Human Behavioral Synthetic Research Environments (HB-SRE)

Organizers

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Overview Information

The task environment provides a great deal of influence through physical and cognitive context, constraints, and affordances on human behavior. It is important to represent these environmental factors in human behavior modeling, simulation, and research efforts to improve understanding of the human-environment interaction and the human behavioral model validity and reliability. Across the HBR community, there is a need for a representative military synthetic environment that facilitates HBR modeling and simulation research over multiple approaches, models, and scope.

The options available for human behavioral representation (HBR) researchers for such simulated environments is limited either in terms of external validity to real environments and domains such as the military domain (e.g., commercial off-the-shelf simulations) or lack the required support and access to HBR researchers (e.g., many military specific simulations). This symposium is intended to explore the possibilities of establishing a human behavioral synthetic research environment for the purpose of identifying the advantages, disadvantages, requirements, and impact of such an effort.

Requirements for Bringing Psychological Plausibility to HBR in Virtual Environments

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Virtual environments do not in general support the integration of high-fidelity cognitive models, and many cognitive models and architectures lack a sufficiently rich representation of the perceptual and motoric world to allow for full participation in virtual environments. The resulting deadlock slows progress in research that depends on their combination. One potential solution for bridging this gap is the definition of a platform that provides both a useful task platform for interaction with humans, and a viable cognitive interface. A candidate set of requirements for such a platform is:

- **Provision of same information to human and synthetic task participants.** Revealing ground truth to agents may get around limitations, but also creates brittleness in observed behavior.
- **Support of Two- and Three-Dimensionality of the Virtual Environment.** Environments such as flight simulators are naturally three-dimensional, while others such as route planning tools are more naturally two-dimensional. An environment should support both of these fundamental variations and cognitive models ought to be perceptually fluent in both of them.
- **A Hierarchical View of the Perceptual World.** Cognitive models need access to a hierarchical representation equivalent to human perceptual organization, and the ability to process it. Virtual environments should provide this hierarchical representation relating the configuration of architecture, terrain, and actors in the environment.
- **Principled Identification of Objects and Actors in the Virtual Environment.** Virtual environments should use existing validated ontologies, and should provide the ability to configure the mapping of entities in the environment onto existing ontologies.

Recognizing the Interactions between Task Environment and Model Fidelity

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The task environment strongly determines the ultimate validity and/or utility of an HBR. Our presentation focuses on three key drivers: the targeted level of fidelity, the simulation-model interface, and simulation software environment. We take the position that research-oriented task environments must support multiple levels of abstraction along these dimensions, given the variability one encounters in these dimensions when developing new applications:

Targeted level of fidelity: An HBR usually needs only to model those aspects of behavior that result in observational differences in behavior, a requirement we term *observational fidelity* (Wray, Laird, et al, 2005). We view this a distinction between HBRs and cognitive models, the latter of which tends to model behavior at psychological levels of detail for research rather than application purposes (Wray & Chong, 2007). As a simple example, kinematic control and animations are often needed for HBR modeling in virtual environments but this level of detail is generally superfluous in wargaming simulations such as OTB. Today, however, the field lacks a scientific process for mapping all but such coarse/obvious application requirements to the level of fidelity needed. Soar Tech has developed a simulation environment that commits to a higher level of abstraction than most task environments. This environment is designed to enable more rapid development of core cognitive capabilities and fast prototyping against application requirements. Models can then be specialized and refined for higher-fidelity representational requirements.

Simulation-model interface: Models tend to reflect the representational choices of a simulation's implementation. For example, the representation of physical space in a particular simulation will strongly drive the way the space is modeled (e.g., Reece, Kraus, & Dummanoir, 2000). We have been developing several interfaces, targeted to different levels of fidelity, with the goal to decouple models from the specific representations and abstractions used in different simulation environments. Examples include a general perceptual/motor interface for HBRs, a more psychologically-detailed perception interface for cognitive models, and cognition-animation interfaces for virtual character rendering.

Simulation software environment: HBRs should be largely decoupled from specific simulation environments, making it easy to integrate existing models into new applications (thus amortizing model development cost). However, model implementations typically are strongly coupled to their task environments. This coupling is often due to the complexity of the software environment and the difficulties of extracting perceptual information from the environment. We outline how we are decoupling model implementations from the simulation software environment, while also maintaining model-execution performance and minimizing latency.

dTank: A Lightweight Synthetic Environment for Teaching and Theoretical Research

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When we wrote a review a few years ago (Ritter et al., 2003), one of the co-authors proposed creating a Java-based synthetic environment as a research project. This seemed unusual at the time, but soon after that report I found my group having to create dTank, a simple Java-based simulation, to test models that explain themselves.

dTank is designed to be easy to use to facilitate rapid prototyping and for use in an academic environment. dTank has also been designed for cognitive modeling: it includes the ability to record agent behavior. The model of interaction attempts to provide a psychologically plausible theory of interaction based on effortful perception, rather than simply a simulation harness. We continually attempt to provide the same information to the human player and the agents (and we are continually surprised by this aspect).

We have used dTank for teaching undergraduates in modeling and simulation classes (Cohen, 2005), testing models that explain themselves (Cohen et al. 2005), exploring communication between teams and architectural comparisons (Sun et al., 2004), examining performance variability in situation awareness (Ritter et al., 2007), and we are starting several other projects with it, including exploring how variability and behavior moderators influence performance Evertsz et al. (2008).

In this presentation I will present the advantages, disadvantages, requirements, and impacts of dTank so far.

mōsbē: Exploring the Use of a Game-based Simulation for Military focused HBR Research and Experimentation

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Our defense organizations are faced with progressively more irregular environments marked by asymmetric warfare. In many cases our forces operate with local populations divided along ethnic, religious and ideological dimensions. As the political, cultural, and militaristic stance of our adversaries becomes increasing complex, traditional force-on-force models decline in their ability to predict or design successful outcomes. While victory is still achieved through traditional concepts of offensive action, it is maintained by implementing stability and reconstruction operations at the tactical level that achieve national security outcomes.

Many research efforts are underway to try to understand and model complex human interactions within sophisticated social and cultural networks. While this research is making strides in modeling the complexities of HBR factors in military operations, the programs have not emphasized the practical visualization of their models' effects. Once models exist, significant effort must be exerted to present information in meaningful ways for training, visualization and testing. The way a model manages information may not fit a construct that the user, in this case – warfighters, can understand. A game-based training platform will provide the end-user a unique ability to visualize and understand the impact of specific actions on complex societies. The mōsbē™ toolset provides the end-user the ability to generate virtual worlds from real-world data and create engaging scenarios with the help of a ready-to-use library of objects and assets. Modification of the mōsbē toolset will provide a sandbox for analysis and experimentation with various HBR models within a military context.

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Author Biographies

Brad Best is a Principal Scientist at Adaptive Cognitive Systems, LLC, in Boulder, CO., where he focuses on cognitive modeling of adaptive behavior in complex environments that have significant spatial and temporal aspects. His current research interests include integrating perception with decision making in robotic and virtual agents and the development of methods for analyzing, understanding and visualizing model behavior in these environments.

Robert Wray received a Ph.D. in computer science and engineering from the University of Michigan. His doctoral research focused on maintaining logical consistency in agent reasoning systems and his innovations were incorporated in the Soar architecture. At Soar Technology, he leads or has led R&D projects for the Air Force and Navy research offices, and the Defense Advanced Research Projects Agency. Dr. Wray's research encompasses many areas of artificial intelligence, including agent-based systems and agent architectures, machine learning, cognitive science and knowledge representation and ontology. His recent work focuses on the development and application of AI technologies in computer games to support more realistic and adaptive training.

Glenn E. Taylor received a B.S. in Computer Science (1994), and an M.S. in Computer Science and Engineering (1996), both from the University of Michigan. His research and development activities cover agent-based systems, human behavior modeling, intelligent user interfaces, and natural language systems. He has extensive experience in knowledge elicitation and engineering, and has numerous publications in the areas of intelligent agents and agent-based systems and has managed over $4M in government R&D programs, spanning the DOD and the intelligence community.

Randolph M. Jones is the scientific lead for many of Soar Technology's intelligent agent projects. Dr. Jones has worked with a variety of agent architectures and models, and has participated in the TacAir-Soar project since its inception. He has over 20 years of experience researching agent architectures, machine and human learning, graphical user interfaces, cognitive modeling, and a variety of related areas. His current research focuses on architectures for knowledge-rich intelligent agents, computational models of human learning and problem solving, executable psychological models, computer games, automated intelligent actors, and improved usability and visualization in information systems. He received a PhD from the Department of Information and Computer Science at the University of California, Irvine.

Frank Ritter is on the faculty of the College of IST, an interdisciplinary academic unit at Penn State to study how people process information using technology. He edits the Oxford Series on Cognitive Models and Architectures and is an editorial board member of Human Factors and AISBQ.

Jennifer McNamara is the Director of Strategic Partnerships at BreakAway, Ltd. In this role, she directly supports customers in creating their own serious games and simulations for experimentation and training using mōsbē™ -- BreakAway's simulation development platform. Working closely with organizations that are actively engaged in simulation development provides Jennifer with an insider's view of the needs and experiences of customers and the demands they place upon the available simulation technologies – as well as a view of how applied technologies can solve mission-critical problems. A professional background in cognitive and human factors psychology, intelligent training, and agent-based system development inspires her interest in providing tools-based approaches to simulation development. Prior to joining BreakAway, Jennifer worked at CHI Systems, Inc., where she researched, designed, and managed development of intelligent training and decision support systems for customers throughout the United States Department of Defense. Jennifer holds a B.S. in Cognitive Psychology from Drexel University and a M.Ed. in Instructional Systems Design and Development from The Pennsylvania State University.