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New Fungus Eater Experiments[1]

Thomas Wehrle

Université de Genève
Faculté de Psychologie et des Sciences de l'Education
9, route de Drize, 1227 Carouge-Genève, Switzerland
Email: **wehrle@fapse.unige.ch**

Abstract

Although there seems to be a high agreement among researchers that the concept of autonomous agents should also be applied in Psychology, especially in Emotion Psychology, most work did not exceed the theoretical level yet. One reason obviously is the lack of adequate tools for applying and exploring this concept. This paper describes, on the bases of an implemented software package, what such a tool could look like. This simulation package has already been used for several applications. As an example we discuss an application that implements the basic concepts of the Emotional (or social) Fungus Eater of Masanao Toda.

Keywords

AUTONOMOUS AGENTS - SIMULATION - EMOTION - SOCIAL BEHAVIOR

1. Introduction

Psychologists mostly agree that phenomena like emotion cannot be investigated separately from perception, memory, cognition and behavior. Since more than a decade so-called ecological approaches have been proposed, e.g. Gibson (1979) or Suchman (1987), trying to account for the natural complexity of behavior as well as the properties of the environment and the ongoing interaction with this environment. Such an integral approach requires that we make our models explicit on the level of concrete mechanisms. Unfortunately traditional psychological methods, like observation, test, experiment, and statistics do not automatically enable us to model a mechanism that could explain the phenomenon. Masanao Toda already in the early sixties proposed to use the concepts of autonomous agents and micro worlds to approach the problem (e.g. Toda 1962, Toda 1982). He proposes to use micro worlds (micro cosms) both for modeling mechanisms and for gathering empirical data (e.g. for the external validation of a model):

> "Here, a "microcosm" means a problem consisting of a wide variety of mutually dependent subproblems, and the subject may not be able to 'survive' (in) the microcosm without letting his major basic functions jointly come into play. ... A microcosm is practically a closed problem insofar as it is a microcosm, and this very closeness renders it a theoretical feasibility. We can obtain the particular set of constraining conditions that makes the subject's behavior optimal in a given microcosm." (Toda 1982).

The concept of micro worlds is closely tied to the concept of autonomous agents:

> "It seems certain that, as we understand more about cognition, we will need to explore autonomous systems with limited resources that nevertheless cope successfully with multiple goals, uncertainty about environment, and coordination with other agents. In mammals, these

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cognitive design problems seem to have been solved, at least in part, by the processes underlying emotions." (Oatley 1987).

Although both concepts are theoretically well elaborated there is little work done that uses micro worlds as complete but simplified environments for autonomous agents. What seems to be missing is the availability of adequate formalisms and tools. This lack of appropriate simulation languages and simulation tools is at least for psychologists an important reason why these concepts are rarely used.

In the next section we give a short overview of the functionality of an implemented software package as an example of what such a tool could look like. In the third section we present an autonomous agent that implements the basic concepts of Toda's Social Fungus Eater.

2. The Autonomous Agent Modeling Environment (AAME)

The Autonomous Agent Modeling Environment is a tool for designing autonomous agents in research and education (Wehrle 1994). The intention is to have an adequate tool that helps exploring psychological and Cognitive Science theories of situated agents, the dynamics of system-environment interactions, and the engineering aspects of autonomous agent design. An autonomous agent is a hypothesized organism or a real robot. In the case of the AAME the interesting aspects of such an agent are not so much the modeling of realistic sensors and effectors but the coupling mechanisms between them. The supported modeling process is a top-down / bottom-up approach. Of importance are on the one hand the *iterative* construction of the control architecture with an adequate formalism, and on the other hand the *interactive* instruments that help exploring a mechanism in a free and intuitive way. In iterative or incremental modeling theoretical propositions are translated and formalized into a computational model in a first step. Interactive experiments should allow one to test the behavior of the concrete system, i.e. the quality of the formalization and the plausibility of the underlying theoretical constructs. These experiments may then serve as a basis for further theoretical refinement and changes.

2.1. Object Oriented Simulation Language

The AAME includes an object oriented simulation language for modeling complex microworlds and autonomous systems. The simulation language currently consists of several hundred language constructs for the following objects:

- Regions (e.g., wet zones and other ecological properties)
- Manipulable objects with arbitrary properties (e.g., obstacles, landmarks, food, tools, etc.)
- Attractors (e.g., light sources, odors, dynamic processes like circadian cycles, etc.)
- Agents with different dynamic morphologies, different types of generic sensors, actuators and attractors
- Communication protocols (attractors or blackboards between agents, local and global messages between user and agents)
- Building blocks for autonomous control architectures (structures and processes), e.g., artificial neural networks, cybernetics systems, production systems, ADT programming support, etc.

The animation of the micro worlds, the agents, and other objects is independent of the application. The simulator can simultaneously handle as many agents as the memory limitation allows. This also includes having different types of agents at the same time. Agents can dynamically be created or removed. Dynamic agent morphology (including sensors, actuators, and attractors) also allows the modeling of ontogenetic processes (e.g., growing, maturing, aging). There is a set of tools for the data analysis (e.g., statistics) and external data protocols. The user interface utilities include FM sound card support. Because of the object oriented system design, the user can easily extend its functionality, e.g., for special types of artificial networks.

2.2. Interactive Simulation Instruments

The AAME includes a set of interactive simulation instruments that allow the inspection and manipulation of all objects during runtime with a WIMP interface (see Fig. 1). The animation is interactive, i.e., the user can control the speed or change the microworld, e.g., the location or properties of objects and agents. The semantics of objects is defined in the applications. It is also possible to inspect or change the control architecture of agents during runtime, e.g., with the network editor and browser. The body of an agent together with its sensors, effectors, etc. can also be changed with a morphology editor. The user can communicate with agents by sending them messages, e.g., to change their parameters, to get their trajectories, or to start protocols. This includes a recorder facility to memorize interesting sequences of behavior.

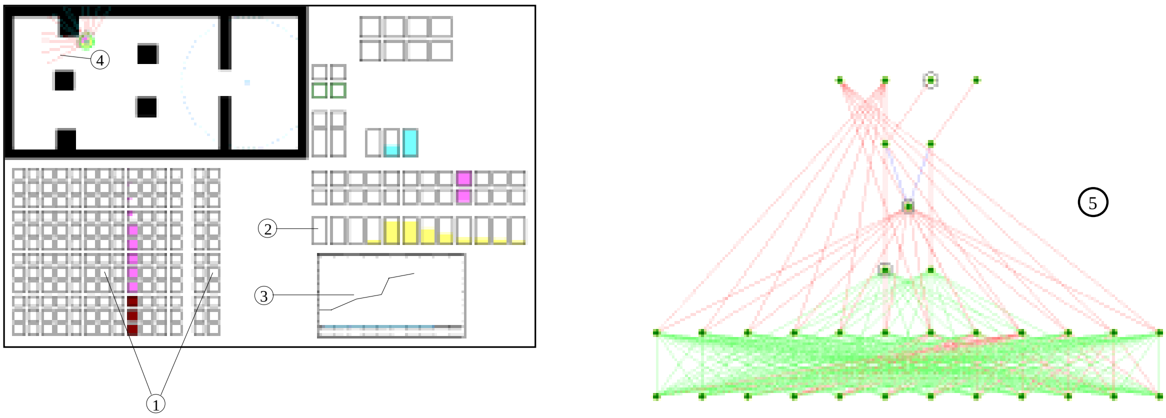


Fig. 1. An animated microworld and inspection facilities: 1. weight matrices for ANN; 2. bar displays (here for the range finder); 3. oscilloscopes; 4. perception area of a sensor; 5. network editor.

3. The Social Fungus Eater

Several applications have been implemented with the Autonomous Agent Modeling Environment, e.g., a microworld for the basic *Braitenberg vehicles* (Braitenberg 1984) or the *Distributed Adaptive Control* architecture of Verschure (1992). One of them is a model of the *Social Fungus Eater* by Masanao Toda (1982), which we want to describe in this section. The Fungus Eater concept as a test-bed for simulation models in emotion psychology has also been proposed by Pfeifer (1988). Now, the required technologies seem to be sufficiently developed.

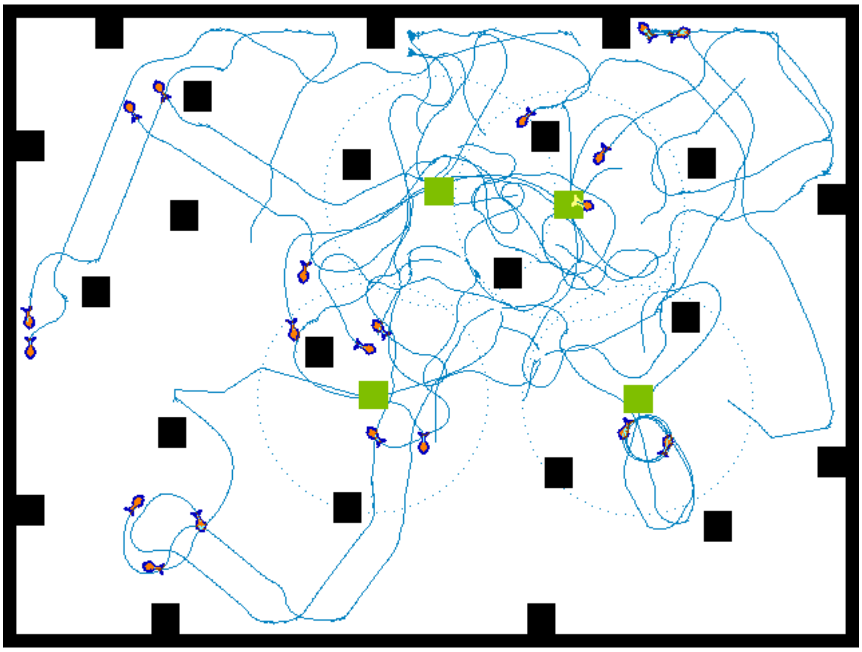
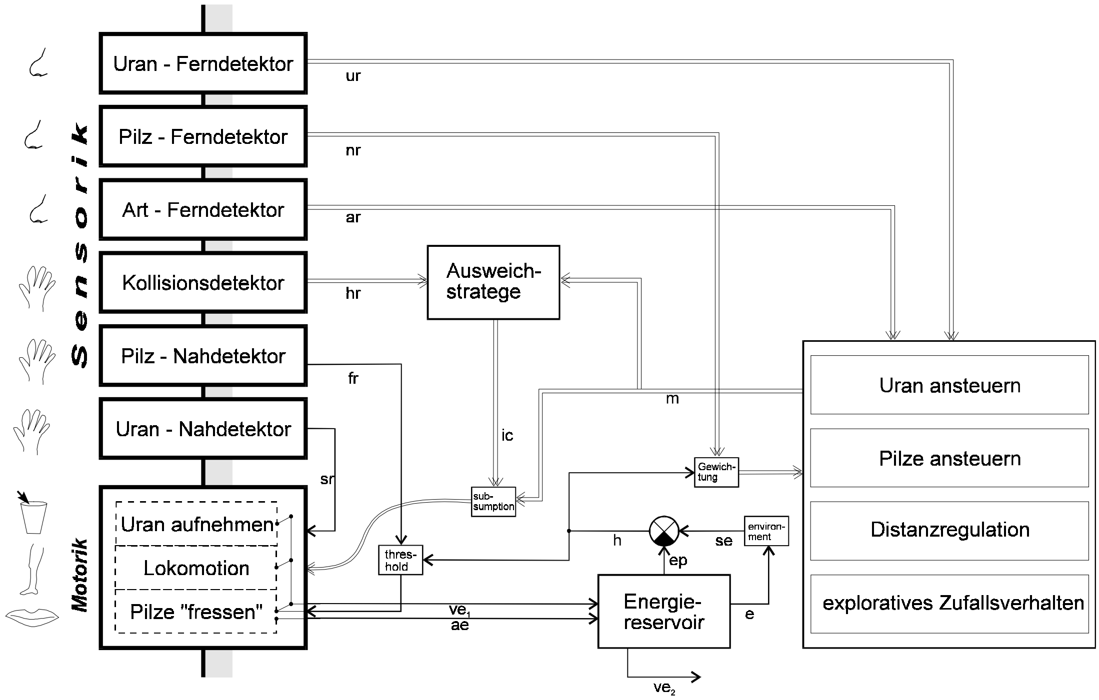


Figure 2. Trajectories of a Fungus Eater society

The Fungus-Eater is a fictitious mining robot that is sent to a planet called Taros to collect uranium ore. It uses wild fungi growing on the surface of the planet as the main energy source for its biochemical engine. Little is known about the distribution of uranium ore and fungi. Every activity of the Fungus-Eater, including the brain-computer operations, consumes some specified amount of fungus-storage. If the Fungus-Eater runs out of fungus-storage it dies. Its mission is to collect as much uranium ore as possible, and there is no reward for the amount of collected fungi (adapted from Toda, 1982). Since uranium ore and fungi are usually not found in the same place there is a conflict in the robot's action selection.

We made some further assumptions for the concrete implementation of the Social Fungus-Eaters: They keep a certain distance to each other in order to avoid conflicts at food places and to avoid inefficient mining. On the other hand they also maintain loose contact in this potentially hostile environment, e.g., to help each other in emergency situations. The (emergent) behavior of the Fungus Eater, achieved with our model can be described as follows:

As expected, the agents are mostly found around food sources and mines (see Fig. 2). They gently alternate at food places. Agents with similar hunger conditions build circles of 2 to 5 members. The consumption of fungi is more or less equal for each agent in a circle. A circle breaks up when a certain level of energy is reached or when other agents approach the source. Depending on the parameters, agents leave even rich food regions, e.g. to collect ore or to explore the environment. Often these explorers form a couple (but the partner is irrelevant). Sometimes circles may also be found in places without food or ore. These circles collapse when the consumption motive of one or several members becomes stronger. If they do not find enough food in a reasonable time they die. At the food places, very hungry homecomers push less hungry agents aside and clearly misbehave.



ur : Uranreiz
nr : Nahrungsreiz
ar : Art-Reiz
hr : Hindernisreiz
fr : Fressreiz
sr : Sammelreflex

se : Sollwert Energie
e : Erfahrung über Enegieschwankungen
h : Fressappetenz
m : Motorische Kommandos
ic : Coping Kommandos

ve_1 : motorisch verbrauchte Energie
ve_2 : verbrauchte Lebenserhaltungsenergie
ae : aufgenommene Energie
ep : Energiepegel

Figure 3. A Model of the Social Fungus Eater

Toda uses cost functions and 'urges' to describe the expected behavior (observer perspective). We modeled this with a cybernetics system (see Fig. 3), using a hedonistic principle based on the energy concept (mechanism in the agent). A Fungus Eater is equipped with remote sensors for ore, fungi and other Fungus Eaters and contact sensors for fungi, ore and obstacles. There is a dynamic set point for the energy level that determines the current hunger condition and thereby triggers eating and approaching food sources. Also dependent on the current hunger condition is the regulation of the social distance to other Fungus Eaters. In situations when adequate sensor signals are missing an explorative behavior is produced. Obstacles temporarily intervene in the ongoing behavior whereas the latter is used as a heuristic for the avoidance strategy.

The control architecture enables the Fungus Eaters to adapt to a dynamic environment. They internalize the current properties of the environment, i.e. the distribution of food and obstacles with their individual energy curves to regulate the ore-food dilemma appropriately.

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