LISTENTREE: AUDIO-HAPTIC DISPLAY IN THE NATURAL ENVIRONMENT

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ABSTRACT

In this paper, we present ListenTree, an audio-haptic display embedded in the natural environment. A visitor to our installation notices a faint sound appearing to emerge from a tree, and might feel a slight vibration under their feet as they approach. By resting their head against the tree, they are able to hear sound through bone conduction. To create this effect, an audio exciter transducer is weatherproofed and attached to the tree trunk underground, transforming the tree into a living speaker that channels audio through its branches. Any source of sound can be played through the tree, including live audio or pre-recorded tracks. For example, we used the ListenTree to display live streaming sound from an outdoor ecological monitoring sensor network, bringing an urban audience into contact with a faraway wetland. Our intervention is motivated by a need for forms of display that fade into the background, inviting attention rather than requiring it. ListenTree points to a future where digital information might become a seamless part of the physical world.

Figure 1: A spectator pays a close ear to the excited tree.

1. INTRODUCTION

We consume most our of our digital information through dedicated portals—devices we wear and carry with us—that tend to demand attention and remove us from our surroundings. Over nearly two decades, researchers have been motivated by these issues to create so-called calm technologies, where interaction can occur in the user's periphery, inviting attention rather than requiring it [1]. Inspired by ambient interfaces, and looking for new ways to embed information in the natural environment, we present ListenTree, an audio-haptic display that invisibly introduces sound and vibration into trees, enabling passers-by to hear sound through bone conduction when leaning against an instrumented tree and feel vibration when touching it or walking nearby.

To create this effect, an audio exciter transducer is attached to a tree trunk several inches underground. A nearby solar-powered controller provides computation and wireless network connectivity, and drives multiple transducers independently using underground cables, allowing the whole system to be off-grid. Our approach lets the technology disappear from a user perspective, producing an almost magical effect of sound seeming to emerge from inside the tree itself. We have used the ListenTree in a number of installations with both live and pre-recorded sound. Currently, we plan a number of new, simultaneous installations in museums and at an ecological sensor equipped conservation site, using trees to connect visitors to information and one another in new ways.

Audition through bone conduction occurs when vibration is conducted through a listener's skull and into the inner ear, bypassing the eardrum. One of the earliest examples of bone conduction apparatuses is attributed to Beethoven, who is said to have compensated for his hearing loss by attaching one end of a metal rod to his piano while holding the other between his teeth. Exciter transducers have been used in art (as well as increasingly in consumer products) for several decades. Despite their widespread use, by seemingly magically producing sound through bone conduction and from inside objects, transducers continue to draw audiences in. Early on, Laurie Anderson's installation *The Handphone Table* allowed participants, facing each other at a table, to hear sound when they placed their elbows on the table and their hands on their heads [2]. In his work *touched echo*, artist Marcus Kison used transducers attached to an outdoor railing to reproduce through bone conduction the sound of a Dresden air raid that occurred at the same site [3]. Blurring the space between hearing and feeling, artist Wendy Jacob uses infrasonic and audible transducers in her work with deaf students and collaborators [4].

2. SYSTEM DESIGN

The ListenTree system consists of a single controller unit wired to multiple underground transducers, one per tree. The controller is designed to be a self-powered, self-contained plug-and-play module, adaptable to any tree. We use a 30-watt solar panel to charge a 12-volt, 12-amp-hour battery. In our testing, power consumption varies significantly depending on the audio source, but rarely exceeds 20 watts. Currently, duty cycling is sometimes required to conserve power, though we intend to incorporate motion sensing to solve this problem in the future. Computation and wireless network connectivity is delivered by an embedded computer running Arch Linux and Python for web-based control. We have successfully used both Raspberry Pi and BeagleBone Black model computers, and have come to prefer the latter for its stability, more efficient power regulation, and enhanced performance. Audio signals for each tree are generated on the computer and output through a USB sound card and a 20-watt stereo audio amplifier. Weatherproof connectors (Switchcraft EN-3) on the control module lead to buried speaker cables, which run underground to the transducers. We chose the Dayton Audio BCT-2, a model designed for bone conduction, as it best balanced size, efficiency, and mechanical interface. In many applications besides bone conduction, transducers are affixed to objects using adhesive rings, and are designed to produce audible sound rather than silently conduct vibration. In contrast, bone conduction transducers are usually pressed against the skull using a soft rubber interface to dampen their audible sound. We replaced the rubber interface on the BCT-2 with a hanger bolt so that the assembly could be screwed into the tree approximately 1.5 inches. The transducers were cast in silicone rubber to protect them from the elements. In our testing, 2 transducers remained functional after being underground for nearly 9 months, through the difficult conditions of Boston winter.

2.1. Exhibitions

We have presented ListenTree on several occasions, both indoors and outdoors, streaming live sound as well as pre-recorded audio. The first exhibition, in April 2012, was part of a festival of art and design work at MIT. We chose two medium size trees located in a public courtyard, and used ListenTree to display live streaming sound from outdoor microphones on a wetland restoration site 60 miles away (that site has been instrumented with a sensor network documenting the ecological changes). Our goal was to connect our urban audience to a remote natural environment in transition. The streaming sound captured a lively ecosystem; croaking frogs, chirping crickets, and squawking geese punctuated a background of birdsong and occasional thunderstorms. The inexplicable emergence of these nature sounds from the inside of a tree situated in an urban landscape created a eerie telepresence, drawing spectators in with sound that seemed to blend into the environment but not belong to it. The installation ran unattended and continuously for several weeks; the only description of the project was a small sign placed on the facade of a nearby building. The audience included not only festival attendees but also passers-by drawn in by faint sound or vibration under their feet. Audiences frequently listened in pairs, each holding a branch to their ear.

In summer 2013 we were invited to install the ListenTree at a meeting of diplomats at MIT. For the indoor venue, we placed a potted red maple tree on a pedestal and displayed a selection of prerecorded Chilean poetry. This unusual decontextualization of the tree made it the center of attention, and since the small size of the tree did not allow for simultaneous listening, the audience formed a long line to experience it one by one. In June 2014, a large potted ficus ListenTree will be installed in the MIT Museum lobby, where it will serve a variety of programming.

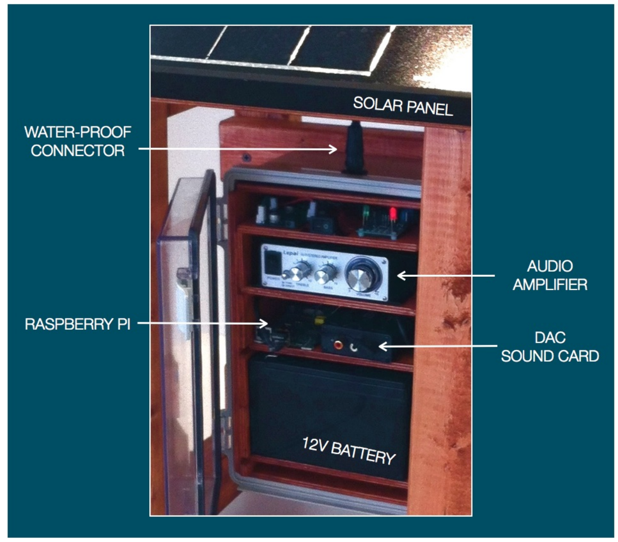

Figure 2: Components of the ListenTree controller.

3. CONCLUSIONS AND FUTURE WORK

We are planning a number of new exhibitions of the ListenTree. In a forthcoming wetland installation, the trees will be used to connect visitors to the environment through sonification of the ecological data we are collecting, as well as through display of live and recorded sound from the site itself. For example, the tree could play sound recorded from the summer in winter, or night in day. For the MIT Museum exhibit, we are developing a tree-to-tree portal, so live sound can flow back and forth from the indoor installation to a tree in a public square. Many of our ideas rely on developing a method for user touch input; currently we are experimenting with swept-frequency capacitive sensing as in [5]. We have had some success, especially indoors where the tree's electrical ground can be isolated, but more work is required. For power savings, we intend to add motion sensors to the controller.

In its early exhibitions, audiences have found the ListenTree to be magical, yet understated—producing mysterious sound and vibration in a wholly unexpected place, but never demanding their attention. We are excited by the possibilities of using this form of display to bring audiences closer to the nature in their midst, giving trees a voice in a cacophonous digital world.

4. REFERENCES

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