SpeakerPhone: a platform for dynamic human-navigable soundscapes

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ABSTRACT
SpeakerPhone is a high-density array of speakers for presence applications. Scenarios for its use include networked soundscapes, data visualization and spatialization, interactive location-based narratives, and customizable sound landscapes. SpeakerPhone is an enabling technology that focuses on the opportunity to provide rich immersive experiences through highly tailored spatial sound environments. It differs from past research in its modular structure for realizing a diverse range of applications and its emphasis on revealing the physical pathways of data through spatialized audio. The project attempts to contribute to an overall infrastructure for human-navigable technology-mediated spaces.

Keywords
Spatialized audio, data visualization, location-based storytelling, responsive audio, telepresence

INTRODUCTION
SpeakerPhone is a framework for creating hybrid spaces combining audio spatialization, data visualization, telepresence, narrative environments, and audience participation. Unlike traditional audio spatialization techniques in which listeners must be passive, SpeakerPhone enables the creation of multi-layered, architecturally integrated, physically-navigable audio soundscapes. These dynamic soundscapes can be controlled telematically or through direct sensor feedback. SpeakerPhone also enables modes of data visualization for information moving across networks as a way of increasing awareness of these concealed information pathways.

RELATED WORK
SpeakerPhone's focus on ubiquitous spatialized audio, data visualization, telematic systems, and narrative spaces uncovers a diverse amount of related work. Projects range from Perry Cook's *NBody* musical instrument modeling project [1], which recreated instrumental sound through specifically arranged speaker arrays, to Interval Research's *ThunderWire* [2], an audio-only media space for networked audio transmissions between remote locations. *VisualRoute* [3] and the Unix *traceroute* utility illustrate methods of accessing and visualizing the physical path of information across international networks. Finally, the interactive Argentina-based performance *De La Guarda* [5] demonstrates the power of a mobile audience mediated by technology.

Benefits of SpeakerPhone
SpeakerPhone's approach differentiates itself from past research by both using sound as a medium to reveal the path of data in a physical space as well as by focusing on scenarios for the capture, transmission, and precise layering of spatial audio information from one architectural environment into another.

TECHNOLOGY
The SpeakerPhone prototype consists of a high-density array of 24 miniature speakers installed in a room at our laboratory [Fig. 1]. These speakers can be controlled via a computer interface to a microcontroller that instantaneously switches between relays that address different speakers in the array [Fig. 2]. The SpeakerPhone architecture provides the ability to create customized effects, such as making a sound travel around the room in various directions and rates of speed, or having a sound follow someone moving through the room.

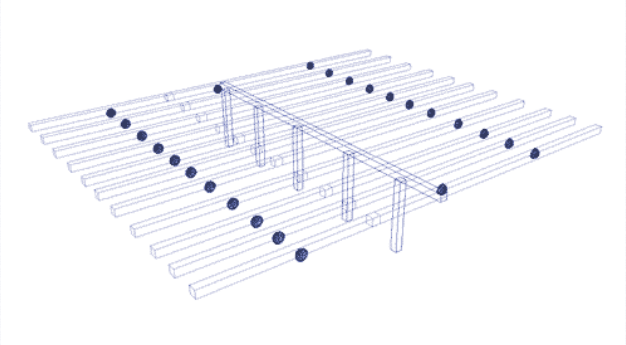

Figure 1. 3D model of the speaker arrangement in a room at our laboratory

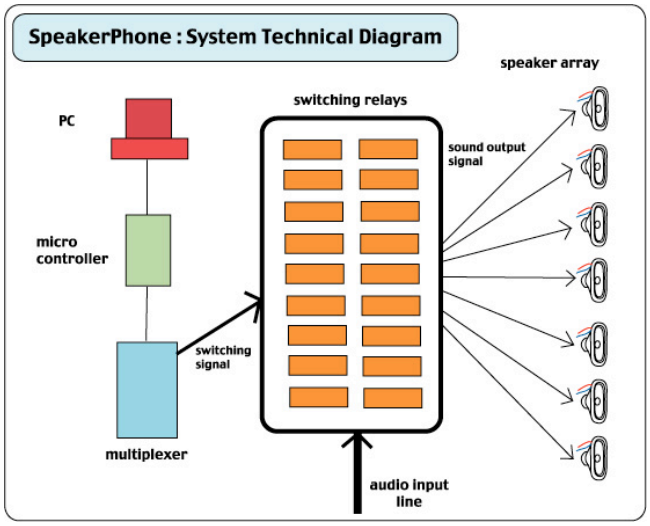

Figure 2. SpeakerPhone technical system

SCENARIOS

SpeakerPhone provides an inexpensive modular platform for the realization of a diverse range of potential applications such as networked soundscapes, data spatialization, interactive narrative environments, and customizable sound landscapes. Below are a few specific scenarios in which the system might be employed.

1. Data Spatialization: Speakerphone uses sound as a means of exposing data moving through physical spaces. SpeakerPhone attempts to free information from the hidden pathways of wires. The movement of sound becomes an audible illustration of the information overload infiltrating our daily connected lives.
2. Networked Audio Mapping: When various necessities dictate our being separated from our friends, family, and colleagues, the need to maintain some kind of contact becomes more urgent. By creating a continuous two-way ambient auditory link between a pair of similar spaces through accurate sound layering, we can create a hybrid "connected" space. Such a scenario would require mirror arrays of microphones and sophisticated echo-cancellation technology.
3. Narrative Audio Targeting: Escaping the passive audience model, SpeakerPhone enables dynamic narrative sound applications and allows for a mobile relationship between audience and content in a story, presentation, or performance. The audience can help drive the narrative because their investment in the narrative becomes both physical and mental.
4. Smart Speakers: Like the Audio Spotlight [4], SpeakerPhone can focus audio on specific locations in a space and transform the audio landscape based on sensor feedback of various kinds. With further enhancement to the technology, individual speakers in the array could be made to sense their surroundings and create dynamic soundscapes based on their proximity to each other or other objects.
5. Telematic Audio Control: Remote networked control of audio placement would allow for collaborative audio environments created across distance by multiple performers or participants.
6. Pathways of Data: SpeakerPhone's node-based architecture enables users of the system not only to dictate the final location of audio but also the path it travels to a specific destination. In this way, the system suggests the ability to customize the routes taken by other kinds of data in communications networks.

FUTURE RESEARCH

Future research on SpeakerPhone will include building a new type of speaker architecture that provides independent computational capability within each speaker node, and forming a self-organizing ad-hoc networking protocol for controlling playback and movement of audio from node to node. Other improvements include equipping each speaker with its own audio processing circuitry and adding a wireless transceiver for collecting new audio data or broadcasting the audio source or stored sound in each speaker to other nodes. This would simplify deployment of the system in new environments and enable it to be controlled via standard wireless networking protocols.

SUMMARY

SpeakerPhone enables the creation of dynamic, physically-navigable audio spaces in which listeners do not have to wear headphones or remain still in one location. The scenarios presented illustrate a variety of application possibilities that relate to interactive narrative, data visualization, spatial audio mapping, collaborative live performance, and ambient communication. The project emphasizes the integration of audio with architectural environments both as an enabling technology for presence applications and as a way of enhancing our understanding of how we interact with digital information in the physical spaces we inhabit.

ACKNOWLEDGMENTS

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REFERENCES

1. Cook, P. R., Essl, G., Tzanetakis, G., Trueman D. N >> 2: Multi-speaker Display Systems for Virtual Reality and Spatial Audio Projection, ICAD '98, Glasgow, UK.
2. Hindus, D., Ackerman, M., Mainwaring, S., Starr, B. Thunderwire: A Field Study of an Audio-Only Media Space, in *Proc. CSCW '96*, ACM Press, 238-247.
3. Visual Route, http://www.visualroute.com (last visited 12 June 2002).
4. Pompei, F. J. The Use of Airborne Ultrasonics for Generating Audible Sound Beams, in *Journal of the AES 47*, 9 (September 1999), 726-731.
5. De La Guarda, http://www.delaguarda.com (last visited 12 June 2002).