

# **MASTER OF SCIENCE IN MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION**

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## **AN ANALYSIS OF AUDITORY CUES FOR INCLUSION IN A VIRTUAL CLOSE QUARTERS COMBAT ROOM CLEARING OPERATION**

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**Master of Science in Modeling, Virtual Environments, and Simulation—September 2002**

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The purpose of this thesis is to examine which auditory cues need to be included in a virtual representation of a Close Quarters Combat Room Clearing Operation. Future missions of the United States Armed Forces, especially those of the Army and Marine Corps, are increasingly likely to be conducted in cities or built-up areas. A critical need exists for MOUT (Military Operations in Urban Terrain) training by our armed forces, and the entire spectrum of military training needs to be addressed. Doctrine and principles, classroom instruction, drills, live fire exercises, as well as live and virtual simulation all have a part to play in developing an acceptable level of expertise in MOUT. The way in which training tasks are represented in a VE, including which audio cues must be presented, needs to be explored. This study will examine the auditory cues used during a MOUT mission and how those cues should be presented in a virtual MOUT scenario.

This thesis uses the Critical Decision Method of knowledge elicitation to obtain an auditory Critical Cue Inventory from room clearing subject matter experts. Those experts will then conduct a virtual room clearing operation using the game America's Army: Operations, and compare the auditory cues presented in the game scenario to the real-world execution of the task.

**KEYWORDS:** Close Quarters Combat, Room Clearing, Virtual Environments, Auditory, Critical Decision Method, Sound, Critical Cue Inventory

## **AN AUDIO ARCHITECTURE INTEGRATING SOUND AND LIVE VOICE FOR VIRTUAL ENVIRONMENTS**

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The purpose behind this thesis was to design and implement audio system architecture, both in hardware and in software, for use in virtual environments. The hardware and software design requirements were to provide the ability to add sounds, environmental effects such as reverberation and occlusion, and live streaming voice to any virtual environment employing this architecture.

Several free or open-source sound APIs were evaluated, and DirectSound3D was selected as the core component of the audio architecture. Creative Labs Environmental Audio Extensions (EAX) was integrated into the architecture to provide environmental effects such as reverberation, occlusion, obstruction, and exclusion.

Voice over IP (VoIP) technology was evaluated to provide live, streaming voice to any virtual environment. DirectVoice was selected as the voice component of the architecture due to its integration

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with DirectSound. However, extremely high latency considerations with DirectVoice, and any other VoIP application or software, required further research into alternative live voice architectures for inclusion in virtual environments. Ausim3D's Goldserver Audio Localizing Audio Server System was evaluated and integrated into the hardware component of the audio architecture to provide an extremely low-latency, live, streaming voice capability.

**KEYWORDS:** Virtual Environments, Audio, Voice Over IP (VoIP), Sound, Spatialized Sound

## **VISUAL FIELD REQUIREMENTS FOR PRECISION NAP-OF-THE-EARTH HELICOPTER FLIGHT**

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Helicopter flight simulation visuals must display terrain for high altitude flights as well as flights within a few feet of the terrain. Currently high altitude visuals are well understood and supported, but extremely low altitude visuals are not. Terrain relief and texturing that appears convincing at high altitudes is drastically oversimplified at NOE altitudes, eliminating critical visual cues. Without adequate visual cues, simulated NOE flight is pointless, or worse, may induce negative training transfer. Too much visual complexity will overburden a real-time 3D graphics pipeline adversely affecting frame rate and usability. This thesis attempts to identify the minimal visual requirement for NOE helicopter simulation, thus enabling future simulator and trainer designers to make informed decisions regarding design criteria tradeoffs.

Based on a task analysis of hovering over an unprepared landing site, critical cues were implemented in a fixed base helicopter flight simulator and tested on ten military helicopter pilots. Results indicate that a critical density of visually complex three-dimensional vegetation in combination with high-resolution terrain textures enabled experienced military helicopter pilots to accurately determine helicopter motion and make control corrections. Hover performance was degraded using lower vegetation densities and significantly degraded using just high-resolution textures.

**KEYWORDS:** Helicopter, Flight Simulation, Nap-of-the-Earth, Hovering, Task Analysis, Training, Visual Requirements, Visual Cues, Motion, Training Transfer, Real-Time, Design Criteria

## **IMPLEMENTING REALISTIC HELICOPTER PHYSICS IN 3D GAME ENVIRONMENTS**

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The U.S. Army contracted The MOVES Institute at the Naval Postgraduate School to create a first person action game, America's Army, in support of Army strategic communication. The Army Game Project Team licensed Epic Game's Unreal game engine to produce this game. As the project progressed, the Army realized that the game had the potential to cover a much larger scope than originally planned. Several of these "add-on" applications would call for the addition of realistic third person helicopter physics. Unfortunately this capability was not included in the award winning game engine nor the initial design of the game.

These limitations are addressed by utilizing Unrealscript to design a physics system that interfaces with the Unreal Engine to smoothly interpolate between physics states within the bounds of helicopter capabilities, with the appearance of realism.

The resultant helicopter physics system was incorporated into a game-like interface and compared to a similar system produced with a commercial graphics system. Overall, 53% of the test subjects thought the

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helicopter physics were Very Realistic or Totally Realistic, and 72% found them to be better than those of the system produced on the commercial graphics system. In a follow-up study, 86% of the participants found the helicopter physics to be equal to or better than the physics of a high quality commercial 3D helicopter game (57% better).

**KEYWORDS:** Helicopter Physics, Army Game, 3D Virtual Environments, Game Engine, America's Army, Interpolation, Simulation

## **THE IMPACT ON QUALITY OF SERVICE WHEN USING SECURITY-ENABLING FILTERS TO PROVIDE FOR THE SECURITY OF RUN-TIME EXTENSIBLE VIRTUAL ENVIRONMENTS**

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The Naval Postgraduate School is developing NPSNET-V, a Run-Time Extensible Virtual Environment (RTEVE) framework. RTEVEs differ from traditional VEs in that applications within the environment can both discover and use new object types and behaviors at runtime. As the use of this technology has become more valuable to organizations, the need for adequate security has arisen, particularly for sensitive military and commercial applications. The level of security measures employed by these applications must be weighed against their impact on Quality of Service (QOS).

To address RTEVE security issues, a taxonomy was developed identifying twenty-five information assurance (IA) areas within RTEVEs. We then designed and implemented a Security Management System for NPSNET-V (NSMS) that provided security through the use of three communications filters that provide for encryption, sequencing verification, and integrity. This design addressed four of the twenty-five areas identified in the taxonomy: component authentication; and communications confidentiality, integrity, and authentication.

Analysis of the encryption, sequencing, and integrity filters indicates that their use introduces a negligible delay of 0.111 milliseconds for a 156 byte data packet, at the cost in packet size increase of 41 bytes; this indicates the technical feasibility of RTEVE data packet security at minimal cost to QOS.

**KEYWORDS:** Virtual Environment, Virtual Reality, Collaborative Environment, Runtime Extensible Virtual Environment, Security, Quality of Service, Cryptography, Integrity, Encryption

## **THE IMPACT OF EMOTIONAL AROUSAL ON LEARNING IN VIRTUAL ENVIRONMENTS**

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Research on animals has shown that injections of adrenalin paired with a learning experience improved memory retention. Adrenalin is a key hormone in emotional arousal and fight or flight responses. It stands to reason that emotional arousal (in moderation) may also have a positive impact on human learning. The purpose of this thesis was to investigate the impact of emotional arousal on learning in virtual environments. An experiment was conducted to observe learning differences in a low-arousal condition and a high-arousal condition. A first-person shooter videogame (America's Army: Operations) was used as the virtual environment. In the low-arousal condition, participants wandered peacefully through a scenario memorizing objects they encountered. High-arousal participants wandered through the same environment, but were required to fight through the scenario while under attack. Results indicated that individuals in the

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high-arousal condition performed better on recall tasks immediately following the exposure and also 24 hours later.

**KEYWORDS:** Training in Virtual Environments, Emotional Arousal, Memory, Transfer of Training, Stress