VisAural: A Tool for Converting Audible Signals into Visual Cues

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Abstract
Although our senses of hearing, smell, and vision allow us to sense things at a distance, the detection of many day-to-day events relies exclusively on our sense of hearing. For example, finding a ringing phone lost in a sofa, hearing a child cry in another room, locating a dripping tap, and using our car alarm to pinpoint the location of our vehicle in a car park are all initiated by audible signals. However, individuals with total or partial hearing loss have difficulty detecting the audible signals that the rest of the population relies on in these situations. To address this, we are developing VisAural, a system that converts audible signals into visual cues. Using an array of head-mounted microphones, VisAural detects the direction of a sound, and uses visually-peripheral LEDs to guide the user to the source of the sound.

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Assistive Technology, Perception, Hearing, Sensing, Vision

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
For many people, the ability to hear allows them to detect everyday events such as a misplaced phone ringing, a baby crying, and a kettle boiling. But for the large number of people who have a hearing impairment (almost 17% of the population of the UK - 10 million people [1]), the audible signals used to detect these events are not available.

Hearing aids have been developed to help overcome the challenges this presents, but uptake is low (14% of people with hearing impairments in the UK regularly use hearing aids [1]). Many explanations for this low adoption rate have been proposed [8], along with research which indicates that the benefits of hearing aids also vary depending on the cognitive ability of the individual [7]. Finally it has been demonstrated that hearing aids do not preserve spatial information; localisation of a sound source can be performed better without use of a hearing aid [3].

The positional ripples display [5] is one attempt of solving this problem, however it requires detailed knowledge of the deployment location and is therefore not easily adaptable. Similar work on developing a peripheral display of sound was undertaken in 2007 [2], however this solution was not portable. These pieces of work demonstrate the capability to aid individuals through visualisation of audio; both also demonstrate that more abstract visualisations are more effective.

Demonstration

Step 1: The user will wear the eyeglasses connected to the processing device.

Step 2: Sounds will be produced within the room via mobile devices or through noise produced by workshop participants.

Step 3: The user will follow the visual cues produced by the device in order to locate the source of the loudest sound in the room whilst using their sense of hearing in order to evaluate it's effectiveness.

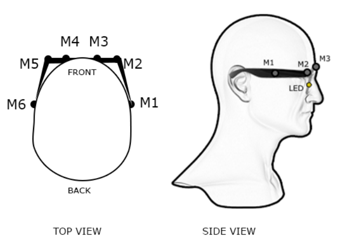

Figure 1:
Top and side view of microphone placement on a pair of eyeglasses.

To address these problems, we propose converting environmental sounds into visible cues. By providing visual cues about sounds around individuals with hearing impairments, they will be able process the signals from the everyday events described above. The visual system is a suitable alternative to the auditory system because out of all our senses, vision is the most synonymous with hearing; both are used to construct spatial understanding of our environment, both enable sensing at-a-distance, and it is arguable that they are the two dominant means with which humans make sense of the world around them. A similar device to the system to be demonstrated at this workshop has been developed [6]. However, evaluations with hearing impaired users were not undertaken so we are developing a similar prototype to evaluate and determine the benefits of such a device.

VisAural

For input, VisAural uses an array of microphones embedded within the frame of a pair of eyeglasses. For output, LEDs are mounted on the extreme left and right of the glasses . Signals from the microphones are passed to a processing unit (an Analog to Digital Converter connected to a Raspberry Pi), which first thresholds the input to eliminate background noise and then through a combination of beam forming algorithms it determines the direction of a sound source. When no sound is detected, both LEDs are off. However, if the loudest post-threshold sound is detected on the left side of the head, then the left LED is activated, signalling the user to turn towards the left. If the loudest sound is detected on the right, then the right LED is activated, signalling the user to turn towards the right. When the left and right have roughly equal volumes, both LEDs activate to tell the user to move straight forward. In this manner, the user will be able to "hone in" on the source of the sound.

Future Work

In the future we will evaluate the tool in a user study with hearing-impaired participants. We will also consider how the LEDs can be used to display other properties of a detected sound, (e.g., intensity) as proposed in [4]. Furthermore, by incorporating a small transparent display, textual descriptions of recognised sounds (e.g., "baby") can be provided to the user. Finally, the end goal of the system would be to combine it with a transparent display and a camera; objects from which sounds originate will be given a visual overlay showing the sound wave "emerging" from the object.

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