First-Combat Sound Simulator: Military Training Application using 3D Sound Spatialization

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Abstract

Modern-day warfare is very demanding on the human body. A soldier needs to be courageous, committed, and above all, concentrated. For new soldiers, the first battle can be very dangerous, as the loud sounds of warfare coupled with their inexperience can result in disorientation and panic. Military training exercises are effective for improving a recruit's physical performance on the battlefield, but are unable to entirely replicate the same enveloping sensation of actual warfare that can affect a new soldier's mental state. Similar to how virtual reality exposure for "shell shock" victims can help with their PTSD, our application is designed to help prevent trauma and prepare soldiers for what it's like on the battlefield. The goal of the First-Combat Sound Simulator is to provide a realistic audio combat environment using 3D sound technology. The application uses spatial audio playback to improve a soldier's effectiveness during their first combat experience, while saving ammo during training.

Introduction

Cluster 5, Sound for Virtual Reality as an Exploration of 3D Sound and Movement, centers around using the programming language, Swift, to create an application with sound spatialization. We learned different microphone techniques for studio and field recording. We worked with Audacity to edit sound files. Then, using Xcode and Swift, we integrated them into a three-dimensional space. Our group recorded military voice commands at the UCI Music and Media Recording Studio and utilized pre-recorded audio files for battlefield sounds.

The First-Combat Sound Simulator consists of an app and a headset to be worn while running training exercises. The headset is comprised of two components: headphones, and an IMU (Inertial Measurement Unit) sensor that records acceleration data from all directions. The app detects the position of the user's head and calibrates the environment's audio accordingly. In addition to preset situations and environments, the application also includes a customizable mode that allows a user to adjust the location of different objects in an environment.

Materials and Software

MBientLab MetaWearC Sensor: As the application launches, the software will track and connect the user's sound devices and sensor to the virtual reality system.

Signal Flow

The microphone first picks up sound from a source, then connects to the preamplifier, which can alter the gain and frequency of the audio. Finally, the recorder changes it into an electric signal.

Sennheiser ME67 Long Shotgun Microphone

Sound Devices MM-1 Portable Mic Preamplifier

H5 Zoom Digital Recorder

Xcode is an IDE (Integrated Development Environment) that allows users to develop software for iOS. Xcode is used with tools developed by Apple to write, build, and run applications on a user interface. Xcode also contains an iOS simulator to test projects and applications on Apple devices, such as the iPhone, iPad, MacBook, Apple Watch, and more products.

GitHub is a service that allows users to share repositories of code online. With the feature to share, pull, and merge repositories, GitHub is an immersive environment for users to collaborate and contribute to many projects.

Audacity is a free and open-source software for recording and editing audio files. With sound represented as waveforms, this program utilizes tools and features that allow cutting, mixing, and other effects to manipulate the sound through its gain and frequency.

Swift is an open source modern OOP programming language first developed by Apple to develop iOS applications. It includes the **AVFoundation** framework for audio playback and management, which provides tools to build media applications on Apple platforms.

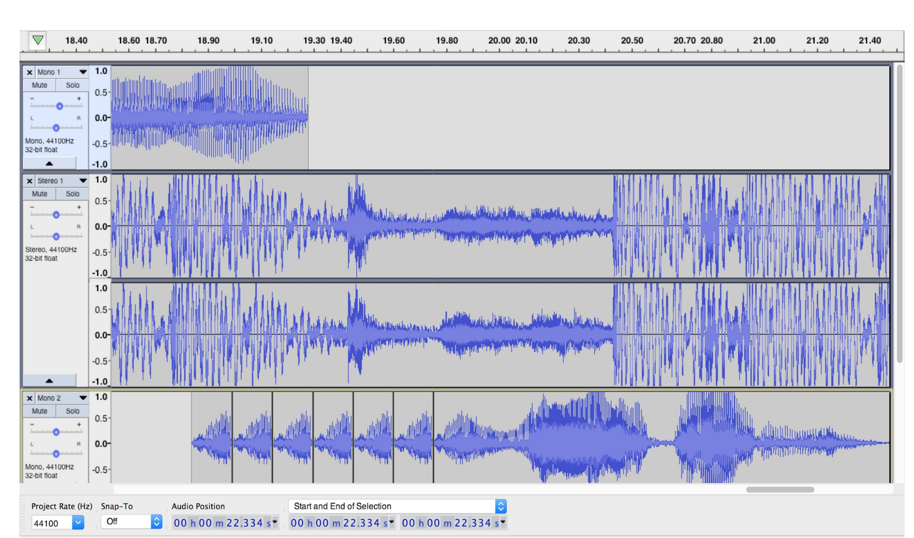
Methodology

Field Recording Techniques:
Our group learned how to analyze sound parameters, including amplitude, frequency, velocity, and wavelength. We then recorded outdoor environmental sounds using equipment such as the microphone, preamplifier, and zoom recorder.

Developing the Application with Xcode and MetaWear Sensors:
We created the First-Combat Sound Simulator with Xcode using Swift, the iOS programming language. MetaWear software enabled us to use the MBientLab sensor's IMU capabilities while the AVFoundation software let us manipulate sounds within the app. Core principles of Object Oriented Programming and Protocol Oriented Programming enabled us to efficiently transfer data from the sensors (accelerometer, gyroscope, magnetometer) that were provided in the form of sensor fusion data.

Sound Spatialization
The basis of the sound spatialization technique is a sound engine utilizing buffers, various sound nodes, and a spherical head sound spatialization algorithm. The AVFoundation software was imported into the code, and sound files were loaded into the buffers. Functions were then implemented in the engine that allowed us to update and modify the perceived position of the sounds based on the orientation of the IMU. As the sensor is able to transmit information about its orientation in a 3D space, the program uses that data to manipulate and mix sounds to simulate the environment.

Data and Results

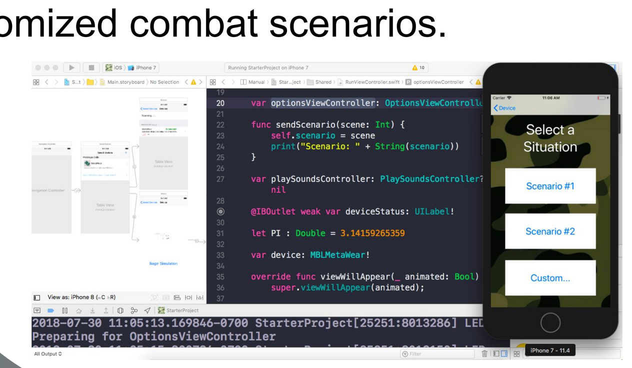


Using Audacity, we could clip and edit our sound files. In the UCI Music and Media Recording Studio, we recorded military commands, and for combat recordings, we used pre-recorded audio files.

Once the app was developed, military sounds were spatialized to remain in the same location even after the user turns or tilts his/her head. As a result, new recruits would be able to train and perform drills while listening to actual audio recordings of artillery and explosions similar to real war experiences.

Our project includes sound masking, and it means, "an auditory phenomenon in which one sound alters the perception of another sound, sometimes making that other sound inaudible" (Jacklyn 1). In other words, our application is able to simulate sounds that the user can tell which frequency is higher or lower in sound masking if there are multiple sounds in one space.

Drag and drop features were implemented to allow the user to move specific sounds to any location on a coordinate plane. This enables a soldier to adapt to a wide variety of sounds, as well as provide military training officers to create highly customized combat scenarios.



Pictured to the left is an example of the code and simulator from Xcode. The storyboard is on the left and shows the navigation controller. Moreover, the code depicts the RunViewController and protocol functions that show the options that a user can select from to play different sounds and simulate new environments.

Conclusion

The possible applications of the First-Combat Sound Simulator are numerous. Going beyond recruit training, the technology could be used to help veteran soldiers to adapt to unfamiliar combat environments without ever stepping foot there in real life. If improving the acoustic awareness of cadets through the simulator becomes a widespread practice in the army, it is likely that the general effectiveness of the military will improve as well.

Further research and development would allow improved optimization of the combat environment. A wider array of sounds could be added to our library to enhance the user experience and add to the complexity of the simulations. Additionally, future versions of the application could include environments customizable in their geographic locations, such as high-altitude mountain settings or dense swampy forests.

Combined with more detailed sound spatialization, the addition of a sensor such as a GPS could enable recruits to use the First-Combat Sound Simulator in much larger environments. More advanced headsets could enable collaborative training exercises where 3D audio is calibrated for the movements of each person. Regardless of what application the technology is used for, the concept of a wearable sound simulator for training exercises could become a prominent part of military training.

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