MuBiks: Tangible Music Player for Visually Challenged

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Abstract. MuBiks is a novel tangible music player, designed for visually challenged to create and manipulate music playlists. Users can manipulate musical controls to play, pause and increase-decrease volume through rotating different sections of MuBiks. We followed a user-centered-design approach to understand user behavior towards existing human-machine interactions. Contextual inquiry in the form of semi-structured interviews among teachers and students were conducted across three blind schools in Assam and Madhya Pradesh in India. A series of tasks was given to users to understand patterns of existing communication through texture and size identification. Heavy dependence on memory and secondary help[1], easy recognition of texture, shape, size and sound and extensive use of hands were observed during the study. Identified insights were referred and accommodated to design proposed music player.

Keywords: Tangible User Interface, Music player, Visually challenged, User-centered design.

1 Introduction

With technology getting cheaper, smaller and smarter, it has opened a new dimension for incorporating different interaction modalities for digital systems. One such relatively new and emerging area is Tangible User Interface (TUI) [34]. TUIs have seen a lot of developments over the past few years across sectors like entertainment [6, 9, 13, 16, 21], education [10, 20, 26, 28, 31], various other complex applications such as urban planning [5, 8, 14] as well as music and performance. Studies show that a host of research explorations has also been undertaken in musical interfaces [1, 19, 23, 24]. Music is an entity that has no cultural or social barriers and can be enjoyed equally by all. Through this project, we have tried to enhance the experience of music for one specific section of the society vis-à-vis visually challenged. India accounts for 20 per cent of the 39 million blind populations across the globe [8] which comes close to 7.8 million blind people. Visually impaired students make use of physical artifacts

[1] help taken from others to perform any task.

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like cubes etc. to form active mental models of the physical world around [28]. The interactions with such artifacts are strictly hands-on. Moreover, people with visual disabilities have been found to have well developed tactile and auditory senses [33, 35] as compared to rest of the population. Several technological and sociological improvements have aided visually challenged people in their everyday life activities [18, 29] such as helping them to navigate without additional help, improving their communication with personal computers, learning character shapes and handwriting, and to track and locate lost objects. Tangible User Interfaces like MICOO [25] and Touch Your Way [18], have lessened the need for manual intervention and enabled independent discovery on the part of visually challenged. However, making music tangible for visually challenged is a relatively unexplored domain. Since, TUIs have the inherent quality of engaging user's perception of the world and thus his sensory and motor skills, they could be used effectively to couple the enhanced sensitivity of the visually challenged user population.

MuBiks is a tangible music player that enables visually challenged to create and manipulate playlists from a database of songs. The playlist is manipulated using familiar interactions identified during user study. Contextual inquiries with semi-structured interviews were conducted across three blind schools in Guwahati, Assam and Bhopal, Madhya Pradesh with teachers and students. The design of MuBiks is based on findings from user study. We developed a low fidelity prototype using arduino board, potentiometers, gyroscope and bump sensors to demonstrate the feasibility of the system. We explain related work in next section, followed by methodology and concept generation. Further, details of low fidelity prototype are explained in prototyping section, followed by discussion for future research work.

2 Related Work

Music applications are one of the oldest and most popular areas for TUIs which have become both ubiquitous and popular around the millennium. Over the past few years, there have been various attempts to develop TUIs for sound and music. Block Jam [12] controls a dynamic polyrhythmic sequencer using 26 physical artifacts as input device for manipulating an interactive music system and interprets the user's arrangement of the blocks as meaningful musical phrases and structures. Cubed [1] is yet another music sequencer integrated into a Rubik's Cube where users generate different sounds by manipulating colors on the cube. Audiopad [17] aims to combine the modularity of knob-based controllers with expressive character of multidimensional tracking interfaces. Table top interface allows users to manipulate volume and effect controls to present associated digital information. While these projects largely involve content generation and manipulations, [23, 24] enable user to access and control musical contents. Music cube [24] is a wireless cube-like object, which uses gestures to shuffle music and a rotary dial with a button for song navigation and volume control. The tangible music player [23] uses a shape of a shelf placed on a wall, where user interacts with different items kept on the shelf to control the player functionality such as play, pause, change volume and tracks. In [19], the author explores various concepts in making digital music more tangible and expressive such as use of physical metaphors, music rhythm visualization multifunctional control, spoken song description and use of gesture control.

In addition to its diverse applications in music interfaces, physically challenged section of the society also has been focused. [3] summarizes how tokens representing frequently used words are used to teach basic concepts of language and space to children with disabilities. While [4] presents a new method to engage people with hearing impairment in interactive storytelling, [30] proposes a system that helps the visually challenged navigate around in an unfamiliar environment. Further, [25, 32] use auditory output to teach statistics and graphs to the visually challenged by series of tokens. However, relatively few tangible interfaces have been developed for visually impaired users in the domain of music. Those developed have been mostly on music sequencing or music education rather than for enjoying and listening to music [11, 27, 36]. Moreover, even though a variety of application domains have been explored in TUI's, the methodology has been mostly data-centric relying heavily on designer's perceptions and understanding of the interactions and affordances with the system. The system is evaluated with users at a later stage, unlike in user-centric approach. MuBiks is one such attempt to integrate the experience of listening to songs with TUIs. It is inspired from the form of Rubik's cube and effectively combines users' auditory and tactile senses, allowing them to multitask with other ongoing activities.

3 Methodology

We followed a user-centered design approach and began with a preliminary study to understand the aspirations and motivations of target users. We conducted semi-structured interviews to understand their everyday behavior, tasks and actions associated with each task. We recorded our insights and designed a few tasks to understand how users interacted with everyday objects. We studied their modes and methods of interaction with the music. Finally, we conceptualized the design and interaction model for MuBiks based on the inferences and conclusions drawn from the user study.

3.1 User Study

Contextual inquiries were conducted at the Guwahati Blind School in Guwahati, a state run blind school in Bhopal and Aarushi, an NGO based in Bhopal. We conducted semi-structured expert interviews with a music teacher, who was himself visually impaired, the director of Aarushi and students at the blind schools. Later, task based analysis was done with 5 students at the Guwahati Blind School.

Expert Interviews. Teachers were interviewed to understand different methods of teaching that they employed. Insights were drawn regarding the equipment used and daily interactions of students with their surroundings. Familiarity with existing technology was analyzed and we inferred that users had heightened tactile and auditory senses.

We drew following major inferences from the expert interviews:

1. Users could identify small subtleties in objects. The music teacher at Blind School in Bhopal mentioned that students could differentiate between two different local newspapers despite having same texture as one of them had a small cut at the bottom of each page.
2. Any new object was identified through exploration of texture and sound. Users identified any new object by understanding its texture or the sound it makes.
3. It was easier for them to remember objects by arranging them in a particular order. One of the helpers at the blind school mentioned that students arranged spices in kitchen in a specific order for easy remembrance for later usage.
4. Students were familiar with computers and mobile phones. Specific software with audio feedback helped them navigate through the system.
5. They learned using digital audio books.
6. They mostly listened to music on media players and were familiar with the use of buttons.

We noted the insights and designed a few tasks aimed at understanding the interaction of the target users with the physical objects in the surroundings and their current music usage pattern.

Contextual Task Analysis. We conducted contextual user enquiry among 5 users at Guwahati blind school, all of whom were males aged between 15-21 years of age, to understand their behavior patterns towards everyday interactions. The students were asked to perform a set of given tasks. After the task, each student was interviewed to understand how he felt while doing the task, what was his approach to finish the task and if he enjoyed doing it. The actions used by them to identify and interact with new objects, or memorize new concepts were recorded.

Users were given different objects such as plastic cubes, cylinders made of mud, wooden cuboids, Jigsaw pieces and magnified Lego blocks [22]. They were asked to perform the following tasks:

- Task 1: Identify texture/material of given objects.
- Task 2: Differentiate between two objects of different shape, size or texture.
- Task 3: Slide an object horizontally and vertically on the table.
- Task 4: Rotate an object.
- Task 5: Place a different face of an object on the table.
- Task 6: Join two Lego blocks.
- Task 7: Solve a Jigsaw puzzle (or try to join two jigsaw pieces).
- Task 8: Play and pause a song (on mobile phone).
- Task 9: Change a song (on mobile phone).
- Task 10: Increase and decrease volume of a song (on mobile phone).

Fig. 1. User differentiating between two cubes for a given task

The tasks were not timed and were given to the user one-by-one, in the order mentioned above. Their actions were both video recorded and noted. The insights that were drawn from the user study are as follows:

- ***Shape, size, texture and sound recognition:*** It was observed that users were able to easily identify objects based on their texture and sounds. Additionally, it was easier for users to distinguish between objects made of mud and plastic than between objects made of different types of plastic. Similarly, it was easier for them to differentiate between spherical and cubical items. One user could even point out the difference in size between two similar objects by aligning their bases together (Figure 1). However, it was difficult for most of them to distinguish through size unless the difference was significant.
- ***Ease of rotary motion:*** It was observed that users were comfortable rotating them, as compared to sliding them horizontally or vertically on a surface. When asked to horizontally/vertically move an object on the table, most users turned the face of the object or rotated it. It was also noted that it was difficult for them to comprehend the idea of linear motion.
- ***Extensive use of hands:*** Users were comfortable manipulating objects with their hands, without using any surface (tabletop). It was noted that they preferred fiddling with them in their hands, rather than placing them on any surface. When asked to identify a wooden cuboid, a user first tried to recognize the texture by manipulating it with his hands and then tapped it with his fingers to make out its sound.
- ***Difficulty in solving puzzles:*** Users were found to easily point out at any unevenness on object's surface; however it was difficult for them to connect the depressions in one object to the elevations in another. They were asked to fit Lego blocks together and except for one user, none of them could connect the blocks appropriately. It was also observed that the level of difficulty increased when the blocks were replaced by Jigsaw pieces.
- ***Memory and secondary help:*** It was found that visually challenged users relied heavily on memory and secondary help from different individuals. They did not use any software application to remember the order of songs, instead remembered through individuals' memory. Similarly, before using a new system

or product, they needed help of another individual to get acquainted with its manipulation controls and interactions.

- ***Music usage:*** Mobile phones were found common for listening to songs. Visually challenged users used existing gadgets like radios, music players and computers to listen to music (Figure 2). Additionally, it was observed that, listening to songs was never a stand-alone primary activity for the users. They generally listened to music after classes in their leisure time.

Fig. 2. User listening to songs on mobile phone

4 Concept Generation

The insights drawn from user study helped us to define the form and interactions of the system. We drew mind-maps and affinity diagrams to consolidate the collected data. Personas, tasks and interactions were also defined based on the analysis. We came up with the following design guidelines for the system after iterative and exhaustive brainstorming sessions:

1. Considering the users' familiarity with identification of shapes, sizes and textures, it should be beneficial to use these material properties to incorporate familiar interactions.
2. Since users were found to be comfortable with rotating objects, the affordance of rotation should be beneficial in the proposed design.
3. The final design should be portable because users were found to be comfortable with hands-on activities, and at the same time, multi-tasking while listening to music.
4. Since users were heavily dependent on memory and secondary help, the system should try to address these issues and be relatively easy to understand from the usage point of view.

4.1 Persona Creation

Once the system goals were defined, the user persona was defined as follows:

"*Nihar is 23 years old, living at the Guwahati Blind School and has been visually impaired since birth. His day starts with attending morning prayers at the school followed by attending classes of Mathematics, Science and English. He is very* *passionate about music and plays the piano after classes. He and his friends listen to music using their mobile phones while walking, and singing in the corridors of the school's hostel. He loves to listen to Bollywood music and is a big fan of Sonu Nigam. He sometimes browses through the net and reads online digital audio books with the help of audio-feedback software pre-installed in the system."*

4.2 System Tasks

System tasks and flow of information was drafted by analyzing the user persona. These included adding songs to the playlist, playing songs, pausing songs, changing the current song, increasing the volume and decreasing the volume.

4.3 Interactions

We referred back to the tangible interface frameworks [34] to incorporate tangible design features and characteristics into the system. We faced the challenge of limiting the number of tokens and imparting portability to the system. Analysis of user study helped us to identify possible list of tokens and relevant interactions:

1. There should be at least two similar tokens, differing in shape or size. One token would contain the database of songs while the rest would be used to create playlists.
2. Both the tokens should be able to perform the following tasks: add songs from database to playlist, play songs, pause songs, change song, increase volume and decrease volume.

5 System Overview

The system consisted of two cubical tokens or MuBiks differing in size. The smaller MuBiks was a playlist (p-MuBiks) while the bigger one contained a song database (d-MuBiks).

Since users were more familiar with the act of rotation, inspiration was taken from the form of a Rubik's cube. Each MuBiks consisted of three horizontal sections (Figure 3). The middle section was fixed whereas the top and the bottom sections could freely rotate along the Z-axis only. The two rotating sections could be differentiated through textures. For instance, the top section was covered with cloth whereas the bottom section was made of metal. The middle section was made relatively smaller in size to help users to hold the cube.

Rotating top section of MuBiks clockwise played a song whereas rotating it anti-clockwise paused it. Similarly, rotating the bottom section clockwise increased the volume while rotating it anti-clockwise decreased the volume. Shaking the MuBiks changed a song. If a song was being played from the database, it could be transferred to the playlist by simply touching the two MuBiks (Figure 4). The confirmation of transfer was given in the form of auditory feedback.

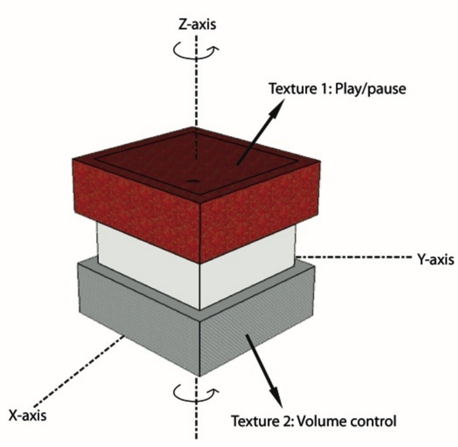

Fig. 3. Sections of MuBiks

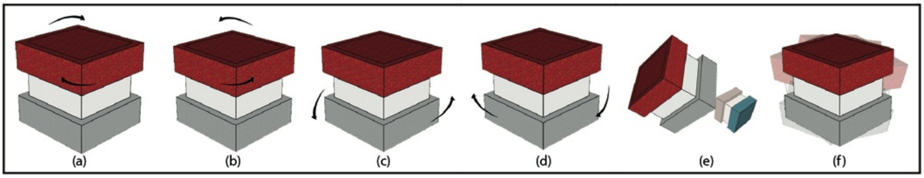

Fig. 4. (a) Rotate top section clockwise to play song; (b) Rotate top section anti-clockwise to pause song; (c) Rotate bottom section clockwise to decrease volume; (d) Rotate bottom section anti-clockwise to increase volume; (e) Add song from d-MuBiks to p-MuBiks; (f) Change current song

Fig. 5. Low-fidelity prototype of MuBiks

6 Prototyping

A low-fidelity prototype was developed using arduino board [2], potentiometers, gyroscope and bump sensors (Figure 5). Potentiometers were set-up inside upper and lower sections of the MuBiks to toggle volume and play/pause controls. Gyroscope was set-up to detect rapid change in motion while shaking the MuBiks to change the songs. Bump sensors were placed to detect collision between the two MuBiks and initiate transfer of the current song from d-MuBiks to p-MuBiks. All the sensors were connected to the arduino board and respective commands were executed (Figure 6).

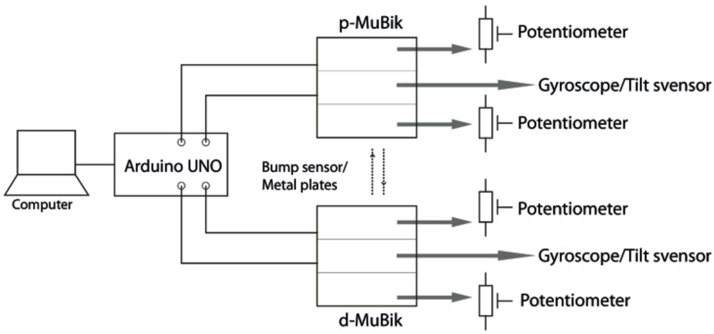

Fig. 6. Schematic diagram of prototype

7 Future Work

The paper introduced a novel interactive way to re-define the experience of listening to music for the visually impaired. The system is yet to be tested to evaluate usability issues. Further improvements could to be done with respect to the shape and form of MuBiks and the kind of feedback received. For instance, instead of a cubical form we can have a truncated pyramidal or frustum like shape. Additionally, the surface could include letters in Braille to identify different playlists or functions. The system could also be made ubiquitous by networking it with external speakers or other music systems and devices. On a broader perspective, the same player, with additional research on its features and functionality, could be imitated for the general population and developed as an accessory-cum-interactive music player. The concept opens wide avenues for further research and exploration.

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