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The Future of Modeling, Virtual Environments & Simulation

Zyda, Michael

The Future of Modeling, Virtual Environments & Simulation

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Outline

Where we are today & how we got there

A fork in the road
  ■ We can continue to hack and make little in the way of technological investments
  ■ We can do better things if we take some time to build fundamentals

Investments we should make

A better tomorrow
In this talk, we will use the acronym MOVES to mean modeling, virtual environments & simulation.

And this talk is about the future of MOVES.

- As we can’t imagine that people today would consider building an M&S system without some sort of visual interface.

- So put it into the title!
Where we are today & how did we get there

We have had great success in MOVES over the last ten or so years.

- Including
  - SIMNET to DIS to NPSNET-IV & beyond …
  - ModSAF & its successors …
  - Many large, monolithic, over-budget, late DoD-sponsored M&S systems
  - We know how to hack code - we don’t necessarily know how to build scalable M&S systems, nor model human & organizational behavior well.
Low-hanging fruit is gone

My belief is that much of the low-hanging fruit has been picked & perhaps now we need to work on some of the longer term MOVES requirements.

We are at a fork in the road …

- We can either take the road less traveled or continue with business as usual.
I propose we take the fork...
A 3 Step Program
- Step 1

We need people trained in MOVES fundamentals.

- We don’t get away from hacking unless we make a concerted effort to provide our systems developers the education they require to carry out development.
## A Recommended MOVES MS Program

<table>
<thead>
<tr>
<th>Programming</th>
<th>Mathematical Fundamentals</th>
<th>Modeling &amp; Simulation</th>
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<tbody>
<tr>
<td>Object-oriented programming, data</td>
<td>Multivariable calculus, linear algebra, probability &amp; statistics</td>
<td>Stochastic models, system simulation, physically-based modeling,</td>
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<tr>
<td>structures, artificial intelligence</td>
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<td>simulation methodology, introduction to joint combat modeling,</td>
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<td></td>
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<td>modeling human &amp; organizational behavior, agent-based autonomous</td>
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<td>behavior for simulations</td>
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<tr>
<td>Systems &amp; Architecture</td>
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<tr>
<td>Computer systems principles, operating systems, distributed operating systems</td>
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<tr>
<td>Computer Graphics</td>
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<td>Computer graphics, image synthesis, computer animation, computer graphics using VRML</td>
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<tr>
<td>Visual Simulation Track</td>
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<tr>
<td>Human Performance Engineering Track</td>
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<tr>
<td>29 classes total in the MOVES MS</td>
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Step 2

We need to set up university-based institutes that focus on research, application and education in the grand challenges of modeling, virtual environments and simulation.

- These institutes should:
  - carry out basic and applied research;
  - analyze modeling, virtual environments and simulation programs;
  - create advanced prototypes; and
  - develop technologies and applications for the defense community.
Step 2b

We don’t really need our universities to be on the critical path for systems that are just hacked together.

- We need our universities to be free to be able to develop the technology that gets us away from hacking.
  - Send such work to defense contractors!
Split that I recommend

<table>
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<tr>
<th>Timeframe</th>
<th>Defense Contractors</th>
<th>University-based Institutes</th>
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</thead>
<tbody>
<tr>
<td>Near-term</td>
<td>90 days to 1 year</td>
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<tr>
<td>Mid-term</td>
<td>3 to 5 years</td>
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<tr>
<td>Long-term</td>
<td>5 to 9 years</td>
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</table>
Step 3 - Research investments to make

Here are the fundamentals we need for the next generation:

- 3D Visual Simulation
- Networked Virtual Environments
- Computer-Generated Autonomy
- Human Performance Engineering
- Technologies for Immersion
- Defense and Entertainment Collaboration
- Evolving Operational Modeling
From fundamentals to application
3D Visual Simulation - Game-engine utilization and handheld visual simulation delivery systems (game consoles, PCs with nVidia cards ...).

- With this, we can build - virtual Naval gunfire support. Immersive ship walkthroughs - damage control VEs. Littoral zone warfare. Building & urban walkthroughs - urban warfare, hostage extraction, operations other than war. Ocean environment tactical visualization. C4I/IW information visualization. Synthetic ocean environment simulations.

XML/X3D - Use of Extensible Markup Language (XML) to deploy 3D M&S products over DoD messaging systems, create interoperable behavior streams, gain database schema interoperability, and define ontologies for software agent interactions compatible with deployed C4I and combat control systems.
Networked Virtual Environments

**VE Architectures For Interoperability** - Network software architectures for scalability, composability and dynamic extensibility. Semantic interoperability.

**Standards For Interoperability** – High Level Architecture (HLA); Next Generation RTI; Web-based interoperability. Standards for streamed interactive 3D as an automatically created component for joint message systems. Guiding M&S standards interoperability efforts with the Web3D Consortium, World Wide Web Consortium and MPEG4 Streaming Group.
Networked Virtual Environments

**Scalability** - multicast & area of interest managers. Software architectures for developing large-scale, media-rich, interactive, networked VEs.

**High Bandwidth Networks** - Experimentation and utilization of next-generation Internet technologies for large-scale, networked VEs, and collaborative M&S development and application.

**Wireless** - Handheld delivery systems.

**Latency-reduction** - Techniques for predictive modeling in distributed simulations.
Computer-Generated Autonomy

Human Representations and Models - Authentic avatars that look, move, and speak like humans.

Modeling Human and Organizational Behavior - Integrative architectures for modeling of individuals, including neural networks; rule-based systems, attention and multitasking phenomena, memory and learning, human decision-making, situation awareness, planning, behavior moderators; modeling behavior of organizational units, military operations, and information warfare.
Agent-Based Simulation – Computer-generated characters that accurately portray the actions and responses of individual participants in a simulation.

Adaptability - Computer generated characters that automatically modify their behavior.

Learning - Computer generated characters that can modify their behavior over time. Organizational modeling.

Story Line Engines - Content production and simulation prototyping. Technologies for autonomous, real-time story direction and interaction.
Human Performance Engineering

Training in the Virtual Environment - Fidelity requirements for wayfinding in the VE. Developing VEs for training, and evaluating their utility.

Human Factors in Virtual Environments - Multimodal interfaces, task analysis, spatial orientation and navigation, performance evaluation, interaction techniques, interaction devices, virtual ergonomics, cybersickness, usability engineering, training transfer, human perception.

Intelligent Tutoring Systems - Developing experts via the use of computer-based VEs.
Technologies for Immersion

Image Generation – Real-time, computer graphic generation of complex imagery, HDTV, DVD compressed video, next generation delivery systems, novel display technologies, handheld and body-worn devices.

Tracking - Technologies for tracking human participants in VEs.

Locomotion - Technologies that allow participants to walk through VEs while experiencing hills, bumps, ditches, and other obstructions.

Full Sensory Interfaces - Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, and haptic.

Novel Sound Systems – The generation and delivery for both interactive and recorded media. Spatial sound. Immersive sound and psychoacoustics.
Defense and Entertainment Collaboration

Technology Transition - Adapt technologies and capabilities from the entertainment industry.

Game-Based Learning - Distance learning via the use of game technology and development.

Internet & Game Delivery Systems - similar to SimNavy, Army Game Project, SimClinic, SimSecurity…
Evolving Operational Modeling

Navy Cyberspace - Full end-to-end simulation of the ocean environment including subsurface, surface, air and space. Oceanographic data sets and models. Tactical databases. Interoperability with live ship tracking message systems. Reusable, in the small or in the large, by fleet assets. Underwater robots. Interoperability with global command and control systems. Virtual ocean environment.


A better tomorrow

We evolve to systems where we spend more time in their use in analysis then in their technological development.

- We are not going to get there without significant investments in both education and research infrastructure.
In closing

The MOVES Institute
Naval Postgraduate School
http://movesinstitute.org