PHOX Ears: Parabolic, Head-mounted, Orientable, eXtrasensory Listening Device

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ABSTRACT

The Electronic Fox Ears helmet is a listening device that changes its wearer's experience of hearing. A pair of head-mounted, independently articulated parabolic microphones and built-in bone conduction transducers allow the wearer to sharply direct their attention to faraway sound sources. Joysticks in each hand control the orientations of the microphones, which are mounted on servo gimbals for precise targeting. Paired with a mobile device, the helmet can function as a specialized, wearable field recording platform. Field recording and ambient sound have long been a part of electronic music; our device extends these practices by drawing on a tradition of wearable technologies and prosthetic art that blur the boundaries of human perception.

Author Keywords

hearing, sensory augmentation, ambient music, field recording, parabolic microphone, wearable technology

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing, H.5.2 [Information Interfaces and Presentation] User Interfaces—Haptic I/O

1. INTRODUCTION

Field recording has played a formal role in music at least since the advent of Pierre Schaeffer's musique concrete in the late 1940s. The subsequent emergence of soundscape, coined by R. Murray Schafer in the 1960s, and the field of acoustic ecology brought natural sound and 'immersive experience' into the compositional toolbox. More recently, the field of human-computer interaction (HCI) has begun to investigate wearable technologies that *immersively* augment human perception and experience [5]. Bridging these domains, theorists have raised questions about the nature of immersion in soundscape and beyond, particularly the ways in which these works are about being continuous (one with) with space and at the same time predicated on technologies of recording and playback [2]. Helmreich writes:

> The soundscape is shadowed by an acoustemology of space as given and listener as both apart from the world and immersed in it [2].

NIME'15, May 31-June 3, 2015, Louisiana State Univ., Baton Rouge, LA.

Figure 1: PHOX Ears device

Motivated by this shared quality of soundscape and prosthetic technology, we present PHOX Ears, a listening device that conspicuously changes its wearer's experience of hearing. A pair of head-mounted, independently articulated parabolic microphones allow the user to sharply direct their attention to distant sound sources, which are amplified and presented by built-in bone conduction transducers or optional external headphones. The microphones are mounted on 2-degree-of-freedom (2-DOF) servo gimbals for precise positioning; joysticks in each hand control the gimbals independently. Paired with a mobile device with a recording input, the helmet can function as a specialized, wearable field recording platform with live monitoring and precise control over the targets of the parabolic microphones.

This project is preceded by a long history of both auditory augmentation and sound art, which we can only briefly review here. Patents for specialized hearing enhancement devices began to appear in the late 1800s. Alfred M. Mayer's 1880 *topophone* [3], for example, was used to aid in navigation through fog. Passive acoustic locators consisting of

Figure 2: Meyer's "turning sound receptor" and Auscher's "acoustic marine locator"

two parabolic reflectors/ horns guiding the sound directly acoustically to the ears of the operator were used extensively during World War I to determine the distance and direction of ships and aircraft in limited visual environments [1]. The shape and form factor of our device inherits from the designs of these early technologies, though ours is an active system.

Presented at NIME2014, Dennis Van Tilburg's *Musique Parabolique* [6] brings the public through a sonic journey in the neighborhood. Equipped with a hand-held parabolic microphone and a portable sampling system, the artist creates a focused real-time location specific soundscape piece. Our device is inspired by Tilburg's project but lets one user select the sounds source location he wants to focus on.

2. ELECTRONIC FOX EARS

The PHOX ears system consists of a modified skateboard helmet with gimbal-mounted parabolic reflector microphones on each side. The mechanical part of the PHOX device uses standard Hitec HS-645MG servos controlled by an Arduino microcontroller and mounted on pan-and-tilt gimbal brackets. The brackets are attached to wooden blocks which are in turn mounted on the helmet, providing enough clearance for rotation of up to 110 degrees around the horizontal axis and up to 140 degrees around the vertical axis.

Firmware on the microcontroller allows the user to simultaneously move the servos using analog 2-axis thumb joysticks in handheld 3-d printed enclosures. The motion of the servos is interpolated for smooth operation. To activate the controls, a user presses down on the joystick select button and moves it to the desired position. The servos lock in position when the button is released. A quick tap on the joystick returns the ears to the home position.

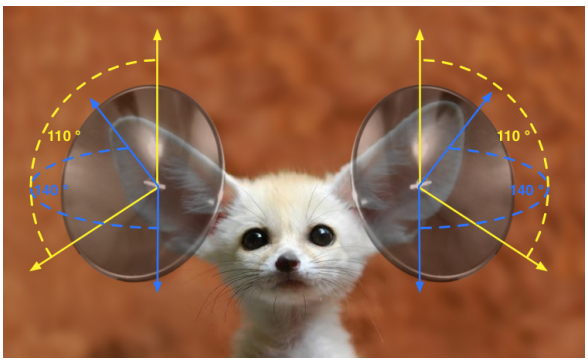

Figure 3: The PHOX Ears device is inspired by the desert fox, which uses its large ears for extremely sensitive hearing in the wild.

We used Primo EM172 electret condenser microphone capsules for low noise at high gain. The microphones are amplified using two stages of Burr-Brown OPA132 series op amps per channel. An initial high gain stage provides a line-level output for recording and a second lower gain stage acting as a headphone amplifier. The system has a maximum effective gain of 500 across the two stages, though in practice we use half that. The microphone capsules are mounted at the focal point of each 12-inch parabolic reflector, 3-inches from the bottom surface. To reduce noise from the servos, we used isolating neoprene washers and wrapped the capsules in rubber jackets.

The PHOX ears device can be used in a variety of contexts. In a natural setting, users can listen to distant wildlife, or to experience hearing more akin to that of a woodland animal. In an urban or social setting, the device appears to some as a spy technology. Besides giving the user a different experience of car sounds, work sounds, or unintelligible crowd sounds, it can also be used to eavesdrop on conversations. Turning the reflectors towards one's own body enables the user to focus on self-triggered sounds such as footsteps, heartbeat, breathing, etc. This circumvents our natural tendency to filter out these self-produced sounds [4].

Figure 4: Using the PHOX Ears in a natural setting allows a user to focus on distant wildlife (illustration by Caroline Claflin).

3. CONCLUSIONS & FUTURE WORK

The PHOX Ears device brings developments in augmented human / prosthetic HCI into soundscape and field recording practices, enabling a user to experience a different kind of hearing while capturing distant sound in their environment. Despite our best attempts to isolate the microphones from vibration, the most pressing issue in our present system design is servo noise. We are working on 2 solutions to this problem. The first is to perform an analysis of the motor sound and build a filter to notch it out of the audio signal. Second, we are designing an alternative actuation scheme that would using clamping brakes to silently hold the servo positions while at rest. This approach would also reduce energy consumption and stress on the motors. Finally, we intend to develop an app for the wearer's mobile device that would act as a remote control, real-time signal processor, and sampling interface, capturing audio and controlling the motors over a Bluetooth wireless connection to the helmet. We see the PHOX ears as an exploratory step towards a blending of soundscape practices with wearable technology.

4. REFERENCES

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