AN INVESTIGATION INTO CUSTOMISABLE AUTOMATICALLY GENERATED AUDITORY ROUTE OVERVIEWS FOR PRE-NAVIGATION

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ABSTRACT

While travelling to new places, maps are often used to determine the specifics of the route to follow. This helps prepare for the journey by forming a cognitive model of the route in our minds. However, the process is predominantly visual and thus inaccessible to people who are either blind or visually impaired (BVI) or doing an activity where their eyes are otherwise engaged. This work explores effective methods of generating route overviews, which can create a similar cognitive model as visual routes, using audio. The overviews thus generated can help users plan their journey according to their preferences and prepare for it in advance. This paper explores usefulness and usability of auditory routes overviews for the BVI and draws design implications for such a system following a 2-stage study with audio and sound designers and users. The findings underline that auditory route overviews are an important tool that can assist BVI users to make more informed travel choices. A properly designed auditory display might contain an integration of different sonification methods and interaction and customisation capabilities. Findings also show that such a system would benefit from the application of a participatory design approach.

1. INTRODUCTION

Maps have always been central in supporting travellers to plan their journeys. As technology is becoming ubiquitous in the world, mapping has evolved and many different ways of using and interacting with maps have been developed. They can be found in mobile phones, sat-nav systems and on computers in general. With easy access to these tools, travelling to unknown or far-off places has become easier for the general population. Often, sighted people plan their journeys before undertaking travel to reduce the overhead of wrongly taken turns leading to wasted time and effort, as well as to gain confidence in where they are going. However, since maps are typically a visual representation of the geographical world, they are only readily available to sighted people. The blind and visually impaired (BVI) community, which, according to WHO [1], is almost 3% of the total population in the UK, does not have easy access to these tools. Even though many applications have been designed to aid navigation, none of them provides a means to plan the journey ahead of time. This puts the BVI community at a distinct disadvantage, as they can not familiarise themselves with the journey ahead. Having means to peruse a map and query it to customise a journey according to their own specific requirements and comfort could potentially improve this experience for them.

[1] World Health Organisation

This project seeks to design a system to provide route information, such as shape of the route and the passing landscapes, as an audio based overview. The intent is to provide the user with the ability to "experience" the route by creating an image or a mental map through the audio. Furthermore, it would provide the user with the chance to utilise functional route information, such as distance and duration, to make informed decisions regarding the route. As a result, the users will be able to familiarise themselves with the journey or decide whether they want to take that route or not. Other information that users can deduce from this system may be how complicated or busy a route is, whether it is safe or not, is an alternate route better suited, etc. These questions distinguish this work from other works in the field as they allow the user to make informed choices according to their own navigation preferences before undertaking the journey.

For this project, audio is the preferred medium of output because of its ubiquitousness, little to no cost and almost universal availability. In addition, according to [1], many BVI travellers highly value environmental acoustic information and rely on it for navigation purposes. This means that having an auditory display (AD) or soundscape of the route beforehand can improve the experience for them.

The design of studies is based on participatory design concepts including needs assessment and requirement gathering through surveys and informal discussions as described in [2, 3]. The relevance and importance of designing an interactive system with user involvement has been discussed by Spinuzzi in [3]. They provide guidelines for conducting participatory design based research, stating it as an iterative method for developing a system which simultaneously constitutes the expertise and knowledge of both the designer(s) and the users of the design [2, 3].

Some of the research questions this paper seeks to examine are:

- Are apriori auditory overview of routes valued by the BVI community?
- What are the best methods to obtain requirements?
- What types of information are important to represent?
- Which sonification techniques should be included? What should be the balance between speech and non-speech sounds? What should be the balance between functionality

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and aesthetics?

- How should different route elements be represented?
- How can such a system best be evaluated?

We do not expect to fully answer to all of these questions within this study, but we strive to provide evidence-based findings towards determining a subset.

1.1. Auditory route overviews

An auditory route overview is an audio based representation of the summary of a route, where hearing is the primary interface channel for communicating information, as opposed to visual. ADs often use a technique called sonification for converting data and interactions into sound, as for example in [4, 5, 6]. Sonification renders sound from data from different sources and produces a time-ordered sequential audio data stream [7]. Auditory displays generally employ three distinctive techniques to convey information such as identities, status, notifications, and events: auditory icons, earcons and speech: either synthetic or pre-recorded. Auditory icons, which were developed in 1989 by Gaver [8], can be described as "caricatures of naturally occurring sounds such as bumps, scrapes, or even files hitting mailboxes". Earcons were developed by Blatner, who defines them as musical motives that can grouped as a family to represent similar meaning sounds [4].

An auditory route overview provides route information, such as direction, distances, landmarks, etc. as audio, utilising the various techniques of sonification. The purpose is to provide the user with information that would help them learn more about the route before embarking on the journey. Some of the scenarios it could help in could be

- Deciding whether to make a journey or not;
- Length and complexity of the journey;
- Choosing between different possible routes, etc.

This paper is organised as follows: first, we review the related work and the motivation for developing auditory route overviews. This includes analysis of a survey to show that there is in fact a demand of such a system by the BVI community. Then we describe our first study in which we conducted a workshop with expert audio designers to gather design ideas, followed by the design implications drawn from the findings. This is followed by a feedback session on the aforementioned designs by BVI users. Here we explore user requirements as they listen to the AD designed by the experts and answer some related questions. This is followed by a discussion of the gaps between the design implications and user requirements and how this gap can be filled. Last we conclude with a brief conclusion and our future plans.

2. THE NEED FOR AUDITORY ROUTE OVERVIEWS

2.1. Related work

The past two decades have seen a significant increase in accessible technology research, including using audio for providing navigational maps. This information, which is mostly geographical, is transformed to be represented as an AD. Depending on the techniques used to transform and represent this information, the user can then learn to interpret this audio input to extract meaningful geographical information. Hennig et al. [9] provide design guidelines and recommendations for developing accessible maps including verbal description of the map content, amount of information suitable, order in which this information should be presented and the best ways of representing functional information like distance and direction. Auditory mapping and navigation is a useful application area for both BVI and sighted users. It promotes and facilitates independent mobility for the BVI users while providing eye-free interaction to sighted users. Auditory maps can either be used passively to explore unknown areas or actively, as a navigation aid to guide en route. There are a number of mechanical and electronic navigation aids such as [10, 11, 5], to name a few.

Pielot et al.[12] designed auditory maps using a movable marker on a table top, encouraging users to explore a virtual space passively. The system determined orientation through rotation of the tangible device, showing improved usability of an auditory map. Similarly, Heuten et al. [13] used a torch metaphor whereby users could only hear objects within a particular radius. Both of these encouraged an exploration of surrounding environment. Auditory route overviews, on the other hand, provide an overview of the route from one location to another, rather than an exploration of an entire area. In his seminal paper, Shneiderman [14] advocates the use of overviews as the first step in any information seeking task: overview first, zoom and filter, then details-on-demand. He argues that the overview allows users to conceptualise the information being presented. Auditory overviews are not currently a major part of auditory interfaces except for a few niche areas like information seeking, graphs, web browsing, etc [15]. Zhao et al. [16] introduced information seeking tasks in auditory overviews by presenting geo-referenced data as audio. They presented various types of information, such as total population, population by age range, etc in menus, sub-menus and multiple pages. The auditory overview swept through the locations horizontally and a spatialised tone played the value range of each state. This could be further extended for subsections of the map to create sub-overviews. They found that the auditory overview successfully displayed patterns in the data and encouraged exploration of areas of interest.

Researchers have used different sonification schemes for representing their data in audio. A. Brown et al. [17] represented line/node graphs as audio and designed guidelines for their mapping as well. These guidelines included mapping y-values to pitch, choosing appropriate MIDI note ranges, exploring different methods to represent multi line graphs, etc. L. Brown et al. also showed that a quick representation, like an overview, can provide the gist of the graph without the need for lengthy explorations. Other researchers suggest using musical timbres as well as panning and stereo output to make interpretation easier [18]. Kildal [19, 20] provided an auditory overview of complex numerical data tables by mapping data values to pitches and then playing them quasi-concurrently to give sense of the magnitude of the data. They also designed an interactive and customisable interface to encourage users to explore the data row or column-wise to reveal patterns and trends.

Guerreiro et al. [5] created auditory overviews of routes to provide navigation information, such as turn instructions and distances, as an overview from one point of interest (POI). They evaluated the merit of apriori mental maps through experiments using route reconstruction as well as real world exposure and showed that users were able to recreate both the sequential structure of the route as well as the approximate locations of the POIs, thereby substantiating the importance of using overviews of route for creating an apriori mental map. However, their application was navigation and not information-seeking.

According to our best knowledge, no significant work has been done on developing playback auditory overviews of routes for information-seeking, planning or preparation of a journey.

2.2. Motivation

To gauge the demand and acceptance of auditory overviews, a online survey was conducted with BVI individuals having at least some experience with assistive technology. The outcomes of the survey helped give a better understanding of which applications could benefit from having overviews as required by people with visual impairments. 15 BVI individuals participated in the survey (5 female and 10 male; aged between 17 and 72) and were recruited from target groups on social media.

As an example, the participants were presented with two non-speech based auditory weather forecast overviews to give an idea of what auditory overviews can sound like. They were then posed 5 questions relating to the importance of overviews, target applications, length of the overviews and type of information presented. The survey showed that BVI individuals favoured applications that would facilitate travelling, as shown in Fig. 1

The first question in the survey established usefulness and importance of auditory overviews, with 10 out of 14 respondents considering them useful. None of the participants thought they were useless.

The subsequent question was regarding the applications for auditory overviews. The participants were asked to rate 6 potential applications that could benefit from having them. The rating was on a scale of 1 to 5, with 5 being most useful. The graph in Fig. 1 shows that overview of route before travel was considered the most useful. Overview of a document, web-page and website were also considered quite useful. This response corroborated the belief that there was in fact a real demand for route overviews to facilitate travel for BVI individuals. The next question in the survey was regarding the length of the AD. According to literature [16], an AD that is too long will have a larger cognitive load. In their paper, Zhao et al. suggested that an AD of up to 10s would be optimal for their application. However, it was felt that for route-based applications this duration might be too short to provide any substantial information. Thus, this question was posed to the users to get a preliminary feel of their preference. Seven out of 15 participants disagreed with Zhao's duration, while 4 agreed. The remaining were neutral. One of the participants P1 commented that,

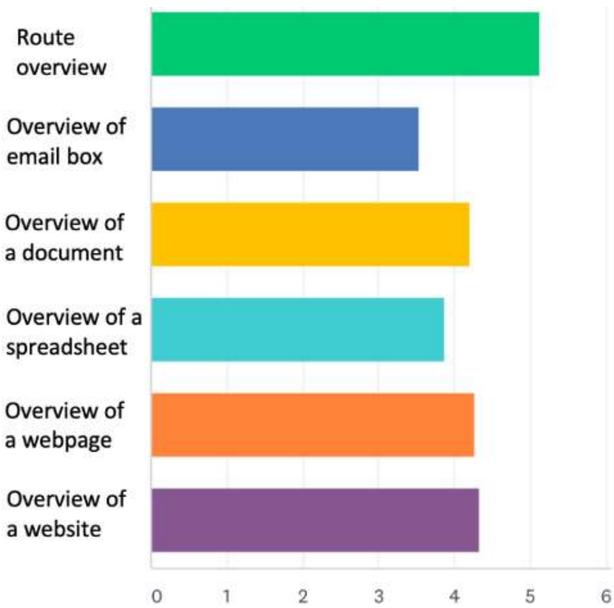


Figure 1: Graph showing responses for preference of different applications of auditory overviews

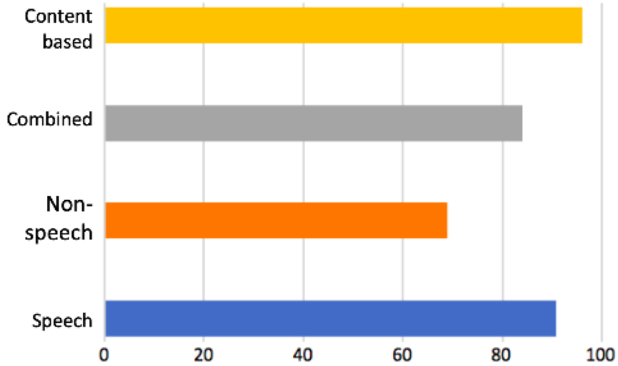


Figure 2: Graph showing preference between having speech, non-speech, a combination of speech and non-speech, and deciding based on application/ scenario in the auditory display

> P1: *"They should be as long as the information they need to convey. If a user finds them too long or gets used to them the user can always silence the description as we do in many circumstances. You could also consider the ability to change the verbosity level, i.e., perhaps an expert mode for those who are used to the information and only want to hear certain details."*

Similarly, participant P15 stated:

> P15: *"I believe they should be customised for the subject. One might only require a few seconds while an other could require a lot more."*

Thus, P1 and P15, in addition to giving opinions about duration, also established a need for customisation in the output AD.

The final question was regarding the constituent content of the auditory display. The participants were asked whether they preferred the overviews to be comprised of synthetic speech sounds only, non-speech sounds only or a combination of both. The participants preferred having content chosen on the basis of application and context, as shown in Fig. 2, however showed partiality towards speech-based information too.

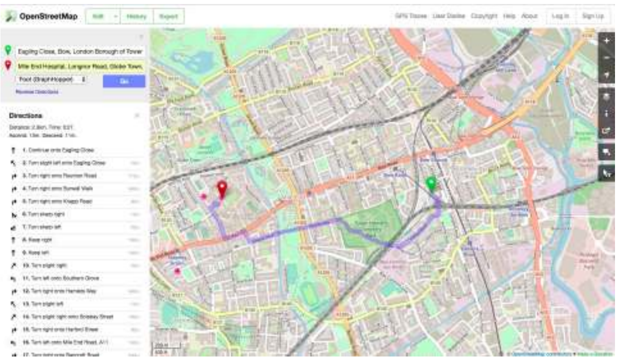
In summary, the BVI participants preferred having route overviews with customisable duration and a speech-based audio content with or without a non-speech matter. This survey helped establish a basic framework of requirements. Henceforth, further studies were done to gather more insight into the design and usage of route based auditory overviews.

3. DESIGN APPROACH

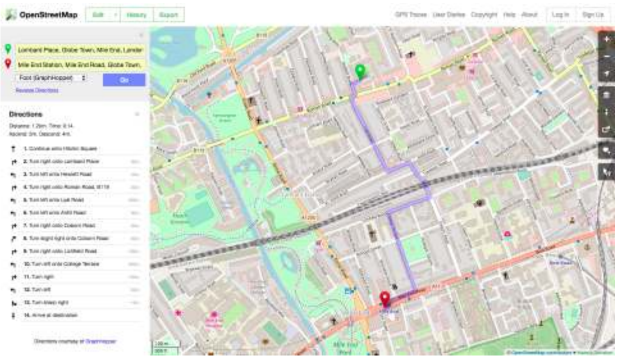
After analysing the results of the survey and gathering preliminary design requirements, a two-part study was arranged to gather design perspectives. In the first part, Study 1, a workshop was held with audio and/or design experts. They were given sample routes (Fig. 3) and asked to design auditory route displays manually. Some of the questions that the study was looking to address are given below:

1. What are some of the considerations that the designers have while designing auditory route overviews?
2. Do the designers have the same considerations regarding duration and content as the BVI users while designing auditory route overviews?
3. What are some of the techniques that the designers employ while designing auditory route overviews?

Eight participants took part in the workshop. They were MSc or PhD students of either audio engineering or sound design and were chosen for their domain knowledge. Participants were encouraged to ask questions and think-aloud while designing if they felt comfortable doing so. It was fully explained that they were part of a targeted user-group and that, as a result, their opinion was important to the iterative design process.



(a) Route 1



(b) Route 2

Figure 3: Routes for study 1

3.1. Task

The study took place over multiple sessions, with a pair of participants in each session. The participants were each provided with a route on Open Street Maps[2]. They were requested to examine their route and design an auditory display for it, individually. Afterwards, they were asked to discuss their design strategies as well as evaluate their partner's design. The evaluation process included listening to the AD and drawing the route on paper. They were also asked to rate the intuitiveness and aesthetic of the AD on a scale of 1 to 5.

[2]http://www.openstreetmaps.org

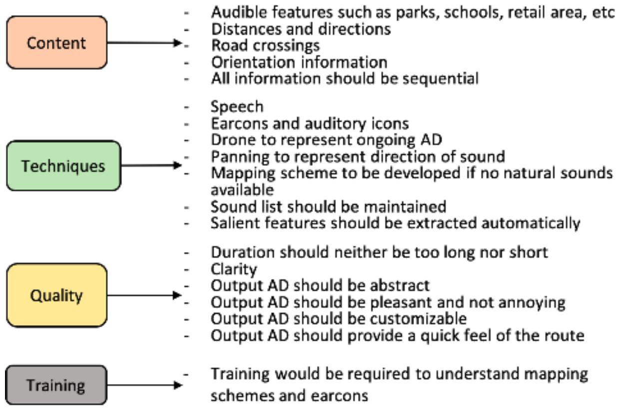


Figure 4: Themes that emerged from applying a thematic analysis to study 1

3.2. Analysis

The data gathered from this study was subjected to thematic analysis, as explained by Braun & Clarke[21]. Ideas which appeared to have some potential but did not recur were also considered. Data was investigated semantically based on a theoretical approach to determine design requirements specific to auditory overview of routes only. The initial themes were identified by analysing the data in a number of ways, including frequently occurring responses or ideas, acknowledging stress words, colour coding similar topics and comparing responses between participants. If an answer mentioned several topics, all of them were considered individually. Themes were extracted from this analysis and then analysed from a broader perspective to draw design implications from the designer's perspective. The themes that emerged from this study are shown in Fig. 4.

These design implications drawn from the designers perspectives give a good sense of how an auditory display for route overviews should be designed, what it should encompass and what qualities it should possess.

4. USER FEEDBACK AND REQUIREMENTS

In the next phase, Study 2, some of the designs developed by the designers of the first study were presented to the BVI users to obtain their feedback. For this purpose, a call for participation was made on groups for BVI on Facebook. Some of the groups which garnered responses are Blind & visually impaired travels –emotioneyes, Blind advocates Texas, Blind and vision impaired community, Blind chat, tips, views and information sharing community, Blind help project, Blind penpals, Blind veterans UK and Wales, Blindwebbers, British blind community, Hadley Institute for the Blind and Visually Impaired support group, iPhone and iPad apps for the blind and visually impaired, RNIB Con-

Table 1: Survey questions to obtain feedback on auditory route overviews

1. Kindly listen to Design 1 and in a few words explain what you understood.
2. The beeping sounds in Design 1 are actually representative of the turn numbers (re-affirmed by the speech sound), for example the third turn on left is shown by three beeping sounds in the left ear
   a. Does having this information change your perspective about this design at all?
   b. Do these two overlain sounds increase or decrease the information provided?
   c. What are the good or useful features in this design?
   d. What are the bad or useless features in this design?
3. Design 1 provides direction information while design 2 provides landscape information. Which one do you prefer and why? If you have no preference, please feel free to make any other comment you wish.
4. Design 2 provides only landscape information, while Design 3 provides landscape information overlaid with direction information. Which one do you prefer and why? If you have no preference, please feel free to make any other comment you wish.
5. Is there any scenario (or application) where you would prefer Design 1 over the other two designs?
6. Is there any scenario (or application) where you would prefer Design 2 over the other two designs?
7. Is there any scenario (or application) where you would prefer Design 3 over the other two designs?
8. Kindly rate the difficulty level of the designs, in terms of understanding and retaining the information provided. The scale is 0 to 10, where, 0 is very easy and 10 is very hard.
9. Kindly rate the length of the designs, in terms of understanding and retaining the information provided. The scale is 0 to 10, where, 0 is too short and 10 is too long.
10. If you are not satisfied with the length of the display, how long do you think it should have been?
11. Do you have any other suggestions for improving this design?

nect–London, RP fighting blindness London, SiteAppsClub, Solent Active Visually Impaired Group and Visually impaired/ blind adults.

Forty three people responded showing interest, however only 8 individuals (4 M, 4 F) from these actually participated in the study. They were situated in different parts of the world, including UK, USA, Canada and Indonesia, and participated virtually via email. Even though the data set of users seems smaller than average, this is common practice when working with a niche population, as seen in many studies [11, 22, 23, 24].

4.1. Task

The study took place on-line. The participants were provided with 3 different auditory displays designed by the participants in Study 1. These files were named Design 1, Design 2 and Design 3. They were also provided with the survey form shown in Table. 1 to evaluate the different aspects in the design files.

4.2. Analysis

The participant responses were collated and analysed to uncover recurrent ideas and underlying themes to guide the design process. Additionally, any ideas that were potentially useful but did not recur were also considered. Similar to the first study, the data was generally investigated semantically. However, in certain instances, implied mentions in participants' answers were also considered to ensure that no important pattern in the data was missed. A theoretical approach to analysis was adopted to determine design requirements specific auditory overview of routes from the user's perspective. Themes were extracted from this analysis and analysed from a broader perspective to draw the design implications, as shown in Fig. 5.

The figure shows different ideas and User feedback from the study. It was mostly regarding the content of the auditory displays presented to them. They considered speech to be of utmost importance in providing functional route information, and wanted it to be clear and coherent. They thought that the auditory icons used to present the information of audible features and points of interest in the landscape were useful to give a feel of the area, as well as aid orientation and localisation. However, by themselves, without any other AD component like speech, they were extremely hard to understand and retain. Thus, auditory icons for landscape features must be accompanied by some other functional information, such as speech for directions. Moreover, they felt that if any transitory audible feature, such as traffic, was not present on the actual route while navigating, it could potentially confuse the user, as they would be expecting to hear those sounds. This showed that the users did not fully grasp the idea that this tool was an informatory tool which would augment their navigation aids during journey.

An integrated AD consists of all or a combination of speech, auditory icons and earcons, presenting different kinds of information via different modalities. All of the designs presented to the BVI users consisted of integrated displays. The users believed that having an integrated display increased their confidence to travel to new places. At the same time, the overlaying audio in such displays obscured information. Thus care must be taken while combining different methods to ensure clarity and effectiveness. The users also stressed on the importance of making the overviews interactive and customisable in order to suit every individual's personal requirements.

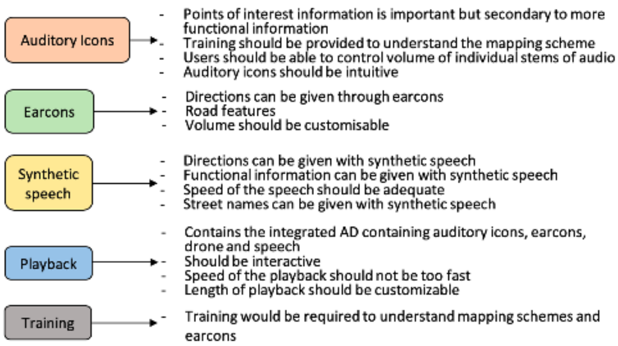


Figure 5: Themes that emerged from applying a thematic analysis to study 2

5. DISCUSSION

Since all users have different preferences and expertise, there is a wide variety of opinions as can be seen from the analysis. As a result, a high level of flexibility is very desirable. This is in line with [24], which states that the success of an assistive system depends on providing means to consider individual preferences. Some of the aspects which highlight the similarities and differences in user and designer perspectives have been discussed in detail below.

According to the BVI participants, direction is the most important route information for them. Moreover, they prefer to have it as speech as it is more explicit and requires no learning. Alternatively, however, most of the designers believe that speech takes up more time and is less flexible in terms of the things that it can represent. They focused their energy on designing soundscapes containing more abstract representations, using auditory icons, earcons and/or panning. This discrepancy is representative of the gap between expert designs and user requirements and shows why products which are designed without user participation are not readily accepted by the concerned community [25]. A BVI user in an informal discussion on social media stated that:

> *"I have noticed with most apps and their flaws [sic.] simply because the developers fail to include VI individuals in their R & D which leads to an app that becomes very frustrating when used by someone who is losing their sight."*

Auditory icons can be used to represent landscape and landmark features, including permanent features like parks or train stations as well as temporary ones like traffic. Some BVI users showed concern that absence of these sounds during the actual journey might cause confusion. For example, if the user is expecting to hear chirping birds depicting a park, but can not hear those sounds due to any reason, such as time of the day, weather, etc. during the journey, they will lose their orientation and feel lost. This problem can be handled by teaching the users to consider this tool as a guide to give a feel of the route, which is designed to augment navigational aids rather than replacing them.

Participating users also stated that landscape/landmarks information alone was useless for guiding travel and must be augmented with a more concrete direction information. They felt that the design in which the components were integrated , i.e. having all or a combination of auditory icons, earcons and speech was most effective.

Both the designers and the users agreed that the 10s time duration, as suggested by [16], was insufficient to provide rich, sequential information. They suggested that the duration should be proportional to the amount of information being imparted.

Representing distance information was one of the major challenges faced by the designers of the study. Some of them proposed to use time delay to depict distance between two instances on the route, such as changing directions or between points of interest, etc. However, none of them was able to effectively include sound representative of distances in their AD as it was difficult in the 10s output time-frame that they had; and hence the users couldn't evaluate or comment on it. Some of the designers and even the users suggested that earcons may be a good choice.

> User_2: *"If the beeps are spaced proportionally to the distance between the streets, I would pay attention to them. For example, if the first crossing is 200 meters away and the second is 100 meters after that, the time interval before the first beep could be twice as long as the time interval between the first and second beeps. That would be useful information to have."*

Using earcons can make the distance information more tangible and easy to follow, as mentioned by User_2. However, whenever earcons are used, a certain level of training is required to understand their meaning. This can be arranged by adding audio-clips explaining the earcons and providing an option for training before using the system.

The designers predominantly thought that the AD should be more abstract. They believed that overviews are supposed to be more metaphorical rather than literal. Furthermore, an abstract auditory display might give quicker representation while a literal description using only speech would require more time. This is again in contrast to the users who considered functional information to be more important. However, it comes down to what is considered an overview and what is useful for the users. This is one of the areas that requires more in depth analysis and comparison of designer vs user perspectives. Related to this is the the issue of how to represent objects that stretch over significant geographical areas, such as a school, university or park. If this information is represented literally, this would mean a repetition of the same auditory icon for the length of the geographical area, which can be tedious and annoying. A way of handling this could be to add a fast-moving footsteps sound to represent an unchanging scene briskly. Another way could be to add the sound of opening a door to represent the starting and closing door to show ending of an area that is stretched over a significant distance, making the whole thing more metaphoric.

There was agreement among the designers and users of the two studies conducted, that the display should be interactive and customisable. Both believed that there should be some provision to choose the amount and type of information available at the output. Moreover, the users wanted an interactive display where they can control the level of volume and speed of the different components of the AD, i.e., the earcons, auditory icons and speech, separately as well. This can be solved by setting up a query system, as suggested by [1], where the users can initiate a request to increase or reduce volume or mute some aspect of the AD altogether. This will provide the user with the flexibility to issue requests when they want. Fig. 6 shows the final design implications drawn from both the studies.

These design implications, along with recommendations from literature [9], are being used to inform the design of the AD in the prototype system. Sample auditory overviews can be found at this link. [3]

6. CONCLUSION

In this paper we propose to develop a system which provide auditory route overviews to assist in independent travel for the blind and visually impaired individuals. For this purpose, we explored several research questions in order to develop an informed design in line with user requirements.

Initially, we tried to determine whether a system for providing auditory overview of routes prior to walking was of any value to the BVI community. We posed this question as a survey and determined that there is in fact a high demand for auditory overviews

[3] https://soundcloud.com/anon-5210/sets/audio-routes

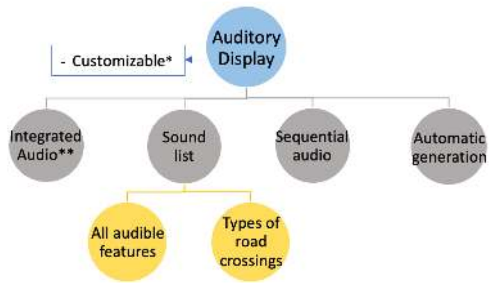
in general and particularly for a system that helps in independent travel.

The next step was to determine user requirements, so we presented some examples to the BVI communities on social media and obtained their feedback. This was an informative exercise and gave insight into their requirements. However, gathering feedback through questionnaires provides limited information. A better way would be to have open-ended discussions/ semi–structured interviews to gain more in-depth knowledge.

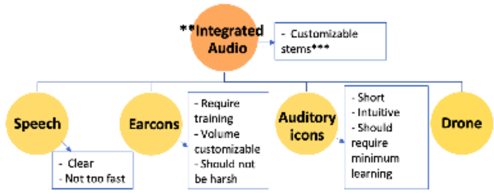
With regards to the techniques of developing auditory displays, it was found that the participants predominantly preferred the use of synthetic speech for obtaining functional information. They also believed that functional information was the most important part of a route map. However, they also felt that having landscape information gave them a feel of the route and landmarks helped them localise and orientate themselves. Hence, we tried to determine how to choose the right ratio of each component in the AD, so as to maximise information while preventing sensory overload. This is an open-ended question in other domains of research with ADs as well, as shown in [4]. The participants suggested that providing the AD with means to control the amount, duration, and amplitude of individual components would allow the users to access each part of the information according to their own needs. However, further user tests are required to determine the effectiveness of this method. This also leads to requirement of exploring different interactive controls and determining which of them are effective.

Similar to selection of components is the question of mapping them to different route elements. Even though the designers in study 1 tried to assign elements of the audio to different road features, the BVI users had a hard time understanding this mapping, whether it was auditory icons or earcons. This showed the need for some training before using the AD or perhaps choosing better representations. This is one the major areas that requires more intense research, and user testing.

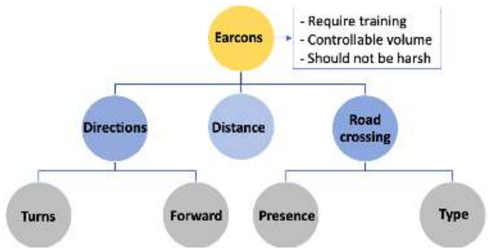
An interesting disparity noticed between designers and users was the balance between functionality and aesthetics in the auditory displays, where designers considered aesthetics to be more important but the users completely disagreed. Since the users will be using the system to aid travel, functionality would definitely have to be given higher priority. However, determining the extent of importance of aesthetics still needs further exploration.



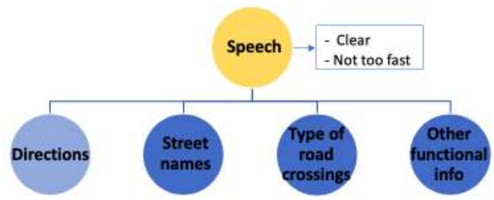
(a) Components of the auditory display



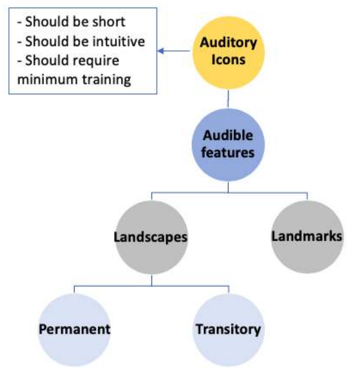
(b) Components of the integrated audio



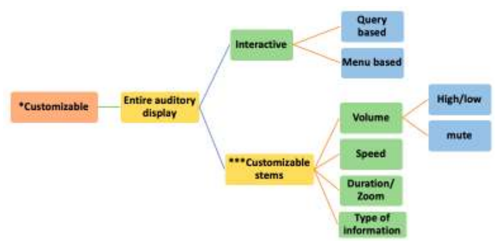
(c) Design implications for earcons



(c) Design implications for speech



(d) Design implications for auditory icons



(e) Design implications for customisable automatic AROs

Figure 6: Design implications for customisable auditory route overviews

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