Integrated Environment for Modeling and Simulation

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LONG-TERM GOALS

Advances in computational technology coupled with budgetary constraints have led DoD and Navy to the increased use of simulation for everything from capability assessment and training to the design of new systems and components. Although a simulated natural environment is represented at the engineering level for components and some systems, neither training simulations nor analysis software make use of environmental information directly. Thus, our assessment and training simulations fail to provide a realistic measure of military capability. The goal is to correct this deficiency in DoD simulation applications.

OBJECTIVES

(1) Establish a robust methodology for determining the required resolution for environmental representations.

(2) Integrate the specified environment with the simulation system and incorporate simulation effects models to use the environmental information correctly.

(3) Deliver and demonstrate the operation of the resulting capabilities in a Navy fleet battle simulation experiment.

APPROACH

Our approach to meeting the above objectives was to execute the following three tasks:

A) Perform a comparative analysis of effects on tactical sonars of predicted oceanographic variables from KB01 by varying forcing functions;

B) Build an acoustic transmission loss server;

C) Design a gaussian beam reverberation modification to the (above) acoustic server.

For Task A, we proposed to analyze the influence of environmental data quality on the performance of a minehunting side-scan sonar by taking sound speed profile data from ECOM model (Estuarine and Coastal Ocean Model) runs using different meteorological and offshore oceanic forcing functions and evaluating mine-hunting sonar performance. We will use different ECOM model generated datasets of

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14. ABSTRACT
Advances in computational technology coupled with budgetary constraints have led DoD and Navy to the increased use of simulation for everything from capability assessment and training to the design of new systems and components. Although a simulated natural environment is represented at the engineering level for components and some systems, neither training simulations nor analysis software make use of environmental information directly. Thus, our assessment and training simulations fail to provide a realistic measure of military capability. The goal is to correct this deficiency in DoD simulation applications.

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the Kernel Blitz 2001 (KB01) littoral environment, where the input data sources are varied. Input data sources include large-scale POM (Princeton Ocean Model) outputs; MODAS; and on-site measurement data. With the resulting water-column data we will model minehunting sonar propagation with PCSWAT and evaluate performance parameters. Gary Sammelmann, NAVSEA, Panama City, Coastal System Station (CSS) developed SWAT (Shallow Water Acoustic Toolkit) and PCSWAT, a PC version of SWAT, for classification sonar prediction. We will use PCSWAT to compute the effects, due to varied input data quality to our ECOM generated environments, on the effective range of a minehunting sonar system. This analysis will be carried out by NRL personnel.

For Task (B) we proposed to design and build an Acoustic Transmission Loss Environmental Effects Server, using time-dependent environmental data, to serve JSAF sonar platform models, and to integrate and evaluate the server in the Navy's Fleet Battle Experiment-Juliet (FBE-J), part of Millennium Challenge 2002 (MC 02).

In our approach we use an acoustic server, which separates the propagation loss calculation to a different computer from the other JSAF model calculations. Representing the environment with adequate fidelity requires large datasets, and a server approach helps distribute computing load. A server approach also helps guarantee consistent environmental effects for all entities in the simulation. Because the Navy runs live assets simultaneously with the experiment, the environment must be consistent between live and simulated assets. This means using live, concurrent environmental data which must be distributed at simulation time.

We also use an acoustic propagation model that has a trait important to real-time Modeling and Simulation: speed. We take FeyRay, an existing high-speed, broadband, range-dependent, underwater acoustic Gaussian beam propagation model, and integrate it with JSAF submarine detection sonar models. FeyRey was developed by Dr Terry Foreman, at Anteon Corporation with whom we are working in this effort. FeyRey is significantly faster than alternatives, particularly models considered more accurate than Gaussian beam models.

We leveraged off of an associated effort with HydroQual, Inc. to create and to handle the distribution of time-dependent oceanographic and atmospheric input data to M&S systems. We used environmental data from a variety of sources. We used MODAS and COAMPS updates during the exercise. We expect to have ECOM (Estuary and Coastal Ocean Model) data for the shallow water regions, as well as larger scale POM data in deeper water, both served using OASES, an environmental data server developed by Defense Modeling and Simulation Office (DMSO). We ensured that the oceanographic data for different regions was consistent so that spurious physical effects would not arise from boundaries or overlapping areas. To integrate the server with a federated JSAF in an HLA setting we used the services of Dan Speicher of Lockheed Martin Information Systems, from Burlington, MA. Integrating ATLoS with OASES was performed by Christopher Scannell at NRL. We demonstrated the resulting product at MC02 and preceding integration events, named Spiral 1, Spiral 2, and Spiral 3.

Our third task, Task (C), was to enhance the FeyRay Gaussian beam model to compute reverberation for monostatic cases. For this task the Gaussian beam model will be used to trace rays from the source to each scattering surface. The beam model would also determine the size and shape of each patch ensonified by each ray. The reverberation model would compute the total scattered field by summing the contributions of scattering patch overlap integrals. This approach avoids a costly and unreliable eigenray search altogether, and the size, shape, and distribution of the scattering patches is determined by the physics of the wave propagation process.

We will perform this task using a proof-of-concept Gaussian beam-based reverberation model developed by Anteon that uses the formulation and methods described above. That model (MARK) uses the FeyRay Gaussian beam model (currently now being used in the acoustic server) as its underlying point-to-point propagation model. FeyRay has the advantages of very high speed (it is as fast as the fastest range dependent ray models and much more than an order-of-magnitude faster than any other Gaussian beam model) as well as some adaptations specifically intended to facilitate reverberation calculations. FeyRay was originally designed to meet the very high speed requirements of real-time systems such as trainers.

The MARK proof-of-concept model consists primarily of a computational kernel, with many software stubs that are intended to be expanded into physics-based sub-models of various scattering processes. The Application Programmer's Interface (API) to the kernel is rudimentary, providing only for preliminary testing; a user interface is lacking. This task takes the basic MARK model and develops it into a demonstration model for incorporation into the acoustic server.

WORK COMPLETED

Task (A) has not been executed, and funding for that task has been extended. It will be completed by the end of December 2002.

Task (C) was only partially funded for FY03. This task has been initiated: a draft design and report will be complete within a couple weeks of the end of FY03.

Task (B) was executed with ATLoS being demonstrated at FBE-J / MC02. The simulation entities using ATLoS and this ocean representation were Joint Semi-Automated Forces (JSAF) ship,s sonars, developed by Northrup Grumman. These ship,s sonars were supplied by the (ATLoS) with acoustic transmission loss estimates due to the effects of the dynamic ocean as a propagation medium. This allowed the sonar models to determine the "visibility" of ships and submarines using an ocean representation close to the true ocean environment.

The synthetic natural environment ocean representation at FBE-J for JSAF based simulated entities was provided by NRL and HydroQual, Inc with DMSO funds. The ocean environment was an in-stride environment based on and contemporaneous with the northern Pacific ocean, offshore of southern California. The bathymetry was drawn from the National Oceanic and Atmospheric Administration (NOAA) Marine Trackline database for the shallow region offshore of Camp Pendleton and the NOAA ETOPO2 database for the rest of the region. The bottom type characterization was obtained from NAVO.

The Estuarine and Coastal Ocean Model (ECOM) was used to provide a higher resolution nowcast/forecast representation of the spatially and temporally variable littoral ocean environment offshore of Camp Pendleton and out to San Clemente Island. To drive it, ECOM used output data from both the Coupled Ocean Atmospheric Mesoscale Prediction System (COAMPS) and the NRL-Stennis North Pacific Nowcast/ Forecast (NPACNFS) model. NPACNFS assimilates the Naval Oceanographic (NAVO) Modular Ocean Data Assimilation System (MODAS) data using the Navy Operational Global Atmospheric Prediction System (NOGAPS) atmospheric forcing. This environment was extended throughout the simulation ocean area using the NPACNFS model The ocean environment was provided on a orthogonal, curvilinear grid with variable horizontal resolution. The grid resolution varied from approx 0.5km to 4.0km. During the course of the experiment the ECOM model was run daily using the 12:00Z outputs from the NRL NPACNFS and FNMOC COAMPS models. This generated an output of 60 hourly forecasts each day for the region. These forecasts allowed for forecasts overlapping with the next day,s set of forecasts. As a backup, we had daily updates of MODAS data provided by NAVO. Finally, we worked with Northrup Grumman to have our forecasts served over the RTI with the Ocean, Atmosphere and Space Environmental Services (OASES) federate.

RESULTS

We found that ATLoS could handle about five requests per second giving high quality propagation loss estimates. We did not know what rate of requests to expect for ATLoS: this was only resolved during the experiment. At FBE-J / MC02 we received request rates varying from between ten and seventy requests per second. While ATLoS was not able to answer all of these individually, a fairness doctrine in queueing requests from the sonar models guaranteed the same rate of service to each sonar/target pair. The result was that the sonar/target pairs were provided with less frequent updates of the transmission loss estimates, and always used the last received value. All in all, the Fleet Battle Experiment environment provided a rigorous performance testing environment for ATLoS, illustrating the need for server robustness in large scale simulations and the need for service for a high rate of requests. We reported our results at the Fall 2002 Simulation Interoperability workshop in September 2002.

We expected to be able to receive the environmental data at ATLoS over the RTI from Ocean and Atmospheric Simulation Environmental Server (OASES). At FBE-J OASES was unable to send the data so that it could be received either reliably or with high probability. This problem was due, in part, to the reliance on the RTI to provide reliable transport, which was not supported for FBE-J. We were able to compensate for this by having ATLoS take our forecast file directly. While integration with OASES was supported with CHSSI funds, we integrated ATLoS with OASES to support our effort for ONR.

IMPACT/APPLICATIONS

Our initial version of ATLoS is currently held at the Naval Warfare Development Center (NWDC) in Newport under configuration management and for use in future Fleet Battle Experiments. We have had requests for copies of the server from NavAir Training Systems Division, the Naval Postgraduate School, and Johns Hopkins Applied Physics Laboratory. In addition to use in future Navy experiments, we forsee its use in trainer stimulator technology.

TRANSITIONS

While we have been able to test our server for providing transmission loss by supporting passive sonar models, at this stage we consider our server to be incomplete. Our intention is to complete the implementation of a server providing service for active sonars, requiring modifications for providing reverberation computations as well as some performance improvements. On the other hand, we expect that the outside interest expressed in our server will likely result in future transitions.

RELATED PROJECTS

We have an association with the ONR Uncertainty DRI, having performed some work in FY01 and incorporating results from that work into the FY02 work reported here.

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