6
Artificial Life of Agents

Carl Eugene Loeffler
Research Director
SIMLAB
NASA/Robotics Engineering Consortium
Carnegie Mellon University
TEL: (412) 681-7294
FAX: (412) 681-7142
cel@andrew.cmu.edu

"The ultimate goal of the study of artificial life would be to create life in some other medium, ideally a virtual medium where the essence of life has been abstracted from the details of its implementation in any particular model. We would like to build models that are so life-like that they cease to become models of life and become examples of life themselves."

- Chris Langton, *Studying Artificial Life with Cellular Automata*, 1986

"The world of the made will soon be like the world of the born: autonomous, adaptable, and creative but, consequently, out of our control."

- Kevin Kelly, *Out of Control,* 1994

Abstract:
The research in virtual reality initiated by Carl Eugene Loeffler, Research Director at SIMLAB, NASA/Robotics Engineering Consortium, Carnegie Mellon University, investigates existence within networked simulation environments. To date research efforts have been conducted in the area of tele-existence, where multiple users share or co-inhabit a common distributed space. As the research progresses, the environments have become populated by agents of varied classes: people, animals, objects, which are assigned prescribed behaviors as varied as themselves. New research directions study the nature of agents, and their emergence into the classification of life forms. Artificial life, or A-Life when assigned to agents, is the investigation of agents as actual living organisms in silico that possess the properties of living organisms in vitro. They are for all intent and purposes alive. This paper describes general direction in the growing field of agent research, and the current research conducted at SIMLAB in the area of the artificial life of agents.

Introduction

Although widely reported in the media, the exact definition of what constitutes an agent is vague at best. This is because the term agent is generic, while the very purpose of an agent is becoming increasingly specific. To address this specificity, various names such

N. Terashima et al. (eds.), *Advanced IT Tools*

as knowbots and personal agents are applied. To the general public, there is a sense of mis-trust and rejection of the very notion of agents, and this is especially true when aspects of automata and intelligence are conjoined. Fear of human displacement is an issue, as well as the disappointment with the capability of agents. Their performance is just not up to the exaggerated claims. Some researchers point toward the societal difficulties in agent integration, and not technical (Norman). None the less, automata, artificial intelligence and agents have already been with us for a very long time.

"AGENTS

Society as a whole is comfortable with certain types of agents. The standard dictionary definition of an agent would generally include the following:

- acting on one's behalf,
- agency manager,
- salesperson, and
- disease causing organism.

It is acceptable for one to visit an insurance agent. In this case the agent may specialize in insurance, but is a generalist as well. Researchers are generally interested in this acceptability of specialization. The counter distinction is that their applications are specific with no generalizations. So why do researchers continue to investigate agents and introduce them to the world in general?

Perhaps the answer resides in what agents do. In contrast to real world agents such as autonomous robots, or artificial life agents (Langton) which propagate within computer memory, the agents referred to here so far are software agents. They are a program. They can be owned by individuals or multiple users such as organizations and institutions. They can appear in different forms: lines of computer code; menu driven interfaces; or 3-D graphical modes for example. They reside within a single computer or on a network, which is our main emphasis at this point.

"We concentrate on the dynamics of groups of autonomous problem solving agents who are engaged in cooperative problem solving. We assume that each agent has been assigned a particular role in the collective. Three distinct types of agent attitude can be identified: (i) responsibility- agents only execute the tasks directly associated with

their rolew in the group; (ii) helpfulness- agents assist other when they have no responsible tasks to perform (i.e. in their spare time); and (iii) cooperativeness- agents assist one another in return for reciprocated support for one of their own responsible tasks."

- Susanne Kalenka, *Formalizing Social Agent Interactions*, 1995

NETWORK AGENTS

Network software agents are autonomous and mobile. They can migrate across networks, exchange data, make decisions and perform correct actions to achieve goals (Beaudoin). Reasoning is essential; to react when confronted with complex and unpredictable circumstances is necessary (Sloman). Motivations such as desire, preferences and intentions transpire (Wright), as well as emotions (Bates). Associative learning (Shing) can occur, and multiple agents can cooperate for mutual benefit, form a society, and require the management of commitments(Kalenka). Agents can also purposely be hostile, or wander away from the user, reinforcing the importance of network security.

ASSISTING AGENTS

While there are many types of agents, those most frequently cited are agents which assist a user, and this can occur in a wide range of ways. Probably the most common is the electronic mail agent, which sorts and manages electronic mail. Yet a more advanced version of this is a personal software assistant, which is customizable, and can help with information retrieval and scheduling, for example. It is forecast that such agents will employ machine-learning to obtain knowledge, and become a software office assistant (Maes).

"The goal of building an autonomous agent is as old as the field of Artificial Intelligence itself. The Artificial Life community has initiated a radically different approach towards this goal which focuses on fast, reactive behavior, rather than knowledge and reasoning, as well as adaptation and learning. Its approach is largely inspired by Biology, and more specifically the field of Ethnology, which attempts to understand the mechanisms which animals use to demonstrate adaptive and successful behavior."

-Pattie Maes, *Artificial Life meets Entertainment: Lifelike Autonomous Agents,* 1995.

ENTERTAINMENT AGENTS

The field of entertainment is becoming increasingly viable for the development of agents. There are a number of factors involved, the down sizing of defense research, and the accessibility of computer games, either stand-alone or networked. Additionally, the spiraling expenses of animation production, is pointing toward the application

of agents which can sense their environment, and act accordingly. They perform in a non-repetitive way, learn and can thus be used to produce forms of entertainment, such as short behavioral animation films (Reynolds). In some cases these artificial creatures parallels the work in field robotics(Levinson). Virtual creatures, which are mobile, perceive their environment and make decisions can be applied to robot prototyping research. If however entertainment is the objective, what is the basis for the content?

"Many artificial intelligence researchers have long wished to build robots, and their cousins called agents, that seem to think, feel and live. These are creatures with whom you'd want to share some of your life- as with a companion or a social pet."

- Joe Bates, *The Role of Emotion in Believable agents*, 1994.

BELIEVABLE AGENTS

Traditional media such as literature, theater and film for example, have an extensive history when it comes to investigating the notion of character and plot. The incentive is to produce the "illusion of life," with which one can identify and to create the suspension of disbelief. (Thomas and Johnson). Leading research in "believable agents," is now based on artistic investigation of agent animation. Moreover, the aspects of emotion, how a character feels, is essential to the credibility of the agents, and subsequently it's believability (Bates).

AGENTS AND TELE-EXISTENCE

There can be little doubt that networked immersion environments, cyberspace, artificial or virtual reality, or whatever you want to call it will evolve into one of the greatest ventures to ever come forward (Loeffler). It will draw from and affect the entire spectrum of culture, science, and commerce, including education, entertainment, and industry. It will be multi-national, and will introduce new hybrids of experience for which descriptors presently do not exist (Pesce). Computing environments are evolving to become very widely distributed, ubiquitous, open-ended, and ever changing (tokoro). The persuasiveness of the data field is near everywhere, and people move about with computer devices. Interfaces become intuitive. Guides or agents co-inhabit the domains, acquire knowledge, become familiar, and grow old with us.

The concept of tele-existence is based upon “existing” within a tele-environment (Loeffler). The initial features are based upon the user's virtual self, his or her virtual body and its ability to perceive and act (Suzuki). Key features of the virtual body include:

- the ability to see other inhabitants,

- maintaining a consistent individual point of view,
- independent motion, and
- the ability to move and interact with virtual objects.

The situation is altogether not that different from life itself, when sharing a location with other people. In this case, the experience resides in the virtual domain. Tele-existence is social; other users inhabitant the simulation.

"The essential lesson that we have abstracted from our experiences with Habitat is that cyberspace is defined more by the interactions among the actors within it than by the technology with which it is implemented."

-Randy Farmer and Chip Morningstar, *The Lessons of Lucas film's Habitat,* 1993.

In cyberspace they communicate in various ways, and are attentive to their virtual bodies (Stone). Key functions of a virtual body include:

- moving arms and hands, waving for example,
- walking and other mobility,
- changing facial expression, and
- changing costume and other aspects of self-representation.

In following, new research, for multi-user simulations, facial modality as well as real-time voice communication among end users are emerging important options (Takeuchi).

As the research progresses, the environments have become populated by agents which closely resemble the participants in some geometric and graphical respects. Distinctions can become blurred, especially when agents are programmed with social behavior which directs agents to flock or mingle with participants. The literary references to this sense of blurring are evident (Stephenson).

"The notion of common ground not only provides a superior representation of the conversational process but also supports the idea that an interface is not simply the means whereby a person and a

computer represent themselves to one another; rather it is a shared context for action in which both are agents."
-Brenda Laurel, *Computers as Theater,* 1991

It has become clearer that the impulse to blur the distinction, is actually a case of identifying a shared relationship to a functionality within a space, if not in fact a common ground (Novak). In this sense both inhabitants and agents are reduced to bits and are anew in a field of pure information. They are, after all, but bits, enjoying the benefits of functionality in a shared informational space (Laurel).

Currently the general types of agents include:

- Adults, of varied gender and morphology,
- children,
- animals, and
- objects.

New research directions study the nature of agents, and their possible emergence into the classification of life forms. To date, investigation in this area is largely informed by A-Life issues , and the modality of the agents resides within distinct perimeters, for example, multi-cellular evolution through natural selection (Ray). Proposed then is the investigation at SIMLAB of a new class of graphical agents possessing complex modalities. The creation of dynamic agents as actual living organisms in silico that possess the properties of living organisms in vitro. For them, acquiring knowledge, maturity, reproduction, and death are natural occurrences. They are for all intent and purposes alive.

References:

Bates, J. "The OZ Project," Loeffler, C. (editor),"Virtual Realities: Anthology of Industry and Culture," Van Nostrand Reinhold, 1993.

Bates, J. "The Role of Emotion in Believable Agents, " Communications of the ACM Volume 37, Number 7, July 1994.

Beudoin, L. "Goal Processing in Autonomous Agents, " Thesis, University of Birmingham, 1995.

Farmer, F. and Morningstar, C. "The Lessons of Lucas film's Habitat," Benedikt, M. (editor), "Cyberspace: First Steps," MIT Press, 1993.

Kalenka, S. "On Social Attitudes:Preliminary Report," Proceedings of the International Workshop on Decentralized Intelligent and Multi-Agent Systems, 1995.

Kelly, K. "Out of Control," Addison- wesley, 1994.

Langton, C. (editor), Journal of Artificial Life, Volume 1, Number 1/2, MIT Press, Fall 1993/Winter 1994.

Laurel, B. "Computers as Theater," Addison Wesley, Menlo Park, 1991.

Levinson, C. "Fishes of the Silicon Sea," The World and I Magazine, Washington Times, 1995.

Loeffler, C. "Networked Virtual Reality," Proceedings on the ATR Workshop on Virtual Space Teleconferencing, 1993.

Maes, P. "Agents that Reduce Work and Information Overload, Communications of the ACM Volume 37, Number 7, July 1994.

Norman, D. "How Might People React with Agents," Communications of the ACM Volume 37, Number 7, July 1994.

Novak, M. Liquid Architectures in Cyberspace," Benedikt, M. (editor), "Cyberspace: First Steps," MIT Press, 1993.

Pesce, M. "VRML: Browsing and Building Cyberspace, " New Riders, 1995.

Ray, T. "Evolving Multi-cellular Artificial Life, " Technical Reports, ATR Human Information Processing Lab, 1995.

Reynolds, C. "Flocks, Herds, and Schools: A Distributed Behavioral Model, " Proceedings of Proceedings of Siggraph, 1997.

Shing, E. "Computational Constraints on Associative Learning," Proceedings of the XI National Brazilian Symposium on AI, 1994.

Sloman, A. "Computational Modeling of Motive-Management Processes," Proceeding of the Conference of the International Society for Research in Emotions, 1994.

Stephenson, N. "Snow Crash," Bantam, 1992.

Stone, A. "Will the Real Body Please Stand UP?: Boundary Stories About Virtual Cultures," Benedikt, M. (editor), "Cyberspace: First Steps," MIT Press, 1993.

Suzuki, G. "Interspace: Towards Networked Virtual Reality," Proceedings of International Conference on Artificial Reality and Tele-existence, 1994.

Akikazu Takeuchi, A. and Katashi Nagao, K., "Communicative Facial Displays as a New Conversational Modality," Technical Reports, SONY Computer Science Laboratory, Tokyo, 1992

Thomas, F. and Johnston, O. Disney Animation: The Illusion of Life, Abbeville Press, 1981.

Tokoro, M. "Toward Computing Systems for the 2000's," Technical Reports, Sony Computer Science Laboratory, Inc., Tokyo, 1992.

Wright, I. "Towards a Design Based Analysis of Emotional Episodes," Proceedings of the Geneva Emotions Workshop, 1995.