Social Synthetic Characters

Bill Tomlinson & Bruce Blumberg
{badger | bruce}@media mit.edu
Computer Graphics Quarterly
Visfiles column

What are social synthetic characters? What good are they? In this column, we'll describe how we make social characters in the Synthetic Characters Group at the MIT Media Lab, and mention a few of the applications where we think they might be useful.

Fig. 1: Two social synthetic characters exchange a glance.

The Synthetic Characters Group, founded in 1996 by Bruce Blumberg, explores ways of making virtual creatures that are inspired by real animal behavior. Over the last several years, we've created a toolkit for building these creatures, including models of action selection, learning, motor control and social behavior. In recent years, we've used the toolkit to make a selection of installations for a variety of venues - *Swamped!* (SIGGRAPH 98), *(void*): A Cast of Characters* (SIGGRAPH 99), *sand:stone* (NY Digital Salon 99), and *sheep|dog: Trial by Eire* (Electronic Entertainment Expo 2001). Our toolkit is more fully described in [Burke 2001].

AlphaWolf

The most recent showcase for our research is a project called *AlphaWolf*, an interactive installation that premiered in the Emerging Technologies program at SIGGRAPH 2001. This installation, headed by Bill Tomlinson, is modeled after the natural social behavior of a pack of gray wolves (*Canis lupus*) [Mech 1998] and focuses on the social abilities of our virtual characters. In *AlphaWolf*, each participant directs the actions of a 3D-animated wolf pup by howling, growling, whining and barking into a microphone. Up to three participants can interact at the same time, directing different pups in the same virtual litter. The virtual wolf pack is composed of the three user-directed pups, and three fully-autonomous adults. The wolves and their virtual world are rendered with a custom-written non-photorealistic "charcoal renderer" that tries to capture the feel of the arctic tundra. Over the course of each five-minute interaction, the pups grow up and, with the help of the participants, find their places in the pack.

While the human participants in *AlphaWolf* are able to direct the actions of their virtual wolves, the wolves are not just puppets. Rather, they maintain their own personalities and social relationships, which affect the style of their behavior. While a pup's attitude toward its social partners may be inferred by the quality of its motions, we also display several wolf-shaped icons at the edge of each screen to serve as a means of visualizing that pup's relationships. Each time the pup forms a relationship with another wolf a new icon appears, showing an image of that social partner in a characteristic pose reflecting the pup's perception of the relationship between them. For example, if a participant is directing the gray pup and a black adult comes over and dominates him, an image of a dominant black adult will appear in the perimeter of the participant's screen. Each icon's pose changes over time to reflect the current state of that relationship; collectively, the icons serve as a window into the social consciousness of the pup.

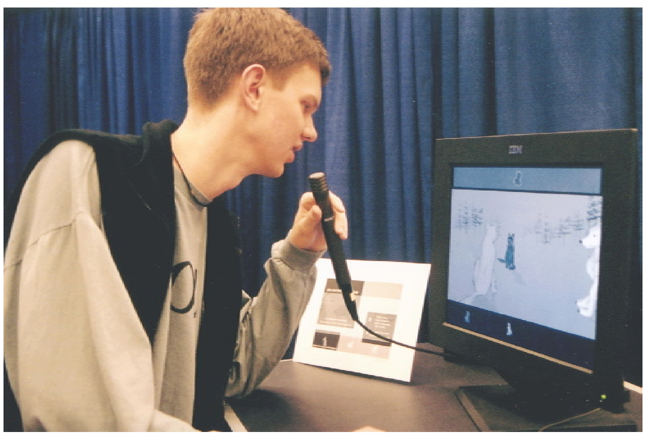

Fig. 2: A participant interacts with the virtual wolf pack.

In *AlphaWolf*, we tried to have each element of the installation focus on the social behavior of the wolves. The aesthetic of the *AlphaWolf* world is very simple – six wolves on a barren snow-scape with a few ghostly trees. This simplicity guarantees that participants won't get distracted from interacting with the other wolves. The autonomous cinematography system frames shots around characters who are interacting to emphasize their relationships. The vocal interface is more appropriate to a social encounter than a keyboard or joystick might have been. The sound effects are tied in to the social experience, as well, with howls being used to help find other wolves in the wind and fog. One of central goals of our toolkit has always been to provide an integrated approach to the different elements of each installation. We hope that *AlphaWolf* demonstrates that our various supporting technologies integrate cleanly with our character-bulding technologies.

Expressiveness, Learning and Development

In building the installation, we found it useful for the wolves to have dynamic ranges of behavior on a variety of time scales.

On a short time scale (<10 seconds), the wolves are *expressive*, exhibiting a range of possible behaviors with which to react to their social partners. We use a synthetic emotion system, a motor system, and example animations to create this dynamic range. For example, during production, our animator crafted dominant and submissive versions of each animation cycle (e.g. "growl", "walk", "howl"). When *AlphaWolf* is running, each wolf has a dynamic dominance value that changes based on its interactions. This emotional state feeds into its motor system, which dynamically blends the example animations to produce the motor action that the wolf then performs. Through this combination of systems, the wolves are able to have continuous expressive ranges of behavior, determined in real-time.

On a somewhat longer time scale (~1 minute), the virtual wolves *learn* about their social partners. The social relationship mechanism in the wolves is based on their ability to form *emotional memories*, derived from Damasio's Somatic Marker Hypothesis. [Damasio 1994] This mechanism allows each wolf to form an association between a social partner and a specific emotional state. On future encounters with that partner, this emotional memory affects the expressive style of the wolf's behavior. For example, if a wolf finds itself feeling submissive around a certain other wolf, it will form an association between the presence of that wolf and its own feeling of being submissive. The next time the wolf encounters that social partner, its emotional memory will cause its current emotional state to become more submissive. It will then perform the actions directed by its participant in a submissive style.

On an even longer time scale (~10 minutes), our wolves *develop*. They are born as pups, grow up into adolescents, and eventually become the fully-autonomous adults with whom the next generation of user-controlled pups interact. This life cycle is reflected both in their behavior, as certain behavioral patterns turn on or off at certain developmental points, and in their physical forms, as their meshes morph from pup to adult over their ten-minute lives.

Each of these three elements – expressiveness, learning and development – is of significant importance in capturing the feel of wild wolf social behavior in the *AlphaWolf* installation.

Applications

Minsky defined artificial intelligence as "the science of making machines do things that would require intelligence if done by men." [Minsky 1968, p. *v*] Similarly, we might define social synthetic characters as the science of making machines do things that would be called social if done by people or animals. Given this definition, the virtual wolves in the AlphaWolf installation are just one example of social synthetic characters. Other examples of existing social synthetic characters stretch across a range of industries and academic disciplines. Over the remainder of this column, we will mention a few applications that we see for social synthetic characters – in particular, entertainment, education, and research. (This is far from a comprehensive list; rather, it represents a selection of areas where we see direct connections to our work.)

The entertainment industry has perhaps the most pressing need for social synthetic characters. The virtual worlds of future video games will be populated with convincing characters featuring elaborate mechanisms for simulating social competence. Characters who can remember the players and each other, and form friendships or adversarial relationships, will provide a much more exciting backdrop for a wide assortment of game genres. Theme parks and other location-based entertainment, too, could use autonomous characters with social competence to help create more convincing interactive experiences for their visitors.

In movies, computer graphical crowds, flocks and herds (e.g., *Antz, Jurassic Park, Lord of the Rings*) already exist. As mechanisms for synthetic social behavior get better, synthespians will take on leading roles without relying as heavily on hand-animation. In addition, as Stan Winston, founder of Stan Winston Studio, pointed out in a recent lecture at MIT, real-time expressiveness in animatronic characters (currently done by puppeteers) is necessary for scenes to "come alive" for the human actors who interact with them. Synthetic social behavior could help automate mechanical actors as well.

Toys that can form relationships with each other and with the kids who play with them also offer interesting possibilities. Consider a set of dominoes that, rather than just falling down and knocking over whichever other domino is in the way, could run to a specific other domino and knock it over. Or imagine a crowd of plastic cave men who learn to be scared of a plastic sabre-tooth tiger over the course of a play session. Although scenarios like these might sound like the opening scene to a Hollywood horror movie, we imagine that social toys will be much less malevolent, simply making playtime more stimulating and fun for kids.

Education is another significant area in which social synthetic characters might be applied. Social toys could be used to help teach children that their actions have long-term effects on the social entities around them – people, pets, etc. These toys could adapt their level of social complexity to the skill level of each child. In addition to helping to teach social skills, socially-enabled virtual instructors are already being developed for a variety of topics. Finally, social characters could be used to teach kids about social dynamics in other species. Imagine a virtual laboratory at a zoo, populated by computational animals, where visitors could set various parameters on the animals and watch as their social structures changed from bird-like to wolf-like to chimpanzee-like.

Synthetic social behavior is also relevant to a variety of scientific research and engineering tasks. The field of animal behavior, which already utilizes a range of computational modeling techniques, could continue to benefit from work in the modeling of social behavior. Multi-robot systems could use social relationship mechanisms like the one in the AlphaWolves to negotiate their interactions. In addition to facilitating the interactions of multi-robot systems, interaction paradigms inspired by social animals could make those systems easier for people to understand and control. As an example, we are currently testing the AlphaWolf emotional memory mechanism in simulation to see if it is useful for coordinating multiple wolves foraging at a single food source (e.g., a caribou corpse). This problem is very much like the challenge of getting multiple robots to recharge at a single power station. Perhaps the arbitration mechanisms of wild wolves (and our virtual wolves) could offer some hints for multi-robot coordination.

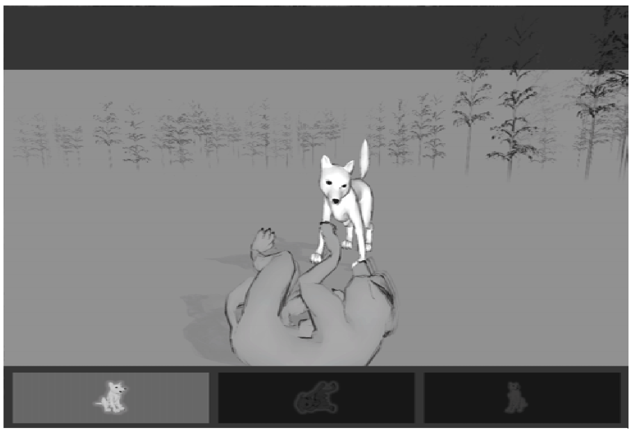

Figure 3: The white pup dominates the gray pup.

In the Synthetic Characters Group, we are trying to build virtual creatures with the every-day abilities that animals have. The *AlphaWolf* installation has given us a chance to explore computational ways of modeling social competence. Despite the variety of existing social characters, we believe the AlphaWolves are unique in their ability to engage in long-term relationships by means of emotional memories. We hope that the simple model that we use in *AlphaWolf* might help make it possible for social abilities to find their ways into a wide array of technologies and products. As a final thought, consider the Machiavellian Intelligence Hypothesis [Byrne 1988], which proposes that human-level intelligence arose as a way for us to maintain our elaborate web of social relationships. Perhaps if computational entities had to keep track of social partners, they might be on their way to "doing things that would be called intelligent if done by men."

If you have any thoughts on *AlphaWolf* or other applications for social synthetic characters, please email badger@media.mit.edu. For more information on AlphaWolf (including a video of people interacting with it) visit:
http://www.media.mit.edu/~badger/alphaWolf.html

Acknowledgements
We would like to thank all of the other members of the Synthetic Characters Group who made AlphaWolf possible: Marc Downie, Matt Berlin, Jesse Gray, Adolph Wong, Robert Burke, Damian Isla, Yuri Ivanov, Michael Patrick Johnson, Derek Lyons, Jennie Cochran, Bryan Yong and Aileen Kawabe.

References

Burke, R., Isla, D., Downie, M., Ivanov, Y. and Blumberg, B. (2001). "CreatureSmarts: The Art and Architecture of a Virtual Brain." Proceedings of the Game Developers Conference: 147-166.

Byrne, R. W., and Whiten, A., eds. (1988). Machiavellian Intelligence. Oxford, Clarendon Press.

Damasio, A. (1994). Descartes' Error: Emotion, Reason, and the Human Brain. New York, G. P. Putnam's Sons.

Mech, L. D., Adams, L. G., Meier, T. J., Burch, J. W., and Dale, B. W. (1998). The Wolves of Denali. Minneapolis, University of Minnesota Press.

Minsky, M., ed. (1968). Semantic information processing. Cambridge, MA, MIT Press.