Comparing Different Cognitive Paradigms with a Virtual Laboratory

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Abstract

A public virtual laboratory is presented, where animats are controlled by mechanisms from different cognitive paradigms. A brief description of the characteristics of the laboratory and the uses it has had is given. Mainly, it has been used to contrast philosophical ideas related with the notion of cognition, and to elucidate debates on "proper" paradigms in AI and cognitive science.

1. Introduction

Virtual laboratories have been used in very different areas with different purposes. They are especially useful when they simulate situations which are difficult to reproduce, control, or observe. Cognitive science studies phenomena that fall in this category.

A virtual laboratory has been developed for the comparison of different cognitive paradigms. Experiments carried out in this virtual laboratory were used as "opaque thought experiments'* for discussing the notion of cognition (Gershenson, 2003). Detailed information about the virtual laboratory can be found in Gershenson (2002).

2. A Virtual Laboratory

Following the ideas presented in Gershenson, Gonzalez, and Negrete (2000), a virtual laboratory was developed for testing the performance of animats controlled by mechanisms proposed from different perspectives in a simple virtual environment. Programmed in Java with the aid of Java3D libraries, this software is available to the public, source code and documentation included, at http://student.vub.ac.be/-cgershen/cogs/keb/. The software allows the user to create and repeat controlled experiments for comparing the different animats in different situations in a friendly and informative fashion.

In the virtual laboratory, the user can create different phenomena, such as rocks (grey cubes), food sources (green spheres), rain (blue semitransparent cylinders), lightnings (black cylinders), and spots of different colours (circles): randomly or in specific positions. These also can be generated randomly during the simulation at a selected frequency. Lightnings turn into rain after ten time steps, and rain turns into food after fifty time steps.

All the animats have an energy level, which decreases when their hunger or thirst are high, and is increased when these are low. An animat dies if its energy is exhausted. Eating food decreases their hunger. They can decrease their thirst by drinking under rains. Hunger and thirst are increased if they attempt to drink or eat "incorrect" stimuli. They lose energy if they touch lightnings or rocks. Basically, an animat in order to survive needs to eat when hungry, drink when thirsty, and avoid lightnings and rocks. We can say that they are cognitive systems if they are successful, because they would *know* how to survive (Gershenson, 2003). The animats can leave a coloured trail in order to observe their trajectories.

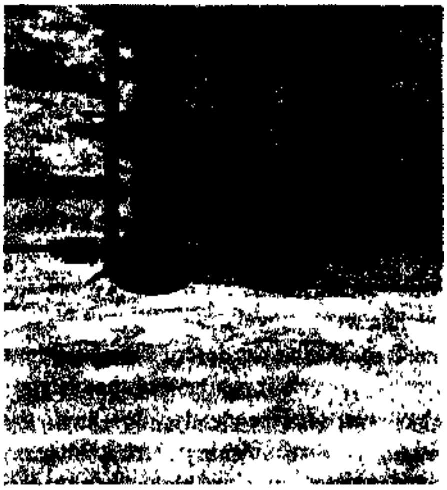

Figure 1. Screenshot of virtual environment.

There are many models that would solve the problem of surviving is such an environment, but it was decided to implement representative models of different paradigms in order to observe their differences and similitudes. These models are as follows: a rule-based system typical of traditional knowledge-based and expert systems; Maes' (1990) action selection mechanism, an already classical behaviour-based system; an original architecture of recursive concept development (Gershenson, 2002) as an example of the novel concept-based approach; a simple feed-forward artificial neural network; and a Braltenberg-style architecture (Braitenberg, 1984). All the animats survive fairly well in the simple environment. A short description of each mechanism follows:

- The rule-based animats have a set of rules (*//.. then).* These receive information from "cheater" sensors, *i.e.* with meaning given by the programmer *(e.g.* food perceived, hungry, obstacle close, etc.), and produce behaviours (e.g. explore, approach food, eat, avoid obstacle, etc.), with which a motor system has to deal.
- The behaviour-based animats also have "cheater" perceptual and motor systems, but the control is determined by a network of behaviours (e.g. approach food, eat, avoid obstacle, etc.) which inhibit and excite according to the types of connections they have.
- The concept-based animats only have basic sensors *(e.g.* redness, hardness, flavour, etc.), and they develop recursively concepts that they associate by reinforcement learning with predetermined behaviours.
- The neural animats have three sensor pairs and two motors. Each sensor perceives if a phenomenon (food, rain, or rock) is left or right of the animat. These signals, and signals from the internal medium (hunger and thirst) are inputs to a three-layered feed-forward neural network with fixed weights. The outputs go straight to the motors.
- The Braitenberg animats also have six sensors and two motors, but they are directly connected: food and rain sensors to the inverse motors (left to right, right to left), and rock sensors to the corresponding motors (left to left, right to right).

3. Comparison

Several experiments were performed in the virtual laboratory to compare the different properties of the architectures that control each type of animat (Gershenson, 2002). The reader is invited to download the virtual laboratory and compare the different architectures as well.

We could see that we can describe the different animats in the same terms, because it can be said that they perform the same behaviours, independently on how these were implemented. Also, distinguishing which architecture controls which type of animat is not possible for a naive observer.

We observed that there is no general "best" architecture for the simple task of surviving in the virtual environment. We can say that each animat is better in different situations. Yet it seems that this is more a consequence of the particular implementation than of the paradigm on which it stands, because the models can be adjusted and refuted to any desired degree of detail. In order to judge which architecture is better, we need to refer to a particular context. Their performance cannot be generally measured, but only relatively to specific tasks.

Some models were very easy to implement in software code, others not so much, but occasionally it is a different story if we want to implement an architecture in a real robot. Moreover, if a model works in a simulation and/or robot, it does not mean that animals function in the same way. Some models are very robust. Others would break up quite easily. Some models are quite good if we have just practical purposes, and this also depends on the experience of the engineer. Still, if we are interested in using them as explanatory models, the simplicity of their implementation might be secondary. Also, if we would like to increment the systems, for example to include more environmental stimuli and internal variables, some would need to be redesigned, others could be easily extended. Some models would have more ease in adapting to changes of their environment than others, but this does not mean that we cannot adjust different architectures in order to obtain the desired behaviour.

We can say that different models, architectures, and paradigms, study different aspects of cognition. Will we find ever a "best" model? It depends on our purposes and our context. Generally speaking, we can say that all approaches are useful, since they illustrate different aspects of cognition.

The observations in the virtual laboratory were useful for discussing and illustrating ideas related to the notion of cognition (Gershenson, 2003), and to clarify debates concerning the "proper" paradigm for studying cognition (Gershenson, 2002).

4. Conclusions

Virtual laboratories allow us to explore different avenues than physical laboratories. This virtual laboratory was useful for illustrating questions such as "what makes a system cognitive?". It helped in showing that the observer plays a great deal in the cognition of the system, and that cognition is independent of the implementation of the system.

References

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