DEMONSTRATION OF AN OUTDOOR AUDIO SHOOTING GALLERY

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ABSTRACT

An audio shooting gallery was created to demonstrate the immersive and interactive audio capabilities of the Army Research Laboratory's Environment for Auditory Research. The demonstration participants come from a wide variety of backgrounds including students, Soldiers, scientists, and technical managers. Targets, selected by the shooter, include various wild animal vocalizations, bird calls and animal rustling sounds. The shooter also selects a weapon which is appropriate for that particular target. Audio targets simulating the wild animal being hunted are played over random loudspeakers in the 110 meters by 25 meter outdoor range. A nocturnal hunting simulation can also be created indoors in the Distance Hall by controlling the ambient light level. As the shooter engages the targets, weapon-specific sounds are played through loudspeakers surrounding the listener to enhance the immersive experience. Environmental sounds, appropriate for the selected wild animal target, are played over the entire outdoor loudspeaker array. Distracting, non-target sounds are played from other loudspeaker locations to force the listener to identify and discriminate the correct audio target among distracting noises. Hits, misses, and false alarms are scored and displayed to the shooter to provide accuracy and performance feedback.

1. INTRODUCTION

A demonstration of the audio capabilities of the Environment for Auditory Research (EAR) [1] was created, based roughly on a shooting gallery amusement park game [2]. In the audio only gaming demonstration, the shooter selects a wild animal sound for the target and a weapon sound of choice for hunting that animal. Based on the shooter's choices, the computer program automatically selects appropriate ambient environmental sounds and other non-target animal sounds as distracters. Up to eleven distracting sounds and one target sound can be played simultaneously over loudspeakers in the outdoor space, and up to sixteen total sounds in the indoor space. When the shooter has identified the location of the target animal sound, he or she aims a pistol shaped pointer at that location and presses the trigger button. Appropriate near-field weapon sounds are played from loudspeakers surrounding the shooter. Also, hit or miss type sounds are played from downrange loudspeakers immediately after the weapon firing sound. Bullet impact and ricochet sounds are played based on the direction the gun was aimed when the target was missed. Target impact sounds are played when the weapon was aimed within an appropriate radius for a particular target. This interactive demonstration provides an amusing way to show the spatial sound generating capabilities of the EAR. The outdoor environment helps to immerse the participant in a large outdoor environment in which realistic animal and habitat sounds can be presented, creating a plausible space in which daytime hunting could occur. The indoor space of the Distance Hall creates a believable night-time shooting experience.

2. FACILITY DESCRIPTION

The Open EAR is an outdoor research space for playing sounds in natural auditory environments. A picture of the Open EAR from inside the doorway of the EAR's Distance Hall is shown in Figure 1. Audible environmental sounds include wind, bird calls, distant aircraft and ground vehicles, and occasional real explosions from Aberdeen Proving Ground's test range. Nominal background noise levels range from 10 to 50 dB SPL.

Figure 1: The Open EAR instrumented with eight loudspeakers as seen through the middle doorway of the Distance Hall.

The Open EAR is instrumented with eight audio interface units, which include loudspeaker, microphone, and 120V AC power outlets. Up to twelve loudspeakers and twelve microphones can be placed at any location spanning the outdoor space measuring 110 meters long by 25 meters wide. All of the presented audio signals are generated by a single computer inside the facility's main control room.

3. DEMONSTRATION

The task involves the correct identification, accurate aiming, and simulated shooting of various target sounds somewhere in the outdoor space of the Open EAR or the indoor space of the Distance Hall. Simulated target sounds "pop up" among a din of background noises, indigenous to the habitat of various wild animal targets. The immersive virtual audio environment of the EAR facility creates a truly first person gaming perspective. The specific equipment and procedures involved in the demonstration is described in the following paragraphs.

3.1. Equipment

The demonstration utilizes: 1) the Open EAR, 2) loudspeakers, 3) an Intersense IC2+ InertiaCube sensor [3] inside a gun-shaped pointer, and 4) recorded sounds of animals, environments, and weapons fire [4][5][6]. A shooter using the gun-shaped pointer aimed at an outdoor target is shown in Figure 2.

Figure 2: A gaming shooter aiming at an acoustic target in the Open EAR.

Three sets of powered loudspeakers are available for use in the Open EAR. These include Genelec 8030A studio monitors and 7060B active subwoofers, JBL PRX512M, and Meyer Sound MM-4XP loudspeakers. Loudspeaker selection is based on the lowest frequency content of the target sound. Sound source locations are sometimes at the physical loudspeaker location and sometimes between the physical loudspeaker locations. Phantom audio sources between loudspeakers are created by using a vector-based amplitude panning (VBAP) algorithm [7]. Stationary and simulated moving sounds can be created using this algorithm.

3.2. Procedures

The subject chooses options from the computer's graphical user interface. Choices include type of wild game to be hunted, audio environments of an animal's habitat, hunting weapons, and skill level of the wild game hunter.

Wild game options include several types of typical wild animals. The bird option includes pheasant, wild turkey, and quail. The big game option includes elk, wolves, and deer. The big cat option includes lions, mountain lions, and tigers. The reptile option includes alligators and rattlesnakes. These last two options, big cat and reptile, include animals that can strike back at the gamer. After a miss, the attacking predator sound appears closer to the shooter. After two misses of an attack animal's target sound presentation, a ferocious growl is played over the Distance Hall loudspeakers surrounding the gamer, followed by a succulent chomping sound. The demonstration is abruptly ended and a "game over" message is displayed on the computer screen.

Audio environments include several typical soundscapes in which a chosen animal is typically found. Examples include a mountainous terrain, nocturnal woodlands, an open meadow, and an African jungle. The mountainous terrain and open meadow soundscapes were made from recorded soundtracks of real environments. The nocturnal woodlands soundscape was created by mixing selected distracting animal sounds with a real recording of a night-time woodland. Likewise, the safari soundscape was created by mixing distracting, non-target African jungle animal sounds with a background jungle waterfall recording.

Hunting weapons include archery, small arms, semi-automatic long barreled guns, fully automatic firearms, and wide area explosive devices. The archery weapon simulates the launching sound of either a bow and arrow or a crossbow. Small arms weapons include pistols and side-arms. Long barreled guns include a standard .22 rifle, a military style M-1 rifle, and a double barrel shotgun. Multiple round weapons include M-16, AK-47, and .50 caliber automatic weapons. Wide area explosives include grenades and small diameter bombs. Lastly, a thermonuclear device can be chosen as a weapon of last resort by pressing the top button on the gun-shaped pointer. However, detonating such a weapon usually destroys the wild animal, the gamer, observers, the surrounding environment in a 20 mile radius, and quickly ends the demonstration.

The shooter can select one of three skill levels from the GUI interface. The levels include a novice hunter exemplified by Elmer Fudd, a weekend sportsman, and a professional marksman characterized by Clint Eastwood. A novice scores a hit when the weapon is aimed within 3 degrees of the target. A sportsman scores a hit for better than 2 degrees of accuracy. A marksman requires 1 degree of accuracy to get credit for a

direct hit. When a target is hit, an impact sound is played over the target loudspeaker for that particular projectile hitting an object. When the shooter misses the target, a ricochet sound is played from the loudspeaker closest to the direction the shooter was aiming his weapon.

3.2.1 Acoustic Stimuli

Stimuli were chosen from the SFX source database, the Macauly Library, the Networks Sound Effects Catalogue, and custom recorded sounds. Some of the small arms and automatic weapons fire were recorded at the known-distance range on Aberdeen Proving Ground. Microphones were placed on a 16 meter arc around the shooter from 0 to 120 degrees off the target line.

Monaural soundscapes were recorded using a B&K 4165 microphone and a B&K 2804 preamplifier onto a Sony digital audio tape recorder. Spatial soundscapes were recorded using an eight-channel Holophone® H2 Pro head recorded through a PreSonus FireStudio FireWire recording system onto a laptop PC. Locations included rural parklands, windy forests, and Spesutie Island at Aberdeen Proving Ground.

3.2.2 Performance Scoring

Shooter performance was recorded in a signal detection framework. Hits, misses, and false alarms were calculated and displayed to the gamer after each stimulus was presented or after each shot was made. Correct hits were scored when the participant aimed the gun within three seconds from the moment the animal sound was played and within three, two, or one degree(s) of the target sound's location, depending on the expertise level of the shooter. For example, if the gamer correctly shoots a legitimate target then a hit is tabulated. A miss occurs when either the gamer does not shoot at the presented target or when the weapon is aimed and fired outside of their acceptable accuracy to the target's location. Upon completion of the shooting session, percent hit and percent miss scores are presented to the gamer. Values of d′ (sensitivity) and β (bias) score are computed, saved, and displayed on the host computer display in the control room.

4. OBSERVATIONS AND IMPRESSIONS

Feedback from participants of the audio shooting gallery is that the soundscapes appeared realistic and readily identifiable. There was general congruency between the selected animal targets and the sounds of their natural habitats. Echoes from nearby buildings added to the sense of envelopment and immersion into the soundscape simulations for loud outdoor sounds.

The ergonomics of the shooting task were acceptable. Unfortunately, the gun produced no "kick-back" or haptic force feedback to the gamer. A CO2 cartridge discharge may help to improve the feel of firing a real weapon. Delays between squeezing the trigger button and weapon sounds were very short and usually not noticeable by the gamer. The nearest target sounds were the easiest to locate and hit. Accurately shooting the far away target sounds was difficult, even at the novice skill level. This may be due to two effects. One is the relatively larger spatial image of nearby sounds. Another is that nearby targets had a high direct path to reflected energy ration, while far away targets had low direct path to reflected energy ratios. The latter condition may have caused a more diffuse sound source with a large auditory source width, which made accurate aiming to the center of the sound source difficult.

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6. REFERENCES

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