MASTER OF SCIENCE
IN
MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

DEVELOPING ARTICULATED HUMAN MODELS FROM LASER SCAN DATA FOR USE AS AVATARS IN REAL-TIME NETWORKED VIRTUAL ENVIRONMENTS

James Allen Dutton-Lieutenant, United States Navy
B.S., Oregon State University, 1994
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisors: Eric R. Bachmann, Department of Computer Science
Xiaoping Yun, Department of Electrical and Computer Engineering

With the continuing gain in computing power, bandwidth, and Internet popularity, there is a growing interest in Internet communities. To participate in these communities, people need virtual representations of their bodies, called avatars. Creation and rendering of realistic personalized avatars for use as virtual body representations is often too complex for real-time applications such as networked virtual environments (VE). Virtual Environment (VE) designers have had to settle for unbelievable, simplistic avatars and constrain avatar motion to a few discrete positions.

The approach taken in this thesis is to use a full-body laser-scanning process to capture human body surface anatomical information accurate to the scale of millimeters. Using this 3D data, virtual representations of the original human model can be simplified, constructed and placed in a networked virtual environment.

The result of this work is to provide photo realistic avatars that are efficiently rendered in real-time networked virtual environments. The avatar is built in the Virtual Reality Modeling Language (VRML). Avatar motion can be controlled either with scripted behaviors using the H-Anim specification or via wireless body tracking sensors developed at the Naval Postgraduate School. Live 3D visualization of animated humanoids is viewed in freely available web browsers.

DESIGNING REALISTIC HUMAN BEHAVIOR INTO MULTI-AGENT SYSTEMS

Chad F. Hennings-Lieutenant, United States Navy
B.S., Illinois Institute of Technology, 1994
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisors: John Hiles, Department of Computer Science
Rudolph Darken, Department of Computer Science

As Multi-agent systems advance toward moving virtual humans such as modeled infantry soldiers around a virtual environment for modeling and simulation purposes, an important factor to be considered is how the agent internalizes and reacts to its environment. One method to simulate this sensory perception and the construction of generalized internal knowledge is the symbolic reactive agent architecture. This architecture utilizes symbolic constructive agents to internalize and symbolically represent the outside environment within the agent and reactive agents to decide what course of action will be taken next based on this internal environment. This type of architecture also lends itself well to putting variability and non-homogeneity into different agents by controlling the level of hindrance or interference that the agent utilizes when constructing this inner environment. A simple path finding task was used to determine the overall utility of this architecture with respect to truly representing human performance in cognitive tasks. Humans as well as different simulated agents were put through the same task in their respective

environment and their results were compared. A concept called the bracketing heuristic was also utilized to determine whether the model may translate well to general path-finding tasks.

MODELING CONVENTIONAL LAND COMBAT IN A MULTI-AGENT SYSTEM USING GENERALIZATION OF THE DIFFERENT COMBAT ENTITIES AND COMBAT OPERATIONS

Esref Mert-First Lieutenant, Turkish Army
B.S., Turkish Army Academy, 1996
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
and
Erik W. Jilson-Captain, United States Marine Corps
B.S., United States Naval Academy, 1995
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisors: John Hiles, Department of Computer Science
Rudolph Darken, Department of Computer Science
Second Reader: Michael Van Putte, Department of Computer Science

There are inherent similarities between the numerous ground combat entities and the numerous ground combat operations. In combat entities there exist common characteristics such as the ability to move, shoot, communicate and more. The levels that each entity is able to operate for these characteristics differentiate it from the others. For combat operations, a common characteristic is that all operations have a starting point, objective point and an endpoint. The different operations take on unique properties based on where these points are located, actions enroute to points and what entities do at these points.

The generalized concepts in combat entities and combat operations provide a framework that can assist developers and users to model the majority of combat situations with a single simulation. This thesis uses three different Multi-Agent System (MAS) combat models to illustrate the generalization framework. Of the three "test" models used, two existed previously and one was developed. The two existing models are Map Aware Non-uniform Automata (MANA), developed for the New Zealand Army and Defense Force, and Archimedes developed by Least Squares Software LLC. The model (GENAgent) was developed based on the redesign of GIAgent, developed by Captain Joel Pawloski, USA, as a thesis at the Naval Postgraduate School.

EMERGENT LEADERSHIP ON COLLABORATIVE TASKS IN DISTRIBUTED VIRTUAL ENVIRONMENTS

Krist D. Norlander-Lieutenant, United States Navy Reserve
B.S., San Diego State University, 1994
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisor: Rudolph P. Darken, Department of Computer Science
Second Reader: Susan G. Hutchins, Department of Information Sciences

Several Department of Defense agencies are currently investigating the use of distributed collaborative virtual environments (CVE) for the training of small dismounted infantry teams. If these systems are to be successful, they will have to do more than simply allow the team members to execute a task. In addition to assuring that essential training in the CVE transfers to the real task, it must be ensured that aspects of team organization also transfer. In particular, this thesis investigates whether or not predicted emergent leadership, as measured by standardized personality tests, holds within a CVE or if aspects of the interface interfere.

For a given "real-world" task domain a leader can be predicted based on personality traits of the individuals within the group. The interface utilized with a CVE may adversely affect these traits. In other words, predictive measures of leadership in the real world may not hold in a CVE.

The study reported here will use this predictability to identify the expected emergent leader within a group and determine how the CVE interface affects the ability of the predicted individual to emerge as the leader. It is theorized that the limitations of CVE interfaces (field of view, realism, etc.) will negatively impact the transfer of leadership personality traits into the virtual environment, but not to a degree that the

limitation cannot be overcome. These limitations may impact the group dynamics and the emergent leader may not necessarily be the predicted leader by personality traits.

ANALYSIS OF ROUGH SURFACE LIGHTING BEHAVIORS WITH OPENGL

Christopher P. Slattery-Lieutenant, United States Navy
B.S., United States Naval Academy, 1994
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisor: Wolfgang Baer, Department of Computer Science
Second Reader: Samuel E. Buttrey, Department of Operations Research

In the physical world, humans gather valuable information about objects through their sight. Information on shape, feel and composition are seen long before the object is touched. This information is generated by light reflecting off the surface of objects. Despite the advancement of computer graphics due to increased hardware rendering capacity, the fundamental equations, which draw three-dimensional scenes, lack the ability to truly model realistic objects. Whether it is smooth like highly polished metal or rough like the shag of a carpet, it is the reflection of light that tells humans what a surface feels like. The attempt taken in this thesis to implicitly model the roughness of textured surfaces through examination of an explicit model rendered with the OpenGL lighting equation. This approach has the potential to successfully increase the realism of computer graphics without increasing polygon count required for explicit surface generation. Through simulation of an explicitly constructed rough surface followed by the analysis of the behavior of its reflected light, the initial behaviors of textured surface reflections are identified. While these behaviors are not enough to create corrections to the OpenGL lighting equation, they lay the foundation for further development.

THE EFFECTS OF NATURAL LOCOMOTION ON MANEUVERING TASK PERFORMANCE IN VIRTUAL AND REAL ENVIRONMENTS

Eray Unguder-First Lieutenant, Turkish Army
B.S., Turkish Army Academy, 1996
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisors: Rudy Darken, Department of Computer Science
Barry Peterson, Department of Computer Science

This thesis investigates human performance differences on maneuvering tasks in virtual and real spaces when a natural locomotion technique is used as opposed to an abstraction through a device such as a treadmill. The motivation for the development of locomotion devices thus far has been driven by the assumption that a “perfect” device will result in human performance levels comparable to the real world. This thesis challenges this assumption under the hypothesis that other factors beyond the locomotion device contribute to performance degradation. An experiment was conducted to study the effects of these other factors.

The experiment studied sidestepping, kneeling, looking around a corner, and backward movement tasks related to a building clearing exercise. The participants physically walked through the environment under all conditions. There were three treatments: real world (no display, physical objects present), virtual world (head-mounted display, no physical objects), and real and virtual world combined (head-mounted display, physical objects present).

The results suggest that performance and behavior are not the same across conditions with the real world condition being uniformly better than the virtual conditions. This evidence supports the claim that even with identical locomotion techniques, performance and behaviors change from the real to the virtual world.

DYNAMIC SCALABLE NETWORK AREA OF INTEREST MANAGEMENT FOR VIRTUAL WORLDS

Michael S. Wathen-Lieutenant, United States Navy
B.S., University of Oklahoma, 1992
Master of Science in Modeling, Virtual Environments, and Simulation-September 2001
Advisor: Michael Capps, Department of Computer Science
Second Reader: Don McGregor, Department of Computer Science

A major performance challenge in developing a massively multi-user virtual world is network scalability. This is because the network over which entities communicate can quickly develop into a bottleneck. Three critical factors: bandwidth usage, packets per second, and network-related CPU usage, should be governed by the number of entities a given user is interested in, not the total number of entities in the world. The challenge then is to allow a virtual world to scale to any size without an appreciable drop in system performance.

To address these concerns, this thesis describes a novel Area of Interest Manager (AOIM) built atop the NPSNET-V virtual environment system. It is a dynamically sized, geographical region based, sender-side interest manager that supports dynamic entity discovery and peer-to-peer entity communication. The AOIM also makes use of tools provided by the NPSNET-V system, such as variable resolution protocols and variable data transmission rate.

Performance tests have shown conclusively that these interest management techniques are able to produce dramatic savings in network bandwidth usage in a peer-to-peer virtual environment. In one test, this AOIM produced a 92% drop in network traffic, with a simultaneous 500% increase in world population.