DESIGN METHODS AND CONSIDERATIONS FOR CASE STUDIES TARGETING THE BLIND COMMUNITY

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ABSTRACT

Visually impaired people benefit from state-of-the-art technology including mobile devices with high computational capacity, different sensors monitoring the environment or computer applications enabling reading books and accessing information. The sonic information design, however, can differ during development of a wearable, transportable electronic travel aid or during the development of a virtual audio display extending or replacing a standard visual GUI. This paper briefly summarizes some recommendations based on former, recent and future developments to assist blind people.

1. INTRODUCTION

Assistive technologies incorporate solutions that help handicapped people integrate into society, help them in everyday life situations, finding work, aid in sport activities or to simply entertain. Methods and considerations for designing auditory representations are important also for sighted people. Warning signals, speech commands in the GPS device, ring tones or music playback are only some of the good examples. On the other hand, blind people can rely only on auditory and tactile information. From the sound design point of view, the main focus have been on portable electronic travel aids for navigation in unfamiliar spaces; and on traditional computer applications, usually based on a text-to-speech application. Recent research also focuses on alternative sound design methods, spatial rendering of sound sources in virtual or embedded realities and powerful hardware development. Furthermore, mobile devices have become all-in-one solutions by offering sensors, high computational capacity, good quality audio and even tactile feedback (vibrations). Sonification is not only a method to map non auditory events into auditory ones, but a more complex design approach including real sound design based on different paradigms and frameworks, spatial hearing research, development of playback methods/devices or even personalized solutions for different target groups and individuals [1-3].

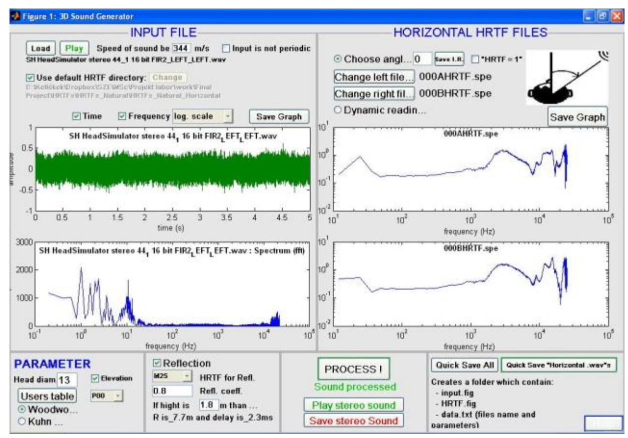

Figure 1: Screenshot of a GUI for spatial hearing experiments in virtual reality. It is capable of testing HRTFs, headphone equalization methods, filtering effects etc.

2. ELECTRONIC TRAVEL AIDS

Electronic Travel Aids (ETAs) are relatively small devices of hardware controlled by a software application. Hardware includes different sensors (ultrasonic, camera etc.), data processors and feedback devices (tactile and/or sound). The main goal of these is to have a lightweight, portable device that scans the environment and gives auditory feedback for the blind user in order to help him navigate in unfamiliar spaces (O&M, Orientation and Mobility). The design approach always begins with the determination what do we have to translate from visual to audible information. ETAs have a long history, so we can find detailed descriptions and comparative evaluation in the literature [3-6].

The audio processing has to focus on the following important details:

- Signal processing from the sensors to the feedback device has to be real-time. Low latency is a key factor for usability.
- Decreasing computational load requires some kind of information degradation: segmentation and filtering of the input data that has to be represented by sounds. Furthermore, spatial rendering of multiple sound sources may not be applicable.
- Determination of the number of concurrent sound sources depends not just on the computational capacity, but rather on the human hearing system's ability to process multiple sound sources. More than 3-5 sound sources at the same time probably cannot be processed and/or localized correctly. This results in a decreased resolution.
- The human localization performance, especially in virtual or embedded environments is in practice quite low. Vertical localization can be a total failure as long horizontal localization can be as low as 30-45 degrees.
- Blind people do not prefer traditional headphone playback during navigation, because it blocks environmental sounds. Therefore, special playback equipment has to be used, such as multi-speaker headphones, bone conduction or active headphones with built-in microphones for transmitting environmental sounds. For indoor working environments or public places, specially designed "invisible audio" transducers can be applied [7]. These have proven to be appropriate alternatives by having acceptable musical quality and speech intelligibility.

The main design approach here from the audio perspective is to find the proper mapping between (segmented and filtered) visual information and sounds. Furthermore, the sonification task is to select the parameters of the sounds that can be easily altered, learned and adapted to. These are: frequency information (pitch, timbre), amplitude (volume) and timing (length or spacing) [8, 9]. Based on this consideration, the following recommendations can be a guideline for developing mobile devices for the visually impaired during navigation:

- To be able to navigate both indoor and outdoor, ultrasonic sensors, accelerometers/gyrosensors and cameras suitable to obtain depth information may be used.
- A sound database (auditory icons, earcons, environmental sounds) of about 20-30 sounds should not be exceeded because learning and remembering more than this can be demanding. This number is based on a survey of a user interface design for the blind [12].
- Speech can be always an extension, but this makes the system language dependent.
- Modification of sound parameters includes pitch, volume and timing.
- Reproduction of spatial information (direction of sound sources) by simple panoramic stereo panning in low spatial resolution in the horizontal plane only, instead of HRTF filtering.

3. SOLUTIONS FOR COMPUTER ENVIRONMENTS

3.1 Desktop or PC

A computer environment differs significantly from ETAs. The main focus here is on the access to the information, on helping to use personal computers. This is a typically an indoor work place environment with a user sitting at a desk with an input device. The interaction begins with the different types of input devices (keyboard, mouse etc.) and ends with the feedback device. The latter is usually a screen that has to be replaced by an auditory display. An auditory display can include loudspeakers or rather headphones. In this case, wearing a headphone is not a big problem; however, it can be uncomfortable after long time of use.

Virtual audio environments usually incorporate with some kind of spatial rendering. Using the HRTF-sets together with a sonification solution can be a good alternative for a feedback device. As always, traditional speech feedback (text-to-speech applications) cannot be neglected or totally replaced by novel methods. However, using different types of sounds (even speech-based) can be good extensions and can enhance navigation and orientation on a computer screen. The following list shows the most important sound types that were proven to be useful in several case studies [10-14]: earcons, auditory icons, environmental sounds, spearcons, auditory emoticons, spindex, morphocons, etc.

Figure 2: Blind users accessing the computer with a virtual audio display.

These auditory representations share the same design problems and goals as those used by ETAs: the number of concurrent sources, the modification method, directional resolution in spatial rendering. The main difference here is that events, menu items, icons etc. are already present and there is no need for sensors scanning the environment. This makes the selection procedure easier and also computational load is usually not an issue.

3.2 Smartphones

Speaking of smartphones, the task is almost the same as above. The difference is that vendors use different operating systems (Android, iOS, Windows), all with different benefits. Furthermore, these devices are portable, have a smaller display (usually touch screen) that serves as an input and output surface at the same time. Designing an auditory display that helps the user both accessing the device, typing etc., and giving feedback about what is happening is very challenging. A benefit is that smartphones are relatively cheap and powerful nowadays and they have become the most important platform for software development. Furthermore, most devices have built-in sensors that can be used for outdoor and indoor navigation. GPS is not preferred due to the outdoor use only and the inaccuracy. However, the accelerometer and the gyrosensor can be used for e.g. "walking straight" navigation tasks [15]. Our current research is about to test an Android application for indoor navigation based on the gyroscope and the magnetic sensors, using vibration and speech for feedback. This application aims to help the user to walk in a straight line by constantly updating the direction of movement and by comparing it with the initial target direction. In case of veering both sound and vibration are applied to drive back the subject to the correct path.

Figure 3. Blindfolded subject during an outdoor experiment.

4. SUMMARY

Development of devices and application assisting blind people has been and will be research topic for a long time. Besides speech, untraditional and novel auditory representations can be used for feedback. Computational capacity is only a restriction if real-time processing of camera images is an issue. By using an auditory display and sonification for the filtered information, proper mapping and selecting the appropriate playback device are the key issues. Unfortunately, due to the restrictions of the human auditory system, only a limited number of concurrent sound sources, a limited number of sound elements and a limited spatial resolution can be used.

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