MASTER OF SCIENCE
IN
MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

REALISTIC EVALUATION OF TERRAIN BY INTELLIGENT NATURAL AGENTS (RETINA)

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U.S. Army and joint constructive simulations require human operators to observe the exercise in progress, conduct analysis of the results, and provide realistic reports and assessment of the action presented on their screens to the desired training audience. Current software tools provide excellent mathematical assessments (such as center of mass calculations, optimal routes, and sensor ranges) but poor human-like assessment of data (most likely route, probable enemy intention, etc.).

This thesis presents an artificial intelligence architecture specifically designed to reduce that manpower requirement by describing a concept for computer modeling that can produce realistic human-like assessment results. Specific concepts described are approaches for conducting a digital terrain assessment, development of avenues of approach, deployment of templated forces to a specific piece of terrain, and a method of adjusting the templated force to react to actual sightings and known information.

Also included are more detailed discussions and implementation details for use of gas diffusion as a method of analyzing avenues of approach through digital terrain. This approach seems quite promising as a method of modeling human movement tendencies and appears superior to classic path finding or optimal route selection methods.

KEYWORDS: Path Finding, Navigation, Computer Vision, Terrain, Intelligence Preparation of the Battlefield, Recognition Primed Decision Model, Agents, Reactive Agents, Assessment, Avenues of Approach, Diffusion, Fluids, DTED, Simulation, Model, Route Selection

TOWARD XML REPRESENTATION OF NSS SIMULATION SCENARIO FOR MISSION SCENARIO EXCHANGE CAPABILITY

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In this thesis, work toward completion of an XML-based Scenario Exchange capability for the Naval Simulation System (NSS) is presented. NSS is a powerful modeling and analysis tool developed by the Navy for use in performing campaign analysis, naval forces studies, and course of action analysis. XML is a World Wide Web specification that allows a designer to develop a new language to structure data, while maintaining a rule-based specification for how to move that data around on the web. XML-based applications can export the contents of internal structures in such a way that another application can easily import the data that is unique to its own input requirements. Research conducted in this thesis produced an XML representation of the NSS Simulation Scenario, along with its validating schema. This pair of documents form the core of the NSS XML-based Scenario Exchange capability. Future work to complete the exchange capability design is defined in the thesis. The XML document and schema are provided in the appendices.

KEYWORDS: XML, Schema, XSLT, XPath, Stylesheet, Web-services, Data Exchange, Simulation, NSS, Object-oriented, Course of Action Analysis, Mission Scenario

ALGORITHMIC APPROACHES TO FINDING COVER IN THREE-DIMENSIONAL VIRTUAL ENVIRONMENTS

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In order for an agent to be credible in simulating a human opponent in a first-person combat simulation, it must be able to find and use cover from direct fire weapons. The ability to find cover is fairly intuitive for humans, but current attempts at replicating this ability in computer simulations and video games have been either simplistic or totally missing. This thesis explores a range of algorithms which computer agents can use for finding cover from direct-fire weapons in high-detail, dynamic, three-dimensional environments. The first method treats the enemy as a point light source and uses binary space partition trees to create shadow volumes to find areas of cover. The second method uses a depth-mapping technique to find potential areas where the agent could get behind cover. The third method uses a sensor grid centered on the agent that allows it to check the area around it for cover locations. The sensor grid technique was implemented inside of the first-person shooter computer game *America's Army: Operations* as a proof of concept.

KEYWORDS: Cover, Concealment, Agents, Reactive Agents, Virtual Environments, Simulation, Army Game Project, Binary Space Partition Trees, Depth Mapping, Sensor Grid

ALTERNATIVE AUDIO SOLUTION TO ENHANCE IMMERSION IN DEPLOYABLE SYNTHETIC ENVIRONMENTS

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The purpose behind this thesis was to examine the effect of vibro-tactile feedback on a user's degree of immersion in a synthetic environment. Sub-woofers usually provide the vibro-tactile feedback in surround sound systems. The alternate method explored in this thesis utilized a "seat shaker" to generate the appropriate tactile feedback in the environment. The solution theoretically enables the user to receive a compelling, multi-modal presentation of the environment with deployable (small footprint), unobtrusive equipment. Physiological responses (electrodermal activity, heart rate, and temperature) were measured in an attempt to determine if there was a statistically significant difference between a user's degree of immersion and emotional response in a 5.2 surround sound environment versus one with stereo headphones and a seat shaker.

A computer based first-person shooter game (*America's Army: Operations*) was utilized as the synthetic environment. The independent variable was vibration delivery method (headphone with no vibration, 5.2 surround sound, headphones with seat shaker). The dependent variables were physiological response.

Results indicated that vibro-tactile feedback did enhance emotional response and therefore immersion. A surround sound system might be effectively replaced by headphones and a seat shaker to achieve the same emotional reaction.

KEYWORDS: Synthetic Environment, Virtual Environment, Vibro-tactile, Virtual Training, Mental Immersion, Sense of Presence, Seat Shaker, Army Game Project, Deployable Trainer

PHYSICALLY BASED MODELING AND SIMULATION OF A SHIP IN OPEN WATER 3-D VIRTUAL ENVIRONMENT

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This thesis addresses the development of a physically based modeling simulator for a ship in a 3-D virtual environment to be used in naval tactical training systems. The objective is to develop a computer simulation program in which physical models are implemented in order to achieve a realistic representation of a ship in a virtual environment, considering its physical features in the presence of environment conditions including waves, ocean current, wind, fog, and day/night issues. The simulator was developed by integrating five marine models with a virtual ocean environment created with a visual simulation builder tool. The marine models include a maneuvering model, a wave model, a wind model, and an ocean current model. The numerical results from another complex wave model were also combined using linear interpolation to increase the realism level of the simulator. The result of this thesis shows that the integration of multiple models from different sources is a feasible approach to meet the application requirements. The result also indicates that the use of the interpolation technique to take advantage of complex models yields a simulator with an acceptable level of realism while imposing very low computational load in the application program.

KEYWORDS: Physically Based Modeling, 3-D Virtual Environment, Ship Maneuvering Simulator, Environment Disturbances

THE ARTILLERY FIRE DIRECTION CENTER SIMULATION

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In recent years, declining budgets, limitations on artillery ammunition, and decreases in training areas have reduced the opportunity to conduct live fire artillery training. For these reasons, simulation systems are available for providing an almost realistic training platform for the forward observer. One of them is "The Forward Observer Personal Computer Simulator (FOPCSIM)," which is the thesis work of two students, David Brannon and Michael Villandre. FOPCSIM is a useful tool for the training of the forward observer without major requirements. However, it is a stand-alone system and many of the actual procedures of the observed fire are provided by the system. This thesis presents another system, which simulates the Fire Direction Center procedures during a firing mission. The two systems have a network communication for exchanging messages, similarly with the real communication messages between the forward observer and the FDC. Now, the training of the forward observer is more realistic because this person must take into account the existence of the FDC, must wait for responses for each message sent out, and must deal with problems such as communication errors, time delays in sending and receiving messages, and modifications in the call for fire from the FDC. The new system will provide feedback by keeping a history of each mission and giving the observer the capability to review the process of each mission and make useful conclusions about performance.

KEYWORDS: Field Artillery, Fire Direction Center, Forward Observer, Call for Fire, FDC, FOPCSIM, Training, Virtual Environment, Fire Support, Simulation