Interactive Educational Dolphin For the Visually Impaired

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ABSTRACT

The Georgia Aquarium offers many enjoyable and educational experiences for visitors. Unfortunately, visitors with visual impairment often cannot fully experience the aquarium, as the use of sight is essential to appreciate the vast majority of its galleries. In this paper, we describe a fiberglass dolphin designed specifically to be educational and interactive for the visually impaired through stimulating the senses of touch and hearing. The design and construction of this dolphin was based off of the feedback of individuals from the Center for the Visually Impaired and the Georgia Aquarium. The ultimate goals were not only related to purposes for the Ubiquitous Computing course, which focuses mainly on technology, but also to satisfy the needs and wishes of the aquarium and for both visually impaired and general users. We attempted to do this by maintaining the goal that the final installation at the Aquarium would not only be enhancing the experience for the visually impaired through technology, but also through creating a final product that is artistically and visually stimulating for the general public as well.

Author Keywords

visually impaired, educational, interactive, aquarium, ubiquitous computing

ACM Classification Keywords

H.5.2. [Information Interfaces and Presentation]: User interfaces.

INTRODUCTION

The Georgia Institute of Technology has been involved with research pertaining to the visually impaired and formulating methods in order to make the Georgia Aquarium more accessible to this select and disabled group of people. Previous and current research includes the "Accessible Aquarium Project", a cross campus collaboration including the College of Computing, Psychology, and Music Technology. This paper presents the design and construction of another partnership project between the university and aquarium with a goal of enhancing the Georgia Aquarium visiting experience for the visually impaired. The project is called the Interactive Dolphin Project.

The Georgia Aquarium, located in Atlanta, Georgia is the world's largest Aquarium [Aquarium]. It has always been a great and fun place for kids and grownups to learn and experience about aquatic life. However, visiting the aquarium could be a challenging and uncomfortable activity for the visually impaired. This winter, the aquarium is planning to open a new gallery which showcases bottled-nosed dolphins. In order to market this new gallery, the aquarium is sponsoring an event called Dolphins on Parade which allows artists to create unique designs for 50 or more fiberglass dolphin statues [Georgia]. We were given one of these statues and entrusted with task of developing an original and creative design. Our final design is catered towards the visually impaired. The final product of this project was the result of multiple visits to the Center for Visually Impaired (CVI) in which we garnered user feedback pertaining to preferences for the dolphin's features, sensors, interaction capabilities, and overall experience.

The low light environment and small information text display are some of the problems visually impaired could encounter. Incorporating touch and auditory feedback is necessary for a design if it is to be suitable for the visually impaired. In addition, the dolphin interface is meant to be a fun educational experience. Though the aquarium wants our design to be appealing for the general public, it was important to us to utilize technology and support some of the current research at the university and make the dolphin accessible for the visually impaired. Therefore, the making of the interactive dolphin was targeted to stimulate both the tactile and audio senses. Our design uses touch and pressure activated sensors in order to generate sound. The sounds are meant to be educational (quite literally with a voice speaking facts), entertaining (dolphin noises), and interactive (3 individuals are needed to fully create a sonic representation of a dolphin's natural environment).

PREVIOUS RELATED WORKS

One of the existing works that created aquarium exhibitions for the visually impaired is a company called RAF Models. Currently, this company has developed tactile talking fish for the North Carolina Aquariums and also helped define the "national guidelines for the design of tactile exhibits that engage all people and give the blind and low vision audience access to the exhibit information [Kostakou]." Rebecca Fuller and William Watkins (of RAF Models, Inc.)

presented their research in "Tactile Exhibits with Touch Activated Descriptive Audio for Aquariums." [Fuller]

Our dolphin prototypes were developed based on their methodologies to interaction and interpretive interaction by the visually impaired community. We spoke with both Fuller and Watkins and they gave us ideas for materials and the technology to be used for our prototypes as well as the audio descriptive information topics. These suggestions included paint and sensors for audio activation.

RESEARCH

During the first phase of the project, we worked with both the client, Georgia Aquarium, and the users, the Center for Visually Impaired (CVI) to help us better understand and define the users, requirements and environment. These three attributes greatly influenced our design process.

Users

The visually impaired are our primary target user group. According to World Health Organization, about 82% of them are above the age of 50 [WHO]. Majority of them are not completely blind but have a wide ranges of different vision difficulties depending on specific causes. There are many different causes for visual impairment, but the most common ones are refractive errors, specific eye conditions and cortical visual impairment [Common].

During our visited to CVI, we learned that many of the visually impaired persons had perfect vision during their earlier years. They were able to function normally in the society and held steady jobs. For many, their visions started to fail either in late twenties or early thirties. Many of them have a good concrete concept of the visual world from before losing their ability to see well. Because of this important fact, many of them expressed that they still would like to learn about the shape, texture, color, and size of the fish through either descriptive or tactile means. Another piece of information we gathered is that, although most people we talked to at CVI had a wide range of vision impairments, majority of them told us that they prefer the dolphin interface to be touched-based instead of visual-based or sound-based.

The final important information we have collected from people from CVI is that those that had or would like to visit the aquarium would do so with their family or friends instead of on their own. We were told that group interaction is highly important to these individuals and that the interactive dolphin should not only tailor to the visually impaired but also for the general public as well. Their wish is to have an interface that assists them with their visual impairment but at the same time, do not make their disability stand out to others.

Requirements

The Interactive Dolphin is going to be a public work that will represent the Georgia Aquarium. As our client, the aquarium has provided several requirements and constraints for the project. First of all, although our target user group is going to be the visually impaired, we have been asked to make the statue accessible and usable for the general public as well. Secondly, the dolphin statue will need to be painted and the aquarium must approve the painting design so that it maintains a consistent look with rest of the dolphin statues for the Dolphin On Parade event.

Other requirements we also had to take into consideration for the final design are that the technology we use will need to be easily detachable from the main body. This would enable the aquarium to easily make changes when we hand in the final statue to them. Some of the changes that we believe the aquarium would make are applying final UV coating to the outer body, adding or removing audio files, adjusting sound volumes, re-calibrating sensor sensitivities, and updating the software.

Environment

Based on given information from the aquarium, we believe the final product will be placed indoor near the dolphin gallery. When we visited the aquarium, we made several observations about the indoor environment. The aquarium has a vast space for visitors. It is easily navigable because most galleries have only one path from entrance to exit. The majority of the galleries use dim lights to create an underwater ambient environment. Each of the exhibits also had information panels that describe and provide information about the fish. In addition, we noticed that there is a small audio enhanced tour about the beluga whales gallery.

While the open spaces are good for the visually impaired, we conclude that the dim lights cause problems for them when they visit the aquarium. At the CVI, several people who have been to the aquarium told us that they had difficulty navigating inside due to the dim lights. They also had trouble reading from the information panels because of glare, font color, and/or font size. These findings tells us that for the visually impaired, we need a better way to display information through either touch or sound to accommodate for the lack of light and visual consideration.

DESIGN CONCEPTS FOR INTERACTION

Based on our initial findings with the client and users, three design concepts were created. Each design concepts for interaction is based on two types of VARK learning styles, aural and kinesthetic [VARK]. The first concept focuses on an interactive audio experience. The dolphin serves as the main platform for synthesizing sound, which encompasses a mix of environmental tones, dolphin sounds, and informative data.

The second concept is based more on kinesthetic learning by paying particular attention to the sense of touch and movements. Flexible parts, various textures, and even a functioning blowhole are some of the features in this concept.

Lastly, the final concept is a hybrid of the aural and kinesthetic learning style. To evaluate our design concepts, we created a prototype dolphin that simulated some of the key aspects from each design concepts. These key aspects include floor pads pressure sensor, direct touch sensor on the dolphin, blow hole on the dolphin and textured.

The dolphin prototype was taken to CVI to see which of the key aspects our primary users preferred. The user feedback was very useful. However, we were not able to implement all their preferences due to constrains from the client as well as available resources.

Please see Appendix 1 on the three design concepts for interaction.

CONSTRUCTION

The final design of the dolphin is based on satisfying both the preferences from CVI users as well as requirements from the aquarium.

Physical

The dolphin itself is a hollow, 5' foot, fiberglass statue. Using the sensor technology suggested to us by the CVI and faculty at the university we outfitted the dolphin with numerous touch sensors. The sensors, which allow direct touch activation on the dolphin, are capacitance sensors. The locations of the sensors are all on the top half of the dolphin. Our decision on sensor placement is based off from the CVI participants' input. A visually impaired person will not bend over to touch a low positioned sensor because it may be disorienting.

Small holes were drilled into six locations on the upper parts of the dolphin including the two on its fins, two on its back, one on its chest, and one on its rostrum. A copper wire protrudes from each of the six holes and is cemented to the outer layer of the dolphin in a spiral shape. Conductive epoxy was then applied to each of these wires to allow for a wider surface area of sensitive area. 1 megohm resistors were soldered on the end of the wires that connected to the micro-controller pins. The resistors are used to discharge the electric charge created by human touch to the wires. We used 1 megohm to ensure that activation is performed by absolute touch. If we have used higher megohm resistors, then the sensor will respond more sensitive with the possibility of being activated 4-6 inches away.

Three reasons inspired the spiral shapes of the wires. First, from a technological standpoint the shape maximizes the surface area so that less epoxy and wire is necessary. This ensures that the area within the spiral will respond to the touch of a hand. Second, from a tactile standpoint, for a visually impaired person touching the dolphin the spiral shape provides the necessary amount of variation (in feel with the rest of the dolphin) within a concentrated area so that he or she may distinguish between a sensor and spot and the non-sensor area. This is important if the user wants to repeatedly activate the audio of a particular sensor or find other sensors. This also allows the user to know that the audio is not generated by chance, but rather that he or she has a certain degree of control. Lastly, from an aesthetic point of view, the spiral shape is visually appealing, yet still subtle enough to not stand out and distract from the visual of the dolphin as whole.

Other than direct touch input on the statue our design includes one more feature. This feature is the floor pads. The floor pads were put in place to create a sonically rich environment, which replicates the dolphin's habitat. Each of the three floor pads was fitted with a pressure sensor so that when stepped on an ambiance audio file is activated. More importantly, the floor pads encourage user-to-user group interaction. Unlike the sounds activated by the sensors directly attached to the statue, which can only play one at a time, the sounds activated by the floor pads can play simultaneously. Each sound file adds an environmental sound and only when all three floor pads are activated will the complete environment be established.

All of the speakers and electronics are placed within the hollow cavity of statue. Additionally, several small holes were drilled into the chest of the dolphin as well as the base, which allowed cleaner output of the internally placed speakers.

Computational

The sensors are connected to an Arduino board that we used as our programmable micro-controller, which allowed us to control both the audio files and capacitive sensors.

To detect capacitance, we downloaded a capacitive sensing library called CapSense from the main Arduino website. This library is able to turn two or more Arduino pins into capacitive sensors [Arduino]. We were able to implement six capacitive sensors from just one Arduino board. The library also enabled us to easily adjust the sensitivity thresholds for each capacitive sensor. This is extremely useful for our project because the sensitivity for sensors would change when a layer of paint and UV Shielding coat are applied on top of the spiral shaped cooper wires. The UV coat is necessary for the final product because it will be installed in a place where it will be touched and felt continuously by the public. It is important to take every reinforcement precaution necessary, as it will extend the life and use of our interactive dolphin.

In order to add sound to our electronic project the AdaFruit Wave Shield for Arduino was used. The Shield plays 22kHz, 12bit uncompressed audio and has a built in DAC, filter, and op-amp [Adafruit]. The files are read off of an SD card. This made connecting to the Arduino very easy and simplified the electronics. The Wave Shield's output is connected to speakers which play the sound.

DISCUSSION

To make an aquarium experience enjoyable for someone with visual impairment, it is necessary to include aspects of interaction that incorporate the senses other than sight. The participants at the CVI convinced us that the best way to do this is through touch activated sounds. Those who suffer from total blindness find it most pleasing if they are able to continuously run their hands across a surface without interruption in a fluid motion. This encouraged us to use capacitance sensors as opposed to pressure, motion or button type sensors on the dolphin itself. Additionally they liked the idea of interaction between peers and thus the inclusion of the floor pads was suitable.

It is important to realize that the Georgia Aquarium is our client and that even though we had our own aspirations of developing a system appropriate for the visually impaired it is also important to satisfy the wishes or our client. We achieved this through constant and continuous contact with the CVI as well as with the aquarium.

FUTURE PLANS

There is still more work to be done before the dolphin can be installed at the aquarium. Now that all of the technological aspects of the statue are functional, the next step is to get feedback from the aquarium and decide which paint design we should use. Similarly to the three design concepts for interaction we developed three design concepts for painting to be reviewed by the Georgia Aquarium. The design options that we came up with will be more suited to please the aquarium and will not incorporate CVI inputs. The design will be purely a creative and aesthetic creation, which is in coalescence with the aquarium's original desires of having artist to paint the statues to advertise the new dolphin gallery opening. After we have painted the statue the aquarium will apply UV coating on it to give the statue an extra layer of protection from external elements and people.

Please see Appendix 2 on the three design concepts for painting.

CONCLUSION

The experience of going to the Georgia Aquarium is strongly associated with the visual stimuli. We hope that we have shown that it is possible to make aquariums accessible to a broader range of people including those that do not use vision as their primary sense. Using the technological developments that are often applied in other fields we constructed the Interactive Dolphin. It provides both tactile and auditory stimuli through sensory input which allows for an educational experience similar to the one provided by the visual tours. However, the Interactive Dolphin is only a small step into making the aquarium more accessible to those with visual impairments. There is still a plethora of research and development in human computer interaction and sonification that can be done in order to enhance the experience for this class of people.

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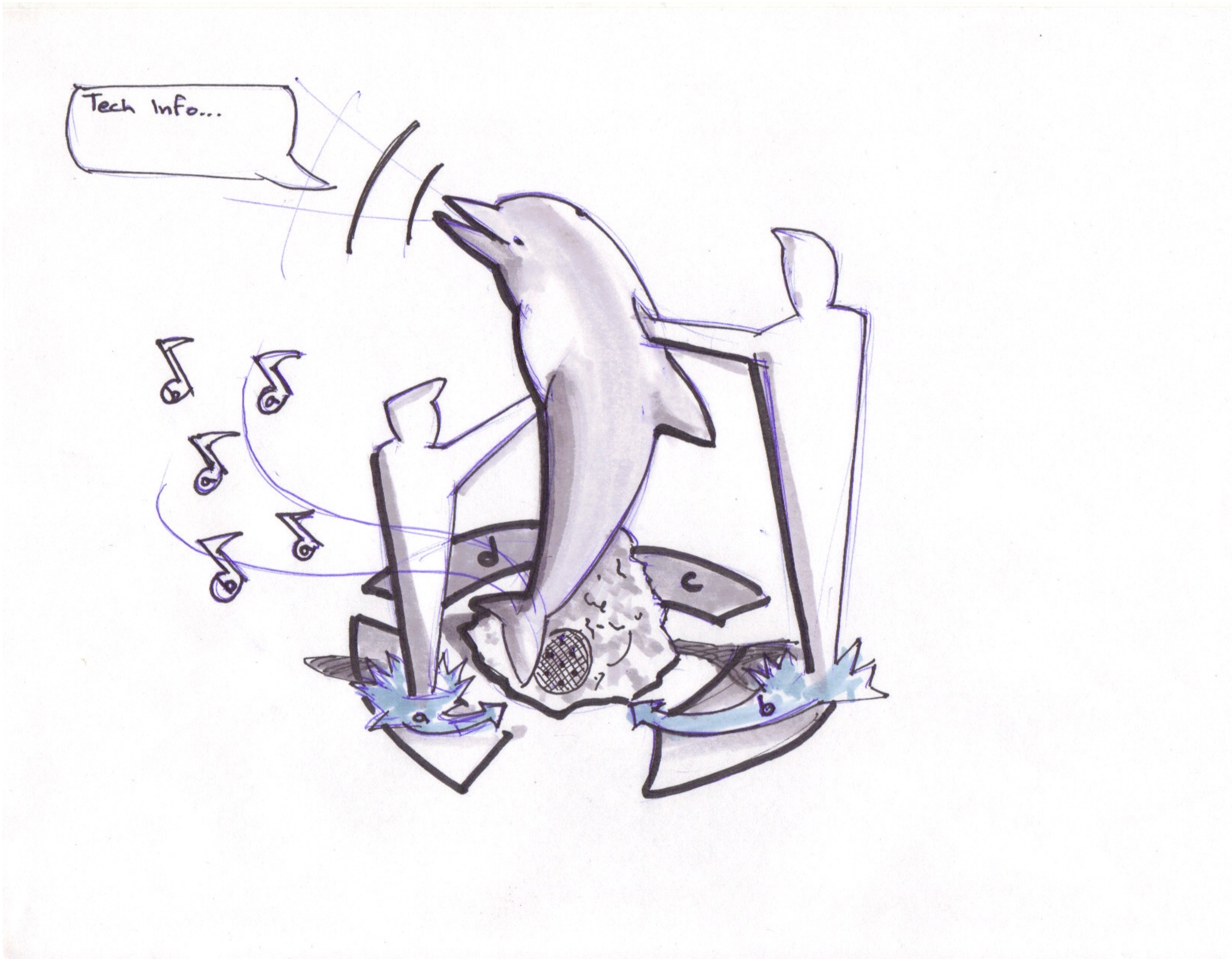
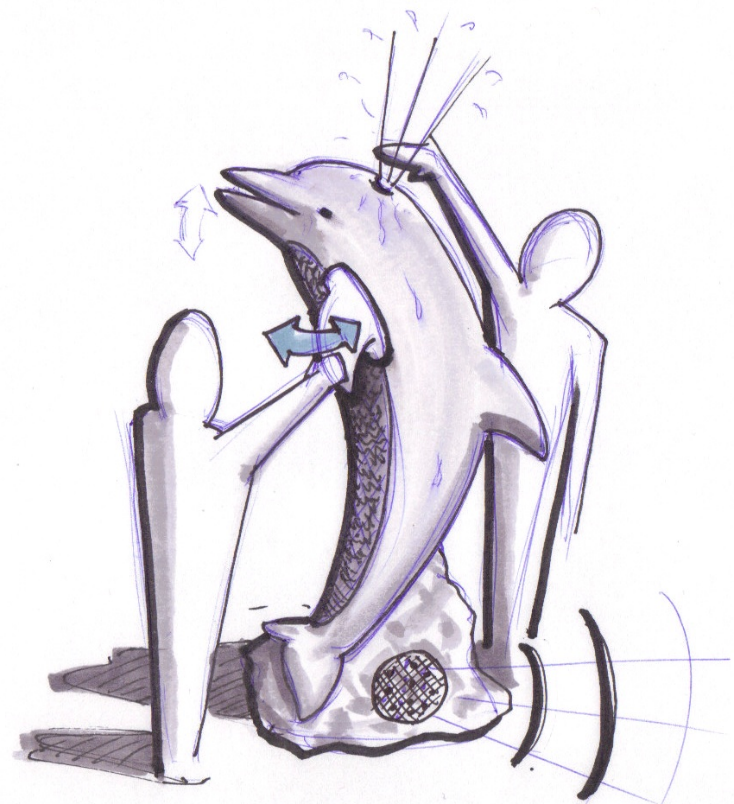
Appendix 1. Audio Learning Experience



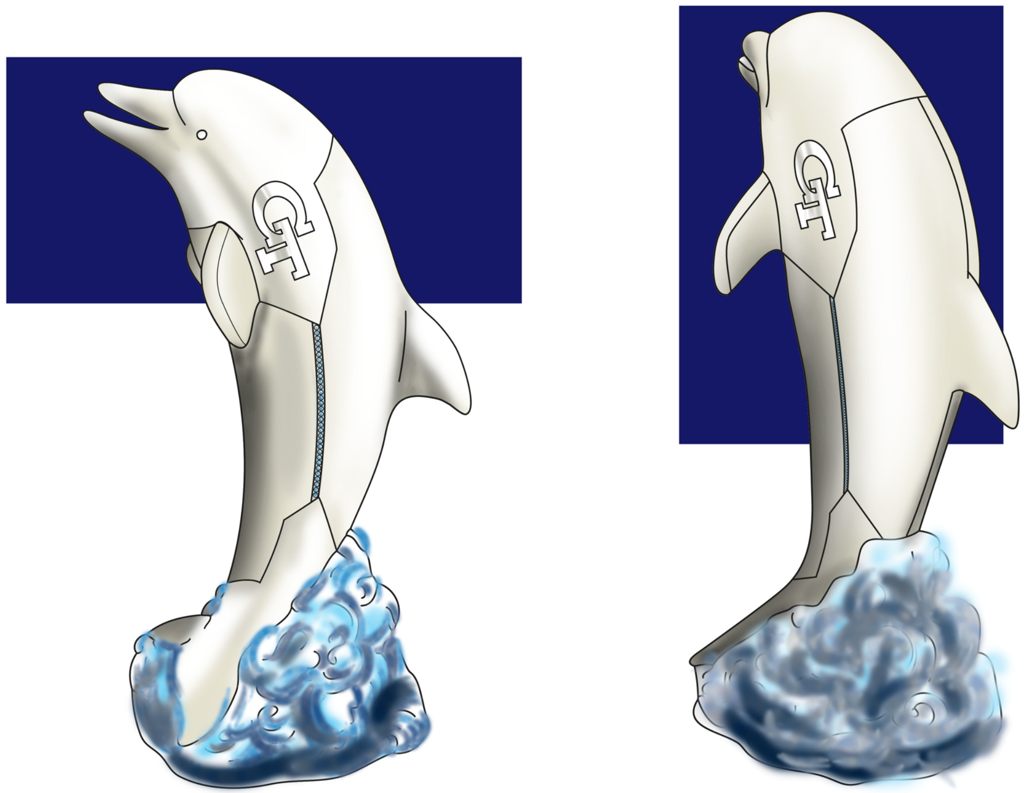
Appendix 1. Hybrid Learning Experience

Appendix 1. Kinesthetic Learning Experience



Appendix 2. Musical Dolphin

Appendix 2. Robot Dolphin



Appendix 2. Sound Ripple Dolphin