Interacting Agents in Artificial Ecosystems

Claes Strannegård
Department of Computer Science and Engineering
Chalmers University of Technology, Sweden
Department of Linguistics, Philosophy and Theory of Science
University of Gothenburg, Sweden

I present a generic computational model [3] of artificial animals living in block worlds, e.g. in Minecraft [1]. These agents are capable of moving, eating, drinking, and interacting with other agents. Together, an initial population of agents and a block world define an artificial ecosystem that develops automatically over time. The agents have individual sets of needs, sensors, and motors. They also have individual memory structures that undergo continuous development and constitute the basis for their decision-making.

The memory structure is a simple form of neural network that is divided into a perception part and an action part. The perception part is defined by a theory of modal logic, where propositional variables represent sensors and complex formulas represent sensory combinations. The only modal operator is $A \rhd B$, which is used for encoding sequences. The agents continuously receive input values to their sensors from the environment. The formula $A \rhd B$ is true at t iff A is true at $t-1$ and B is true at t. The operators $\wedge$ and $\rhd$ can be used for forming memories of spatial and temporal patterns, respectively.

The modal theory develops over time in a non-monotonic fashion, since memories that are not sufficiently useful are deleted. In this setting the modal theory contains concepts rather than beliefs. Also, the modal theory may well contain both the concept A and the concept $\neg A$. The action part of the memory structure connects the modal formulas to actions by numerically encoding the empirical value of performing certain actions in certain situations.

This computational model is generic in the sense that the learning and decision-making mechanisms are common to all agents. The goal of the decision-making is always to keep the needs of the agent as satisfied as possible for as long as possible. All learning is driven by surprise pertaining to need satisfaction. The learning mechanisms update the perception part as well as the action part of the memory structure. The learning mechanisms were inspired by radical constructivism [4]

and multi-objective reinforcement learning [2].

The mechanisms for learning and decision-making operate on arbitrary memory structures, including "blank slates". These agents are autonomous and capable of adaptation to arbitrary block worlds without any need for domain-specific knowledge. I will give a few examples to show that these animats are capable of learning basic skills such as eating, moving, and navigating. I will also show how cooperation and communication can arise spontaneously in such populations.

References

[1] Matthew Johnson, Katja Hofmann, Tim Hutton, and David Bignell. The Malmo platform for artificial intelligence experimentation. In *International joint conference on artificial intelligence (IJCAI)*, page 4246, 2016.

[2] Diederik M Roijers, Peter Vamplew, Shimon Whiteson, Richard Dazeley, et al. A survey of multi-objective sequential decision-making. *J. Artif. Intell. Res.(JAIR)*, 48:67–113, 2013.

[3] Claes Strannegård, Nils Svangård, Joscha Bach, and Bas Steunebrink. Generic animats. In *Proceedings of the International Conference on Artificial General Intelligence 2017*, 2017.

[4] Ernst Von Glasersfeld. *Radical Constructivism: A Way of Knowing and Learning. Studies in Mathematics Education Series: 6.* ERIC, 1995.