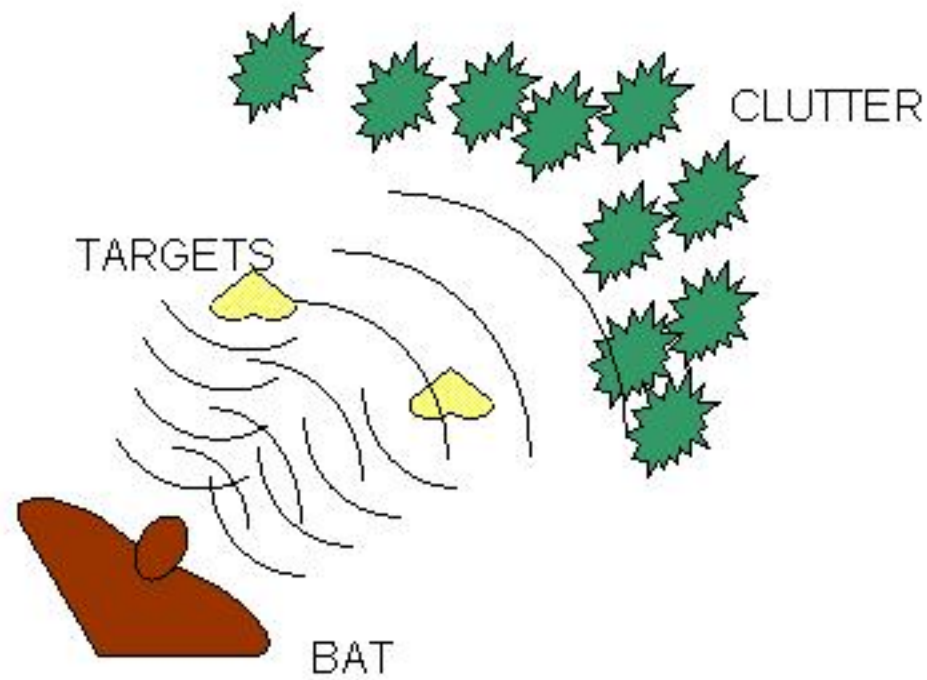


Figure 1. Echolocating bats send out ultrasonic pulses and use the echoes to sense their environment.

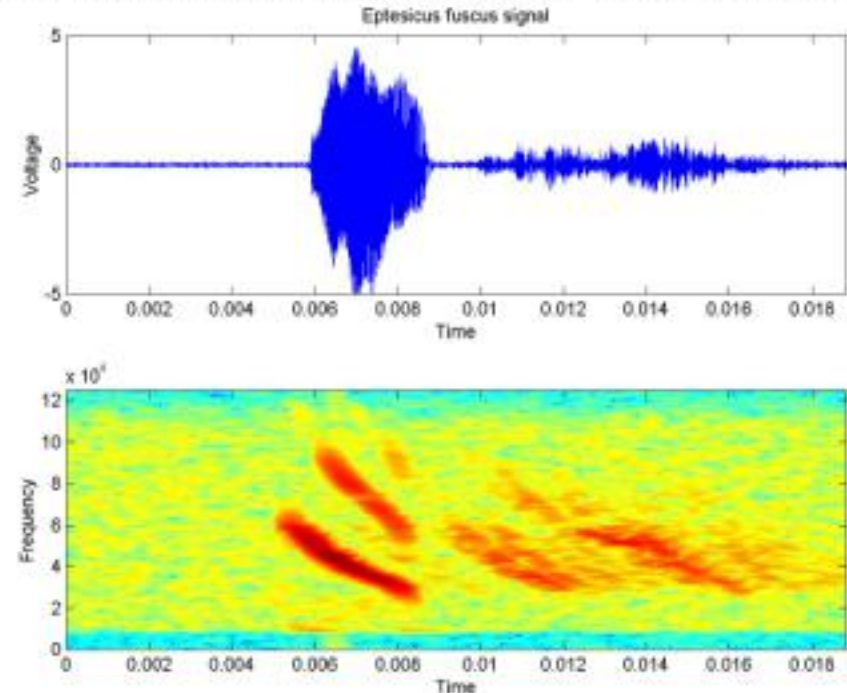


Figure 2. A sample bat sonar pulse.

- The sonar beam is directional

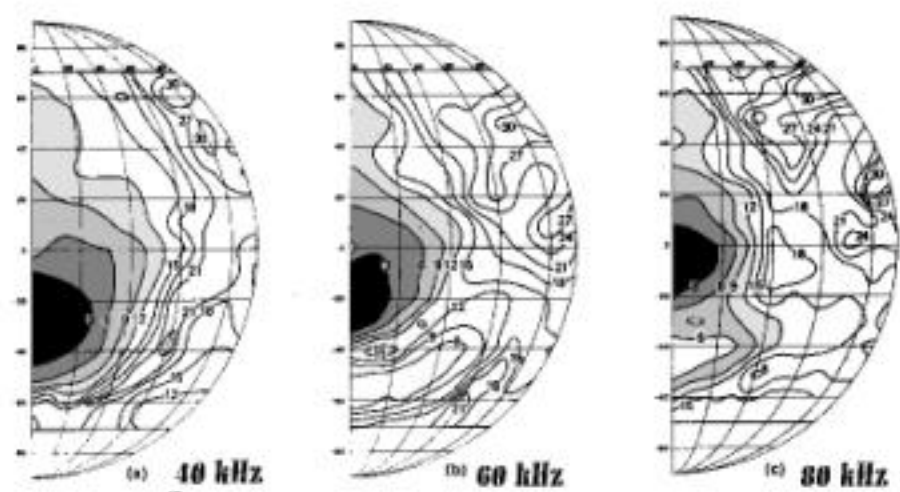
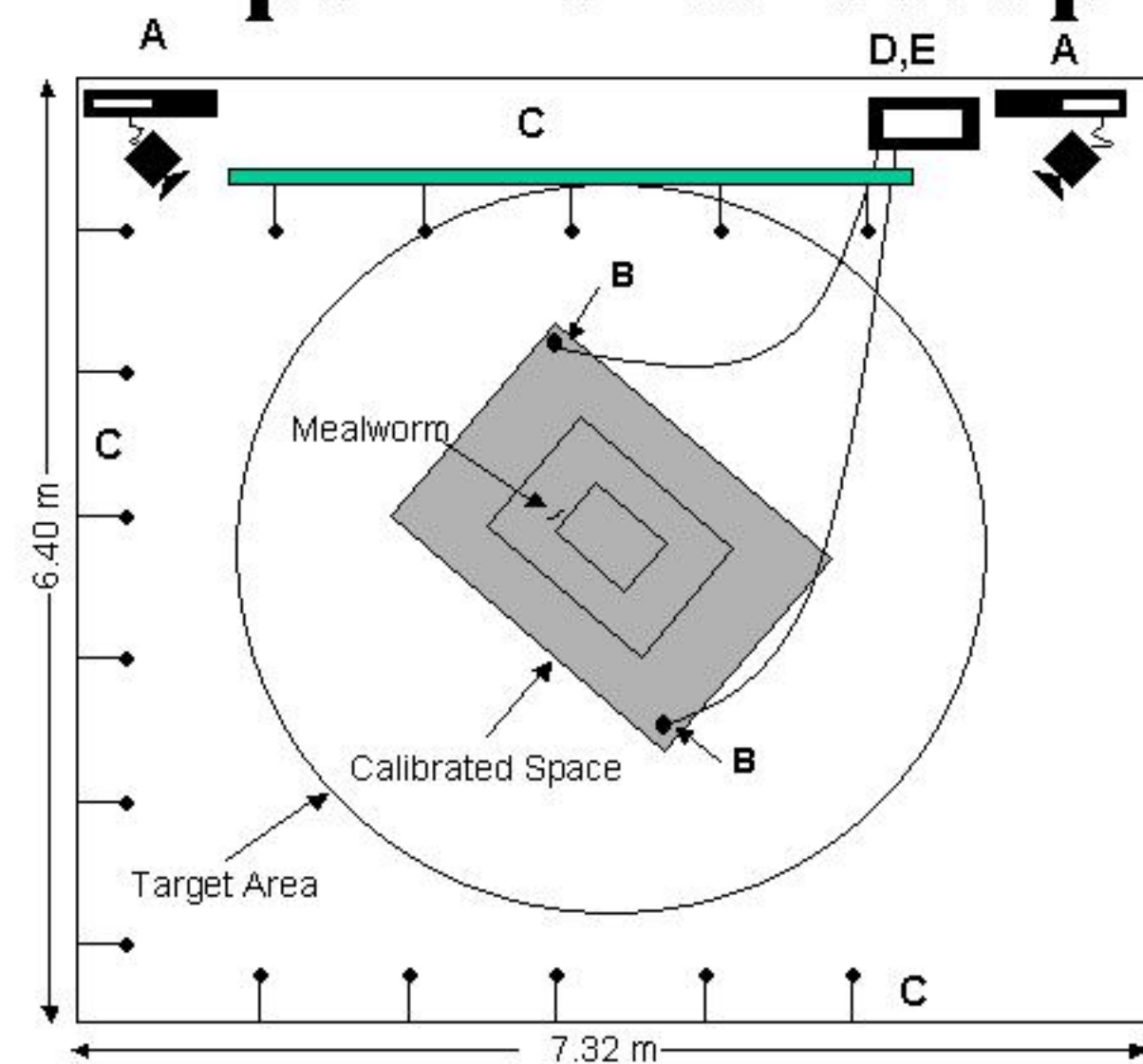


Figure 3. Iso-intensity contour plots of a bat vocalization at three different frequencies. The bat's head is aligned centrally (0,0). The mouth points slightly downwards in elevation. The beam has a prominent main lobe (black region) which spans approximately 40 degrees in azimuth. The beam is directional. Plot taken from Hartley and Suthers (1989).

Hypothesis

The sonar beam direction of the bat may be used as an index of selection and tracking while the bat forages for prey

Experimental setup



VIDEO

- 2 Kodak MotionCorder IR sensitive cameras
- Images captured at 240 frames/sec
- 3D flight path reconstruction using DLT transform

AUDIO

- 2 Ultrasound advice microphones
- Signal bandpass filtered and amplified between 10 kHz and 100 kHz
- Sampled at 250 kHz each channel

ARRAY

- 16 microphones arranged in a planar 'C' shaped array
- Signal envelopes digitized to compute an azimuthal section of beam pattern offline

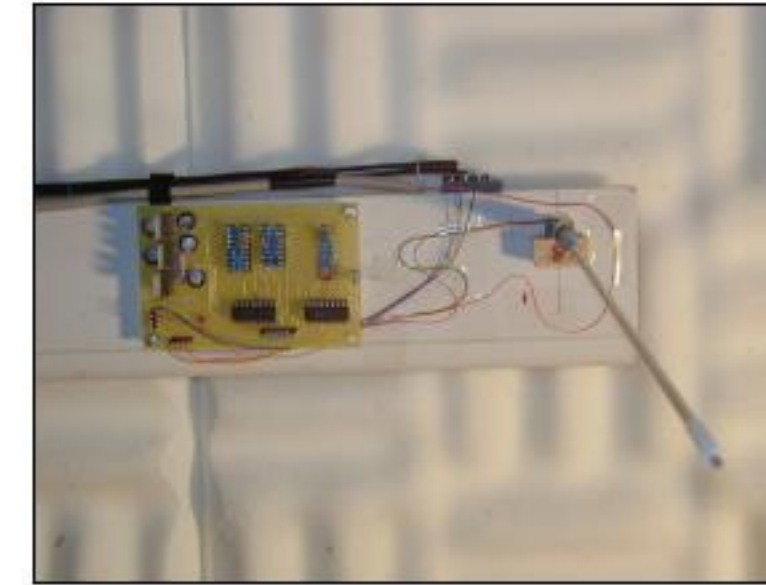
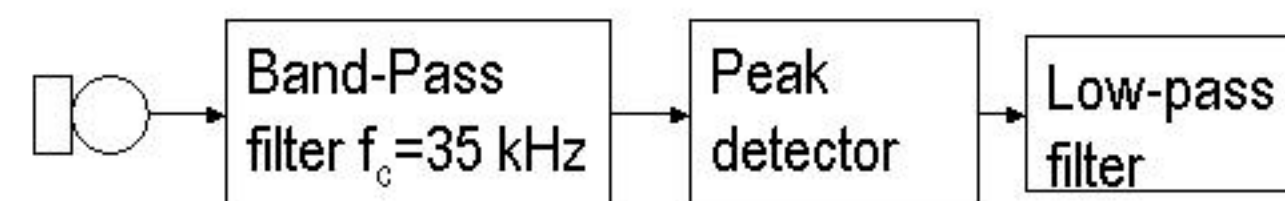


Figure 4. This is a photograph of one of the array elements. The tall stalk supports the microphone at its tip. The envelope extractor is on the circuit board.

Results

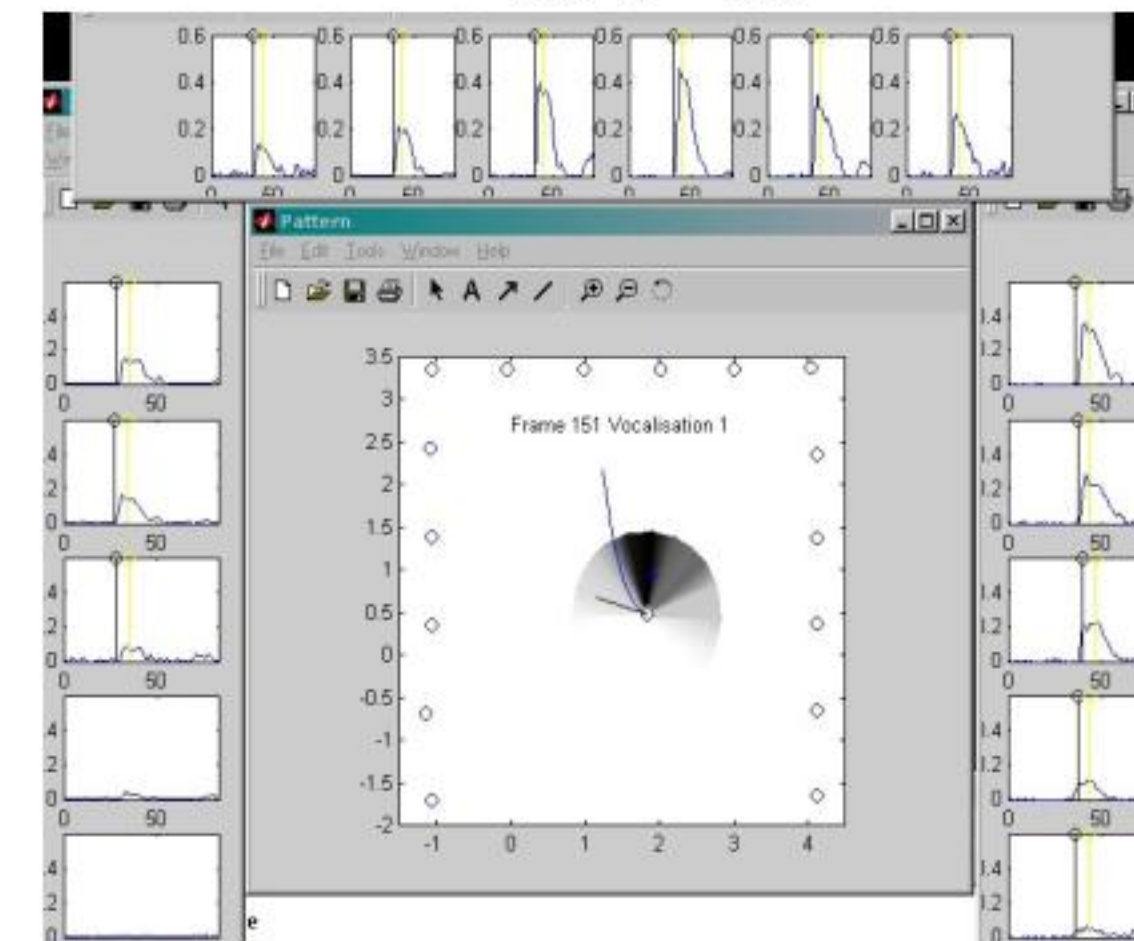


Figure 5. The outer panels show digitized envelopes from each microphone. The inner plot shows a reconstruction of the beam pattern section the array measures. The darker regions indicate higher intensities. The beam aim is computed as the resultant of vectors drawn from the bat to each microphone with length proportional to the measured intensity at that microphone.



Figure 6. Overlay of reconstructed beam pattern and close up picture of a bat.

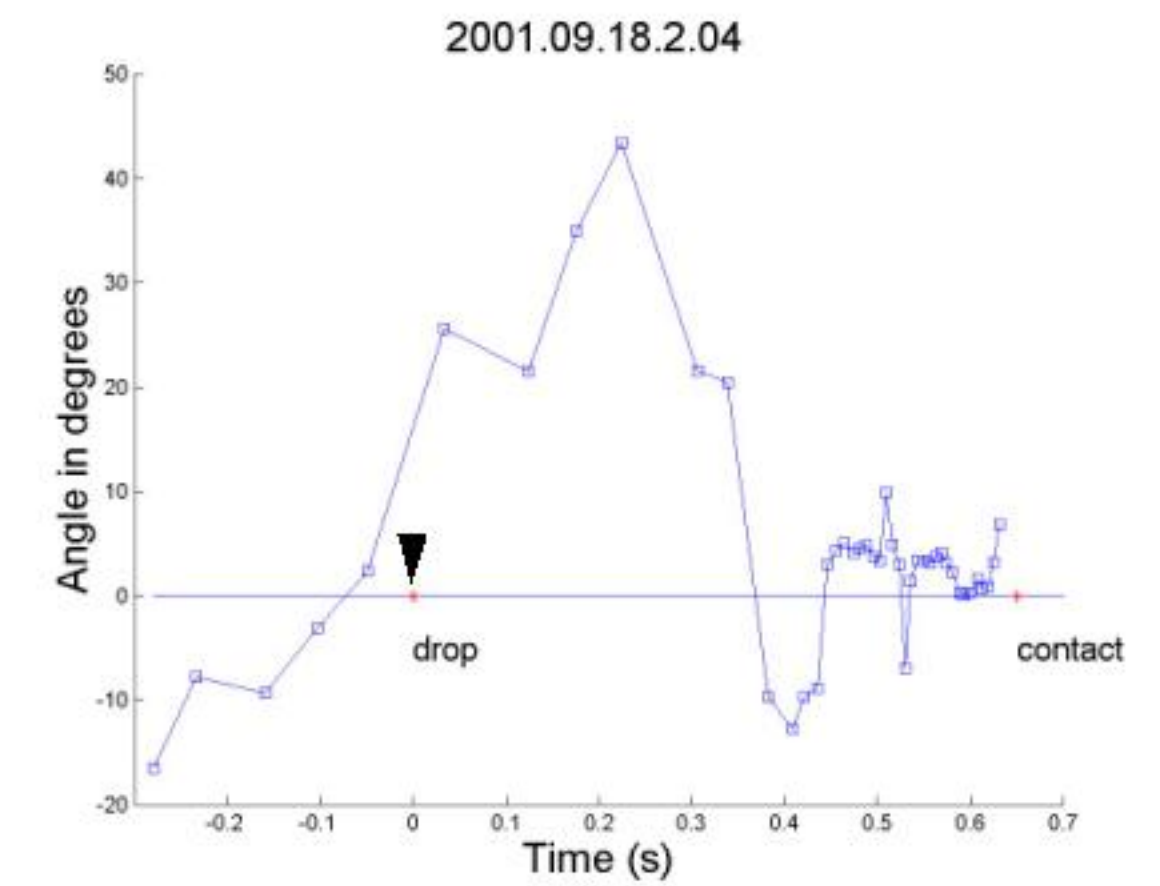


Figure 7. This figure shows the beam aim of the bat as it searches for and then detects and captures a mealworm dropped into the flight space at the moment indicated by the arrow.

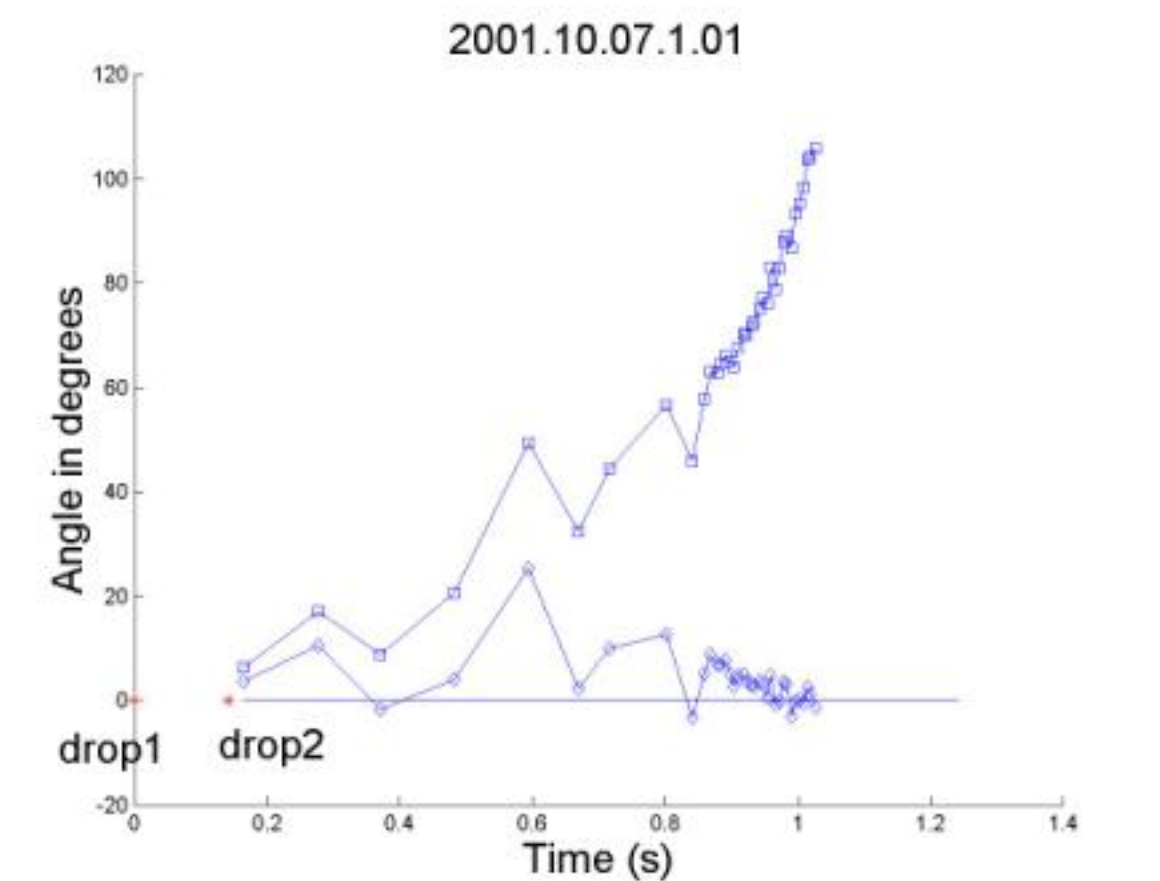


Figure 8. This figure shows the beam aim of the bat as it selects on target of two and captures it.

References

- Hartley and Suthers (1989) "The sound emission pattern of the echolocating bat, *Eptesicus fuscus*", *Journal of the Acoustical Society of America*, 85(3) pp1348-1351
- Masters, Moffat & Simmons (1985) "Sonar tracking of Horizontally Moving Targets by the Big Brown Bat *Eptesicus fuscus*", *Science* June 14;228(4705):1331-1333