3D Virtual Museum Application

Sneha Kurella, Gavin Kliger, Alison Gonzales, Christopher Clark

COSMOS CLUSTER 5 UCI 2016

Dr. Jaroszewicz and Mr. Simmons

5 August 2016

ABSTRACT

The purpose of creating this project is to examine the efficacy of a virtual museum that can run within an iOS device. The project aims to create an immersive and cohesive museum experience using 3D rendering and 3D audio effects. Brick and mortar museums can be difficult to access for members of lower socioeconomic groups due to admissions fees, a lack of transportation, and a lack of time. The virtual museum removes all of these obstacles of entry while preserving the essential characteristics of a museum within a virtual 3D space. The Virtual Museum allows users to interact visually and auditorily with exhibits through an iOS application using touchscreen functionality. By touching exhibits, users can listen to information presented using 3D audio effects, allowing the user to locate the sound in 3D space. The audio files have been extensively edited within Audacity to provide the most realistic 3D sound possible. Three dimensional renderings of museum exhibits compiled within SceneKit and Xcode provide another level of realism and immersion, adding to the authenticity of the museum. Combined, these elements accurately recreate the essential aspects of a traditional museum.

INTRODUCTION

Downloadable virtual museums are important because they can provide people with an immersive, educational museum experience free of many of the problems inherent in traditional physical museums. According to a national survey conducted in New Zealand and published by the Office of Policy and Analysis of the Smithsonian Institution, barriers preventing members of lower socioeconomic groups from visiting museums include a lack of time, admissions charges, and lack of transportation (Smithsonian, 2008). A virtual museum would eliminate these barriers of entrance, by providing access to museums free of admissions charges and lengthy commutes on a time-frame determined by the user. The virtual museum requires only an iOS device running iOS 8 or later to be fully utilized.

In order to locate sound, the human ear uses the process of sound localization. The auditory canal absorbs sound, which causes the eardrum to vibrate and stimulate an auditory nerve. Within the cochlea of the ear, the basilar membrane detects waves of different frequencies, allowing the listener to determine pitch. An interaural time difference, the time difference between hearing a sound in each ear, allows the human brain to determine the location of a sound source (Middlebrooks, 1991).

To create a truly immersive museum experience, several technologies must be utilized. The first of these are 3D audio effects, which are capable of seemingly placing sound at a point in 3D space. By using 3D software such as Blender and SceneKit, it is possible to position these 3D audio effects within a virtual room. The sounds can then be programmed to respond to changes in viewing angle. Essentially, 3D audio will change volume depending on how the user looks at the sound source, much as it would in a physical setting. According to the dissertation of

Dr. Jaroszewicz on 3D audio, it is possible to position a sound within the field of an audio panorama, also known as an image. This can be accomplished in the virtual museum through the use of simple linear panning. This method of generating 3D sound uses computer algorithms to change the amplitude of sound in the right and left ear of the viewer, giving the impression that sound is moving around the viewer in 3D space. This form of 3D sound manipulation is especially useful for giving the impression of circular sound motion to the listener. (Jaroszewicz, 2015).

For the purposes of this application, audio clips must be recorded for use as 3D Audio Effects. To do this, a condenser microphone was used in the field. Condensers microphones are directional microphones that use diaphragms to convert analog vibrations into electrical signals. These electrical signals are then filtered by a connected preamplifier, which edits out distortion. Finally, the electrical signal reaches a recorder which converts electrical analog signals into digital signals and then saves the resultant data (Runstein, 2013).

To generate a virtual room to act as a museum, pre-coded three dimensional objects can be imported into 3D building software such as Blender and Scene Kit, in the form of 3Ds files. To generate original objects that could not be found in publicly available databases, the software Tinkercad was used. The resulting 3D objects can be viewed from multiple angles by placing "cameras" throughout the 3D scene. These "cameras" are simply points of view from which the 3D room can be rendered. This software enables the user to view different exhibits and portions of the museum from different angles and perspectives. Scene Kit also allows users to alter camera angles within 3D scenes, adding an immersive and interactive element to the virtual scene and providing an opportunity for the use of 3D sound effects (Ronnqvist, 2014).

Combined, these 3D technologies allow for the creation of a museum that can both immerse and engage the user through the use of 3D scenes and sound effects while retaining all of the benefits of a virtual space.

MATERIALS

a. Beats Studio Headphones
b. Audio-Technica Studio Headphones
c. Zoom H4 Pro Handy Recorder
d. Microphone: Sennheiser ME 67 Supercardioid Condenser Microphone
e. MacBook Air
f. MM-1 Preamplifier
g. Xcode 7.3.1
h. Audacity 2.0.5
i. Blender 2.77
j. Sonic Visualizer 2.4.1
k. Swift 2.2
l. Adobe Photoshop CC

METHODOLOGY

First, scripts were written explaining each of the four museum exhibits using Microsoft Word 2016 and MacBook Air laptops. The scripts were then read aloud in a quiet, sealed room and recorded using a Sennheiser ME67 microphone, a MM-1 preamplifier, and a Zoom H5 Handy analog to digital converter. The Sennheiser ME 67 is a supercardioid condenser microphone. It has a frequency response of 40 Hz to 20 kHz, covering most of the range of human hearing. The mic itself has dimensions of Ø 22.5 x 221 mm and a sensitivity of 50 mV/Pa +- 2.5 dB. Once the microphone captured sound, electrical analog signals were sent to a Sound Devices MM-1 preamplifier, which filtered distortion from the sound. The processed analog signals were then sent to the Zoom H4 Handy Recorder, which converted the electrical analog signals into digital signals and stored them. Once recorded, the sound sources were uploaded to MacBook laptops, looped, and edited in Audacity version 2.0.5, a multi-track audio editor and recorder. During filtering, some frequencies were enhanced and others were suppressed in order to produce a more clear and convincing sound. Room quality was also altered by adding delayed copies of the sound at dampened amplitudes to create the effect of an echo. The resulting audio files were then extensively analyzed within Sonic Visualizer, an application for inspecting and analysing the contents of music audio files. After sound editing and viewing was completed, 3D objects were constructed in Blender, a free and open source 3D creation suite, and then moved to SceneKit, an Objective-C framework for constructing 3D scenes that use 3D graphics, utilizing a high-performance rendering engine and API. The objects were then placed within a 3D virtual room within SceneKit. Xcode, an integrated development environment, was then used to attach audio files to objects within the 3D scene and to place cameras from which to render the scene. User interface was also improved using Xcode, incorporating touch screen functionality to alter camera and view angles within the application, as well as to switch between different exhibits. To create the app icon, Adobe Photoshop was used.

RESULTS

Figure A shows the sine waveforms associated with the stored digital audio files of two roars. Both roars were recorded using a shotgun microphone at separate times.The waveforms show changes in amplitude (vertical axis) with relation to time (horizontal axis). In this case, the first roar lasted 3.20 seconds and had an amplitude range of .54. The second roar lasted 2.65 seconds and had an amplitude range of 1.18.

Figure A

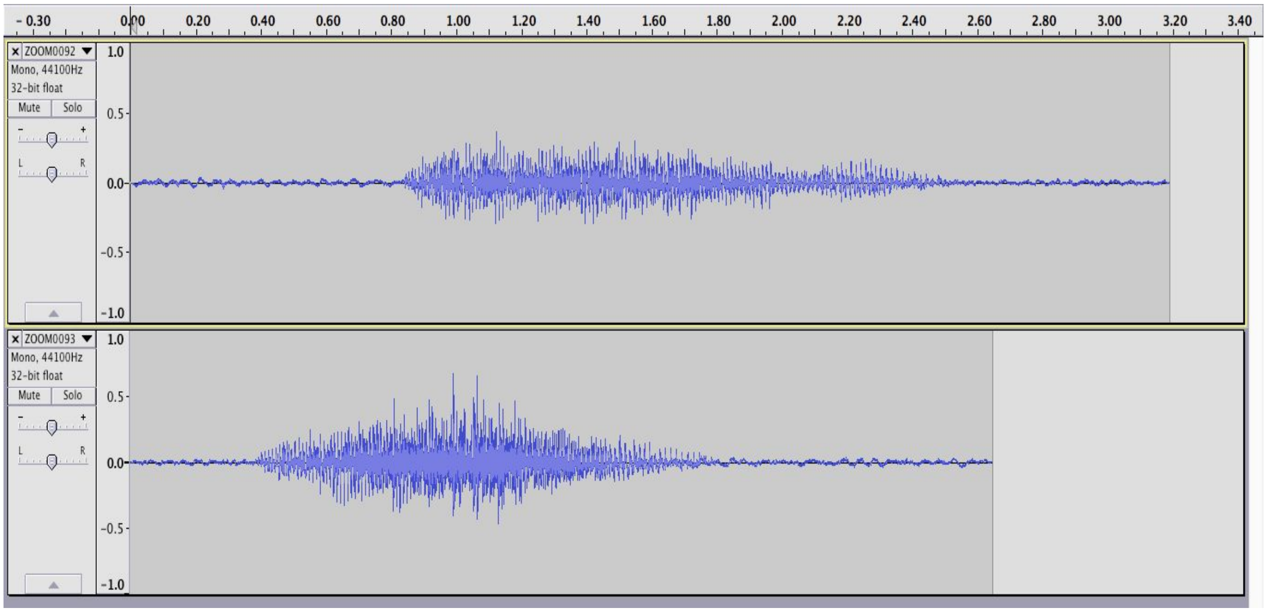


Figure B shows the same two roars combined into a single sound file. This allows both roars to be played sequentially, and allows both roars to be edited simultaneously. The resulting audio was 3.61 seconds long and had an amplitude range of .86.

Figure B

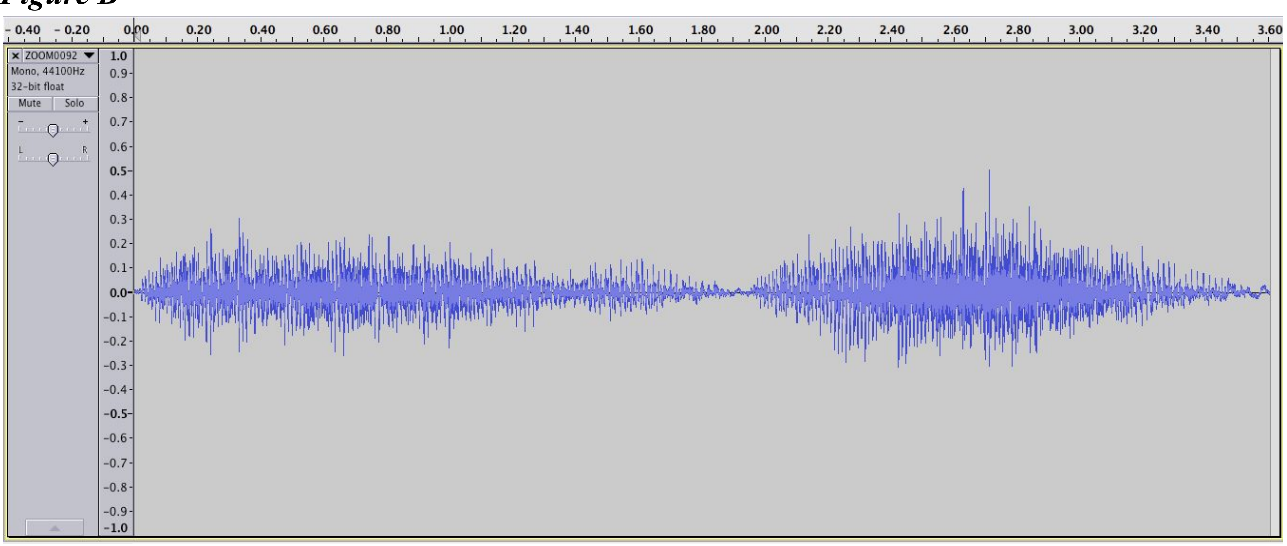


Figure C shows the two roars once editing was completed. The roars were amplified, causing the amplitude, or height of the waveforms, to increase. In the application itself, the roars were played at ½ the speed at which they were recorded. Playing back sounds in slow motion causes the frequency and pitch of the sounds to decrease and lengthens the time the sound plays, which makes the roar sound more realistic. This waveform has a length of 3.61 seconds and an amplitude range of 1.38.

Figure C

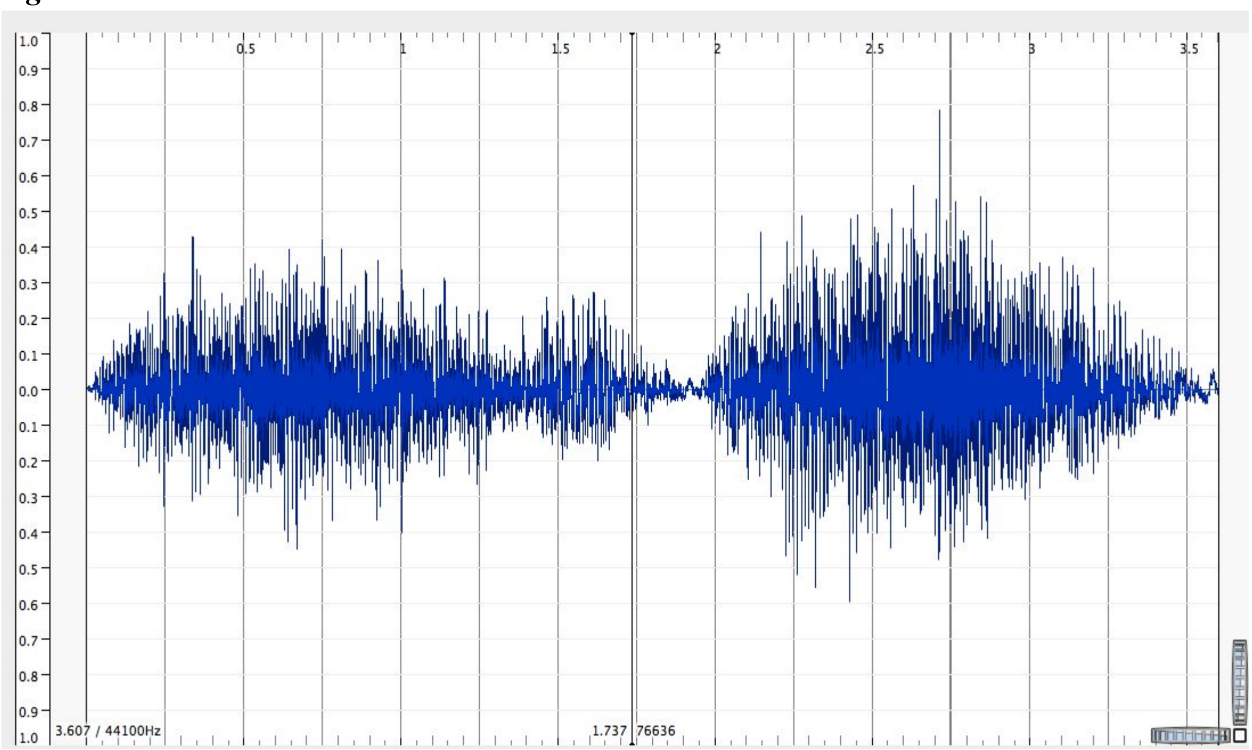
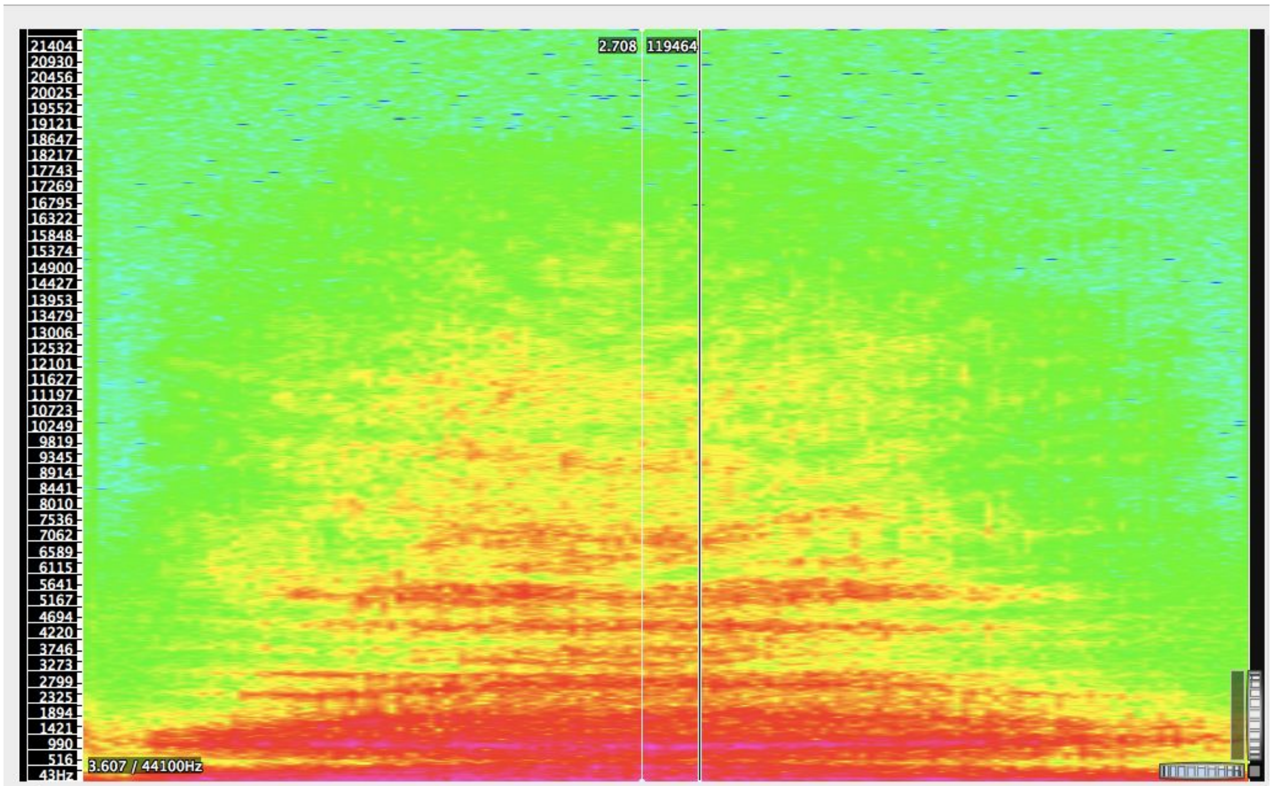


Figure D shows a spectrogram of the second roar as shown in Visual C. To create this spectrogram, Sonic Visualizer uses the Fast Fourier Transform, an algorithm that analyzes chunks of data to determine the magnitude of different frequencies at individual moments in time. Spectrograms show time on the horizontal axis, frequency on the vertical axis, and use color intensity to show amplitude. Because the growl was a low pitch, the color intensity is greatest towards the bottom of the visual, between 43 and 2000 Hz. The middle of the roar has high amplitude at higher frequencies as this portion of the roar has a higher pitch than the beginning and end of the roar. The roars can be heard within the app by visiting the dinosaur exhibit. Other recordings were similarly compiled and edited, resulting in the audio clips that can be heard at each exhibit within the virtual museum.

Figure D



CONCLUSION:

This project aimed to create and evaluate a three-dimensional virtual museum that could be used on an iOS device. To accomplish this, 3D audio effects and 3D renderings were used to create a realistic museum environment. The resulting museum has free admission, does not require transportation, and does not necessitate physical maintenance. Hence, it is more accessible than traditional brick and mortar museums to members of lower socioeconomic groups and those with time constraints. Users were able to effectively navigate the museum and interact with exhibits in a virtual three-dimensional space, proving that virtual museums are a viable alternative to physical museums. To further the study, more time would need to be spent creating a more realistic museum environment by adding more colors, textures, and 3D models, and by recording more sounds for use on different exhibits. Further studies should focus on developing navigation software for helping users move about the museum and minimizing the amount of storage used by the application.

ACKNOWLEDGEMENTS

The members of Group 2 would like to thank all of the staff at COSMOS UCI, especially Dr. Jaroszewicz, Mr. Simmons, Mrs. Bergen, and Ms. Lee. Dr. Jaroszewicz was contributory in assisting with the development and programming of our virtual museum application. Mr. Simmons was instrumental (no pun intended) in explaining and demonstrating the many aspects of sound, as well as explaining the proper use of recording and editing equipment and software. Mrs. Bergen ensured that our group met deadlines, understood how to make a research poster, kept us on task, and provided mentorship and guidance along the way. Last, but not least, we would like to extend our thanks to Ms. Lee for providing help during the recording and editing phases of our project.

BIBLIOGRAPHY

Green, Melanie C, Timothy C. Brock, and Geoff F. Kaufman. "Understanding Media Enjoyment: the Role of Transportation into Narrative Worlds." Communication Theory. 14.4 (2004): 311-327. Print.

Huber, David Miles, and Robert Runstein. "Modern Recording Techniques." (2013) Web. 22 July 2016.

Jaroszewicz, Martin. (2015). Compositional Strategies in Spectral Spatialization. UC Riverside: Music. Retrieved from: http://escholarship.org/uc/item/7wm025g7

Middlebrooks, JC, and DM Green. "Sound Localization by Human Listeners." Annual Review of Psychology. 42 (1991): 135-59. Print.

Puckette, Miller. The Theory and Technique of Electronic Music. Hackensack, N.J: World Scientific Publishing Co, 2007. Print.

Rönnqvist, David. "3D Graphics with SceneKit by David Rönnqvist on IBooks." IBooks. David Rönnqvist, 24 Dec. 2014. Web. 22 July 2016.

Stanković, Stanislav. Virtual Reality and Virtual Environments in 10 Lectures. 2016. Internet resource.

Tallon, Loïc, and Kevin Walker, eds. Digital Technologies and the Museum Experience : Handheld Guides and Other Media. AltaMira Press: Lanham, 2008. Web. 22 July 2016.