: How can behavioral models be used for decision support?

In the Ask Dan! of July 6, 2003 I discussed the question "How can simulation be used for decision support?" That column provided an overview, but I left open the possibility of discussing in more depth complex, realistic visual simulations based upon behavioral models. This Ask Dan! tries to clarify the "how" of agent-based modeling and reinforce the advantage of using this approach for finding robust, workable decision alternatives in complex, uncertain environments.

What is a behavioral model? Let's begin with defining the term. A behavioral model is an explicit statement of variables that impact the observed actions of a system of objects or of a specific object or entity. A behavioral model is used to help understand, explain, and predict behavior. Behavioral models are usually specified as mathematical equations or as computer programs, rather than as verbal descriptions. Models of behavior exist in almost every academic discipline including Physics, Chemistry, Economics and Psychology. A behavioral model is built by observing the previous behavior of an entity or a system; the resulting model can then be used to predict future behavior and performance.

In realistic, visual simulations many models are needed to "drive" the simulation. Models of the physical environment ensure that natural laws are not violated. For example, the simulation "logic" would specify that 2 objects can not occupy the same space. From a decision support perspective, the really interesting simulations are those that help a decision maker anticipate human behavior, i.e. customers, voters, enemy soldiers. These simulations need to imitate physical reality, but more importantly multiple "human-like" agents need to be included in the simulation. Currently this is happening in 2 ways. Some simulations use "real actors" who make choices in a simulated on-line environment. A multi-player simulation like "America's Army" (www.americasarmy.com) is an example of this approach. Another approach is to use behavioral models as the "actors/agents" that are making choices in the simulated environment. We can refer to these approaches as multi-player and multi-agent simulations. Today a multi-player simulation usually also includes some computer-based agents.

So what is a behavioral model for a human-like "agent"? There is no single model, rather various models from Psychology, Management and Marketing can potentially be used. In some cases behavioral models are heuristically composed by the developer and lack any theoretical or empirical foundation. Conceivably simulations can be built using well known models like Maslow's Need Hierarchy, Expectancy Theory, or Herzberg's theory. In the current Artificial Intelligence literature the belief-desire-intention (BDI) model of "practical reasoning" (cf., Bratman et al., 1988) seems to dominate the discussion and the research. According to d'Inverno et al (1998) and others the BDI model is currently implemented in a distributed Multi-agent Reasoning System called dMARS. This system helps a developer program the beliefs, goals, intentions and plans for artificial agents. The plan library is the procedural knowledge of the agent. In building this type of simulation we are trying to capture the global behavior of a large number of interacting autonomous artificial agents.

In general an agent should choose its actions and make decisions for reasons similar to those that a human decision maker would use, i.e. hunger, seeking pleasure, or avoiding pain. Will Wright's game "The Sims" is perhaps the most widely known example of a software program involving behavioral modeling and visual simulation. In an informal class poll recently, many of my 22 and 23 year old students had not however played the game.

In an attempt to try out a behavioral simulation and see what it "felt like" I used "The Sims" software. To remove the game aspect and create a more meaningful simulation my sons helped me use

what's called a cheat code to get unlimited funds so I could build a representation of my home here in Cedar Falls. I populated the simulation with Sims of myself and my wife and of my 15 year old and 9 year old sons. The behavioral model is simple. I could enter values for each of the following five personality variables in the behavioral model: playful, neat, active, nice, and outgoing. The Sim Creator let the user allocate a maximum of 10 of 25 total points to each variable. Once all 25 points are allocated an increase in a value for one variable forces a decrease in some other variable. The Sim Creator has an easy to use graphical interface. Alternatively, I could have chosen the astrological sign of each of us and the default values on the variables would have been displayed for me to adjust. The simulation continually calculates the hunger, comfort, hygiene, bladder, energy, fun, and social scores for each Sim based on what is occurring. These scores "motivate" actions and initiate plans.

Using the Power Family simulation has been interesting and insightful. You can let the simulation run with out intervention in normal speed, high speed and ultra speed. Rather than intervening and directing the Sims (which one does in the game) I have been observing the simulation play out over simulated days without intervention. I can zoom in or out on the simulation and change the speed. You can try this experiment yourself at a modest cost to get a "feel" for multi-agent simulation.

What is a decision support example? I'm trying to find a good case example with screen shots for DSSResources.COM, but that is a few months away. Gimblett, Durnota and Itami (1996) reported a project to develop an intelligent decision support and simulation system that used autonomous agents to assist natural resource managers in assessing and managing dynamic recreation behavior, social interactions and resulting conflicts in wilderness settings. They linked dMARS (Distributed Multi-agent Reasoning System), the Swarm Multi-agent Simulation System and a GIS system to develop the model-driven DSS. They calibrated the autonomous agents using survey data from people using a recreation facility in Sedona, Arizona. The realistic simulation was intended to support forest management activities and assist in evaluating proposed practices for recreation use in the recreation facility.

One of the challenging tasks facing DSS researchers is to identify decision situations that justify implementing realistic decision support simulations for experimentation and repeated analysis. Another challenge is to understand how this type of model-driven decision support might impact decision makers. One claimed impact is that counterintuitive phenomenon may be identified in an agent-based simulation that alters a decision maker’s perception of a situation. My limited experience suggests this is true. Although multi-agent visual simulation will not completely replace traditional simulation, it can be used to simulate some complex systems that traditional techniques can not model or cannot help a user completely understand. Multi-agent simulation provides another lens for anticipating the future of a complex system.

Agent-based modeling can simulate complex systems and it can be a useful management decision support tool. As always the key to simulation is believability. Any model is a simplified description of the real world and that is true for behavioral models. We have much to learn and we need to develop reusable objects and components that academic DSS researchers can use to build innovative, multi-agent simulation decision support applications. I'm currently exploring the costs and difficulty of creating a Java development environment using dMARS, Swarm and other existing tools. Any suggestions or assistance in this quest would be much appreciated.

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Author: Daniel Power
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