AQUARIUM FUGUE: INTERACTIVE SONIFICATION FOR CHILDREN AND VISUALLY IMPAIRED AUDIENCE IN INFORMAL LEARNING ENVIRONMENTS

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ABSTRACT

In response to the need for more accessible Informal Learning Environments (ILEs), the Georgia Tech Accessible Aquarium Project has been studying sonification for the use in live exhibit interpretation in aquariums. The present work attempts to add more *interactivity* [1] to the project's existing sonification work, which is expected to lead to more accessible learning opportunities for visitors, particularly people with vision impairments as well as children. In this *interactive sonification* phase, visitors can actively experience an exhibit by using tangible objects to mimic the movement of animals. Sonifications corresponding to the moving tangible objects can be paired with real-time interpretive sonifications produced by the existing Accessible Aquarium system to generate a cooperative fugue. Here, we describe the system configuration, pilot test results, and future works. Implications are discussed in terms of *embodied interaction* and *interactive learning*.

1. INTRODUCTION

To improve the accessibility of exhibits and promote universal design in aquariums, researchers have studied real-time interpretive sonification as a strategy for translating visual aspects of live animal exhibits [2, 3]. Georgia Tech's Accessible Aquarium Project has focused on designing sonifications for individuals with vision impairments that convey the informational (e.g., the number of animals in view, animal locations, and animal movements) and aesthetic aspects (e.g., the "feeling" or mood perceived by visitors) of live exhibits that a visitor might experience when viewing a live exhibit). This enables visitors with vision impairments to experience an exhibit in both cognitive and affective aspects, and it also provides a shared experience so that visitors with and without vision impairments can discuss their understanding and impressions of the exhibit. One way to accomplish this is through music that communicates both information and feeling. Previous studies [2, 3] showed that we could match musical features such as pitch and tempo with animal information such as height in tank and swimming speed to facilitate understanding of exhibit dynamics. The project also has implications such as *biologically inspired music* or *dynamic sonification* from the sonification perspective [3]. To fulfill and strengthen those two aspects, the current project attempts to enrich visitors' experiences in aquariums by combining and harmonizing animal- and audience-inspired sonification. By increasing *interactivity* [1] among animals, people, and sonification systems, it is expected that visitors will have an enhanced learning experience.

2. RELATED WORK

For interactive sonification, embodied interaction has been used and shown effective in various learning and training domains. To illustrate, Antle et al. [4] has used embodied interaction framework to elicit, train, and apply people's embodied metaphors as a means of developing intuitive fluency with music creation. Based on a specific metaphor of "music is physical body movement", they developed a computational system that helps children understand musical concepts such as melody, harmony, and rhythm in the form of intuitive, physical analogs. Howison et al. [5] introduced an embodied-interaction based instructional design, the Mathematical Imagery Trainer (MIT). They aimed at helping young students develop an understanding of proportional equivalence by applying the embodied cognition paradigm, in which mathematical concepts are grounded in mental simulation of dynamic imagery, which is acquired through perceiving, planning, and performing actions with the body. Recently, in the sonification community, several interactive movement projects have been introduced in sports training [e.g., aerobics, 6, rowing in a boat, 7]. All of these projects have suggested that fully engaging embodied interaction with sonified feedback is effective in enhancing the user experience.

3. CONCEPT AND SYSTEM CONFIGURATIONS OF THE CURRENT RESEARCH

In the current research, we attempt to leverage the real-time interpretive sonifications of the Accessible Aquarium Project to enable a collaborative sonification that includes visitor interaction. The real-time interpretive sonification of the exhibit dynamics contains *coherent responses* with consistent *feedback loop*, which is a subset of interactivity [1]. This new work, adds more interactive elements (e.g., *responsiveness*), by allowing visitors to engage with the live exhibits through tangible user interface objects (TUIOs) that represent the animals in the exhibit. Consequently, visitors will contribute to a cooperative sonification of the live exhibit (generating a counter melody). Additionally, it is anticipated that visitors, including those with vision impairments, will learn about animal movement and perhaps, become interested in other interpretive information. For the rapid prototyping, we have taken a simple movement-to-sound mapping approach to complement the real-time interpretive sonification of live animal movement. Figure 1 shows the schematic system configuration. Two cameras can be used for the system: a HD, high speed digital camera to track animals for the real-time interpretive system and a web camera to track the TUIO in the visitor interaction system.

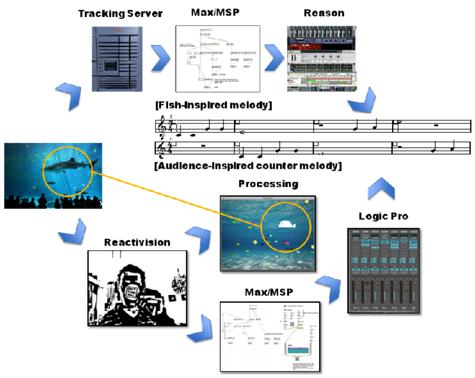

Figure 1: Schematic system configurations of the real-time interpretive sonification and visitor interaction sonification.

While the system is designed to use these two cameras to actively work with real-time computer vision data, the prototype system can also simulate incoming real-time video data by utilizing recorded video. The parameters (x, y coordinates) of visitors' movement is processed in the reacTIVision software and then transmitted into a Max patch that sends MIDI (Musical Instrument Digital Interface) signals into the Logic software which generates the final sounds using virtual instruments.

4. PILOT STUDY

To test our conceptual design, we conducted a pilot study with a prototype "interactive game" scenario via laptop. In this system, users were presented with a short musical motif or melody that was generated based upon the animal movement pattern. The users were then asked to reproduce this melody by maneuvering the TUIOs within the field and select the desired notes with a controller device. Our TUIOs for the prototype were the standard fiducial figures provided by reacTIVision, attached to animal models in order to promote a more concrete link to the virtual animals on the laptop and support interactivity. In this initial prototype, the y-axis of space represented the pitch of the notes (1 octave) and the x-axis represented panning of the sound for spatialization purpose. For example, if the desired sequence was F3-A3-C4-G3-F3, a user would move the TUIO until F3 was heard and then click the controller to select the note. The user would then move the TUIO up to select A3, up for C4, down for G3, and down again for F3, while clicking to select each note as they arrive. This same process would be taken for every note in the sequence and upon correct completion an audible chime and a visual indicator notified the users that they had successfully completed the melody. After an initial training period, we had all participants complete this task using only auditory information, thus providing a simulation of vision impairment as well as focusing the user on pitch detection ("musical ear"). The children (2 female, 2 male, mean age = 5.5) who tested the prototype described the system as, "fun," "interesting," and "engaging." The pilot study yielded several ideas for experimenting with different interface configurations and mappings.

5. DISCUSSION AND FUTURE WORKS

It is important to develop auditory displays that effectively convey exhibit information and aesthetics in order to enhance learning experiences for all visitors, including those with vision impairments. In this work, we are suggesting that visitors can go beyond the limited role of passive learners and explore a more constructive and interactive role. Chi [8] recently provided a framework that offers a way to differentiate *active*, *constructive*, and *interactive* in terms of observable activities and underlying learning processes. Active learning is doing something physically, such as look and fixate. Constructive learning is producing outputs, such as self-explain and elaborate. Interactive learning includes dialogue containing guided-construction, such as revise errors from feedback and co-construction. While active learning is attending processes, constructive learning is creating processes. Interactive learning means jointly creating processes incorporating a partner's contributions. According to Chi, interactive activities are most likely to be better than constructive activities, which in turn might be better than active activities, which are better than being passive. Based on Chi's argument, we are attempting to incorporate interactive activities in this multimodal learning environment, by allowing visitors to interact with animals or peers and construct their own music. To this end, they can create 3rd and 4th counter-melodies by interacting with their fellow visitors. We can employ diverse strategies for using music as sonification. For example, we will investigate various mappings to identify how visitors' approximate movements can create more musically matched sounds. We also plan to integrate two separate sonification systems so that an animal-inspired melody can evolve and adapt to the visitors' music pattern. Furthermore, we expect to incorporate narration as sonification to provide a more transparent form of information and aesthetics. These narrations (or lyrics) could provide verbal descriptions of animal characteristics and facts to accompany the music. These multifaceted efforts are expected to create innovative and engaging soundscapes in aquariums that attract and welcome a wide range of visitors, including those with vision impairments as well as children.

6. REFERENCES

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