Where Visualization Fails, Sonification Speaks

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Abstract

Traveling by public transport can be challenging for a visually impaired traveler. However, visual information can be supported by sonification, the use of non-speech sound to convey information about data. This research project aims to explore how sonification can be used to provide information to a traveler at a bus stop. Three situations are described together with different sonification design approaches that will later be further developed and evaluated.

CCS Concepts

• ***Human-centered computing*** → *Auditory feedback; Accessibility theory, concepts and paradigms;*

1. Introduction

Even if visualization is one of the most common ways to communicate data, there are some situations where visualization fails. There are various challenges for the visual perception like simultaneous brightness contrast [War19] or the Mach band phenomenon [LWP99], that might have impacts on the perception and interpretation of visual representations [SGS*18, ZTSS23]. There are also situations where light conditions or field of view do not allow visual information to be communicated well. Finally, a user can have visual impairments such as impaired visual acuity or color deficits that make perception of visual representations problematic or almost impossible. These challenges for visualization can be addressed by a complementing modality that supports visual perception. Sonification is the use of non-speech sounds for representing data, and can be used to support perception and understanding of visual representations [KWB*10, HHN*11].

In this project we aim to explore sonification as a support for visual information in public transport. Sonification design approaches for three different situations will be explored. These are:

1. Sonification of the distance between the bus and the bus stop. This should support travelers in realizing that the bus is approaching, making them prepared for entering the bus.
2. Sonification of different bus lines. Often more than one bus line is present at the bus stop at the same time, and we see sonification as a help for boarding the right bus line.
3. Sonification of bus door position. Most buses have three doors and these give access to different support opportunities in the bus, a pram or wheelchair should board the bus via the middle door, while assistance from the driver can be obtained close to the front door.

With this poster we hope to introduce sonification for the visualization experts visiting EuroVis 2024, as we see sonification as a suitable support for visualization but also that sonification benefits from being accompanied with visual information. We also hope for fruitful conversations and discussions around the poster and the demonstrations planned to be presented along the poster.

2. Related Work

Some studies have suggested that using sonification as a support for visual perception is beneficial for individuals with normal or corrected to normal visual acuity [Rön19a, Rön19b], and that sonification can reduce cognitive load [ZPR16] on the visual modality [MLS95]. Other studies have shown interesting results on the combination of visual and auditory designs for audio-visual alarms for supervision tasks [AG19] and monitoring [HNR03].

The combination of visualization and sonification has also been explored [HARM16, N*03], and should lead more effective multimodal visual representations as compared to when using visual stimuli alone [RC15]. There are several studies that evaluate visualization and sonification as a combination [BB19, GKW21, MAFP19, NB02, KBBG07, RFK*15, RHR10], and these suggest that there is a benefit of the combination. As a more specific example, sonification can be used to facilitate perception of density levels in scatter plots and parallel coordinates [RJ16].

Sonification has also been proven to be a support for the visually impaired [WM10], by supporting perception of visual representations [FFSR*23], and supporting perception of visualization by using sounds mapped to bar charts and line charts [HEUHEB23], and also supporting interpretation of visualization and text information [HGI*22]. Sonification has furthermore been demonstrated to be able to support visually impaired individuals in avoiding obstacles [PAD*19], in crossing roads [MPG*16], in guidance of manual tasks [GZvS22], in perception of complex systems [LKLF22], and in supporting the use of educational games [RBSS20]. How-

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ever, not much research has been done on sonification for public transport for the visually impaired.

3. Sonification Design Exploration

Sonification has serious disadvantages compared to visualization in terms of simple ways for sketching and co-design. Therefore, for being able to discuss different sonification approaches and designs, a simple cartoon-like demonstration has been created. The reason for using a cartoon-like visual style is to emphasize that this is a demonstration and not a final representation of the sonification design. The sonification ideas mostly involve *parameter mapping sonification* which is the association of data values with auditory parameters such as pitch or loudness [DB13], where the sound output depends on the mapping function between the data and the auditory. Some of the sonification ideas are short musical distinctive sounds that represent specific events, these are called *earcons* [BSG89]. These sounds can be described as sound symbols, and requires an understanding about what the sound represents before it can be beneficially used.

Figure 1: *Sonification of the distance between bus and bus stop.*

The first demonstration has an animated bus arriving to the bus stop (see Figure 1), and the distance between the bus and the bus stop is mapped to 1) sound level with increased sound level for decreased distance, 2) pitch with decreased pitch with decreased distance, and 3) tempo of amplitude modulation with increased tempo with decreased distance. These sonifications can either be explored individually or in different combinations. This demonstration also utilizes an earcon, a brief melody, that highlights when the bus has arrived and stopped at the bus stop.

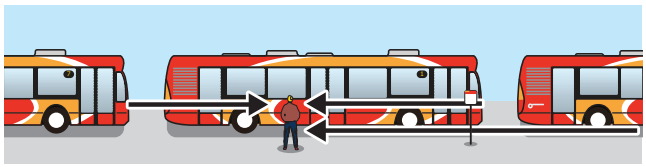

Figure 2: *Sonification of different bus lines at the bus stop.*

The second demonstration shows three bus lines (see Figure 2) and the person standing at the bus stop is animated and can move between the buses. The distance between the different buses (representing three different bus lines) are mapped to sound level and panning (ranging from left to right), and the sonification either use 1) different musical chords, 2) different short and repeating melodies (earcons), and 3) different timbre (i.e., the quality of the sound). These sonifications can either be demonstrated individually or in different combinations.

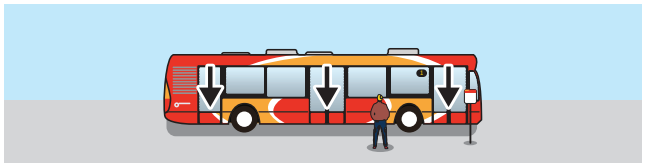

Figure 3: *Sonification of door position on the bus.*

The third demonstration shows one bus at the bus stop (see Figure 3). The person is animated and can be moved between the three doors of the bus. The distance between the doors and the person is mapped to the sound level and the panning of the sound, and the sonification either alters 1) the rhythm, 2) the pitch, or 3) the tempo. Also, these sonifications can be examined individually or in combinations.

These rather simple demonstrators will enable discussions within the research team about the multitude of different sonification approaches that can be feasible to explore, including sound level, pitch, tempo, chord (or harmony), melodic movements, timbre, and rhythm. Based on these discussions the sonification ideas will be further refined and later evaluated in a user study.

4. Composition of the Research Team

The research team consists of researchers in sonification, and urban and construction logistics from Anonymous University, representatives from Anonymous company which is an IT company with expertise in real-time analysis of transport networks, a traffic planner from the municipality of Anonymous city, representatives from Anonymous who operates the public transports in the region, and a representative from an interest organization for individuals with visual impairments.

5. Concluding Discussion and Reflection

The research project described in this text is only in its infancy and will be further developed, new design ideas will be investigated, and many interesting questions will arise along the process.

The sonification design possibilities are great and it is not clear which of these ideas that are most feasible or reasonable to use for the situations described in this text. In addition to examining and evaluating the individual sonification design ideas, the whole of all sound designs when used together, and with environmental sounds, also needs to be explored. There are technical challenges such as where the sound source should be placed. The sound could be emitted from the bus or from the bus stop sign, or from headphones that the traveler wears. These different placement suggestions not only affect the traveler who needs the sonification, but also other travelers and people in the immediate area around the bus stop. Further, it is not yet known how the interaction should best be implemented considering sociotechnical aspects [MJS20]. Possible approaches for sound-on-demand could be a button at the bus stop or a function in a mobile app to start the sonification. Finally, the sonification will exist together with visual information, and there will be a need to consider this information in relation to the sonification for providing the best possibilities to support a traveler.

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