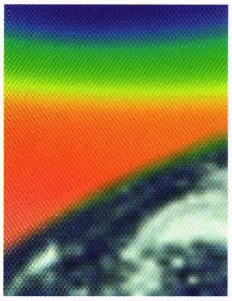

Modeling and Simulation: Guest Editor's Introduction

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This issue of the *Johns Hopkins APL Technical Digest* continues to showcase some of the modeling and simulation efforts currently being pursued at APL. Building on the foundation laid in the preceding issue (Volume 16, Number 1), these articles further illustrate the breadth and variety of APL's work in this area. Topics range from a physical simulation of the Sea of Japan, to a model of reflections from the ocean surface, to simulated images of the Earth's magnetosphere, and include genetics-based learning algorithms, a detailed model of a cavity antenna, the staged development of a prototype strike management tool, and the integration of existing detailed hardware models into higher level simulations. A key idea that emerges from this collection is that simulation can sometimes provide information over a much broader range of conditions and at considerably lower cost than could possibly be achieved through actual measurements in the real world. As pointed out in the final article, the information and insights available through simulation become valuable and trusted only after the simulation has been shown to produce reliable results.

The cover of this issue displays several simulated views of the energetic ions trapped in the Earth's magnetosphere as it would be seen by energetic neutral atom imaging from a satellite in a 1000-km circular orbit. Described in Chase and Roelof's "Extracting Evolving Structures from Global Magnetospheric Images via Model Fitting and Video Visualization," the images were taken from a videotape that shows the stream images from around the orbit during a geomagnetic storm. The article outlines theoretical calculations from which the images were derived, shows a variety of still images resulting from the simulation, and then describes the morphing approach used to produce a smooth movie from a limited collection of images. This type of magnetospheric visualization is now being used to optimize sensor design. When actual imaging data become available from planned missions, outputs of the simulations can be matched to observations from space to reveal the global evolution of trapped ion distributions. Neutral atom imaging can thereby be used to visualize the global electrodynamics of the magnetosphere.

Best and Sanders achieve performance comparable to that of an experienced analyst by letting a genetic learning algorithm train itself to select appropriate parameters for a mine-avoidance simulation. "Using Genetics-Based Learning Methods to Improve Simulation Model Fidelity" explains the concept of genetic learning, presents a simple example, and then demonstrates how such an algorithm makes near-optimal choices of parameters from a complex search space in a much more difficult example. Their algorithm produces generations of solutions, each generation combining traits from the best solutions of the previous generation, with an occasional "mutation" thrown in at random. The authors demonstrate high quality of parameter selection by direct comparison with simulation runs using parameters chosen by a skilled analyst. This approach provides an intelligent parameter selection for simulations developed in the Object-oriented Rule-Based Interactive System (ORBIS) described by Dykton and Sanders previously in the *Digest* (Volume 16, Number 1).

Duven's "Modeling and Analysis of Cavity Antennas on Cylindrical Ground Planes" develops a mathematical model to describe the gain and phase properties of cavity antennas on cylindrical ground planes. The model produces three-dimensional plots of the gain and phase behavior of the antennas, providing insights into the gain and phase differences between vertically and horizontally oriented antennas. Duven validates the model against experimental data, identifying the regimes over which the model and the data agree and providing explanations for where they do not.

"Operator Support Concepts for Tomahawk Strike Management" by LoPresto et al. describes the development of a Tomahawk strike management tool using progressively more capable prototypes. Beginning as nothing more than a set of viewgraphs, the initial conceptual prototype illustrated possible displays and controls for a strike management tool. This simple and easily modified version served as a valuable discussion device for learning exactly what the Navy wanted and needed. The next version simulated only the operator interface, essentially implementing and expanding on the earlier viewgraph approach to show the look and feel of the eventual system. Frequent discussions and demonstrations with the customer further refined system requirements. A functional prototype followed, consisting of a more fully developed user interface where some of the capabilities of the strike management tool were implemented. A simulation driver in the functional prototype responded to strike management commands, simulating missile activities in a realistic environment and providing reasonable results to drive the user interface. As the functional prototype evolves, the user interface develops to suit sponsor needs and requirements as the simulation driver becomes more capable. Decision aids can be prototyped and tested within this framework, providing a powerful tool for early exploration of candidate features for the eventual system.

In "A Simulated Ocean Environment for a Maritime Simulation Demonstration," Newman et al. explore the intricacies of a detailed simulation of the Sea of Japan as it was during early February 1993. The simulation consisted of environmental data such as ocean bottom topography, temperature and salinity profiles, wind speeds, surface waveheight fields, and ultimately a three-dimensional sound-speed field. Computation of the sound-speed field required two detailed models of ocean layers, driven by temperature, salinity, and wind data from historical records, where the bottom topography was realistic and the surface waveheight field was modified to match historical satellite infrared imagery for the days that were simulated. The resulting data served as input to a set of distributed simulations representing various platforms and command centers that participated in a hypothetical naval operation in the Sea of Japan. By feeding this information to the separate simulations, the demonstration showed realistic real-time modeling of acoustic propagation and allowed observation of low-frequency active acoustic system performance in a tactical situation.

Constantikes describes an approach to "Modeling and Synthesizing Infrared Ocean Clutter." This simulation models the statistical characteristics of the infrared clutter observed by a low-altitude sensor over an ocean surface and synthesizes realistic scenes. The article evaluates several ways to model the radiance detected by the seeker and investigates the likelihood of sea glint in the seeker's field of view. Advantages and disadvantages of the techniques are compared. The most promising strategies have been incorporated into a computational model, whose results are displayed. The results of this modeling effort provide a cost-effective and readily available means to test signal processing algorithms and to determine under what conditions target detection will be possible.

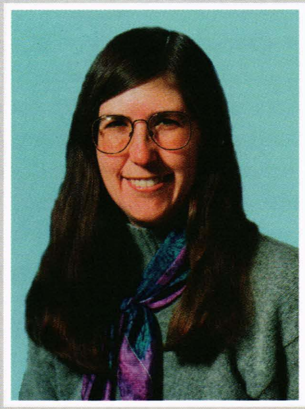
Lutz reports on a method to directly access existing detailed models of hardware systems from higher level models in "Distributed Vertical Model Integration." His experiment captures the effects of a detailed radar model within a much less detailed battlefield simulation involving air, ground, naval, and space-based systems at a mission level. The higher level model has its own low-resolution radar model that supplies results whenever conditions do not require high fidelity. When the simulation needs more accurate information, it calls the high-resolution radar model. Careful matching of results at the boundaries between high- and low-resolution modes provides seamless transitions between the two models. A client/server architecture and parallel computing strategy permit the high-level model on one platform to continue running while the high-resolution model computes the next update on another platform. This experiment shows a practical approach to reusing existing detailed models as an integral part of higher level models without major redesign.

Finally, Youngblood and Pace give "An Overview of Model and Simulation Verification, Validation, and Accreditation." They discuss the importance of verification that a model accurately represents the developer's concepts, validation that the model correctly simulates the real world, and certification that the model or simulation is acceptable for a particular purpose. As budgets shrink, the Department of Defense relies more heavily on models and simulations to evaluate alternatives, making the credibility of such models ever more critical. The authors describe various techniques to ensure a model's correctness and appropriateness, reviewing the state of the art and detailing, as examples, the current Navy Verification, Validation, and

Accreditation Paradigm and the Distributed Interactive Simulation Verification, Validation, and Accreditation Process that they helped to develop.

Many members of APL's staff use models and simulations to answer the questions that arise in their work. The projects described in this and the preceding issue of the *Digest* provide some idea of the wide range of problems to which simulation can be usefully applied. On many scales, for many subjects, and by many different approaches, modeling and simulation provide a useful tool with which to tackle difficult physical problems.

THE AUTHOR



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