A Simulation Environment for Neural/Behavioral Models of Behavioral Choice

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Overview

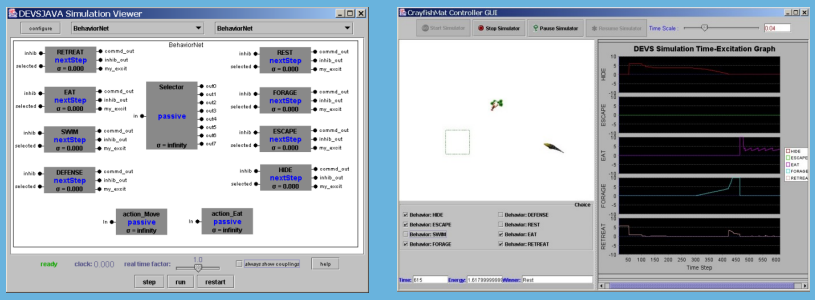
Earlier work showed that a robust mechanism for adaptive decision-making by animals and robots could be obtained from a network of mutually inhibiting centers for specific behaviors [1]. This research aims to extend the development of an initial simulation of behavioral choice to account for more of the complexities of animal behavior, including changes in behavioral state, and formation of social dominance hierarchies. We propose:

- to develop the model in a modeling and simulation environment that will enable us to adopt more complex decision structures and test them individually or in batch model;
- to study and compare several decision architectures that have been proposed over the past years;
- to determine whether the multi-agent crayfish simulation can account for the behavior of a group of crayfish as they interact to form a dominance hierarchy.

The project is carried out in several phases. In the first phase, we have developed a prototype simulation environment *BehaviorSim* [2]. Meanwhile, we have developed a two-layer mutual inhibition behavioral network as a possible decision architecture for crayfish models and autonomous robots [3]. In this second phase, we will continue the development of *BehaviorSim* and apply the two-layer decision architecture to crayfish' s dominance hierarchy formation as well as several robotic control applications.

Results from the First Stage

- A prototype simulation environment *BehaviorSim* has been developed as shown in Figure 1. In Figure 1(a), the model viewer displays a model of behavior network that has eight behavior models (on the left and right sides), one selector model (in the middle), and two action models (at the bottom). In Figure 1(b), the simulation viewer displays the movement of a crayfish, a predator, and the dynamics of the environment. Excitation strengths of selected behaviors (customized by users) are displayed on the right side of the viewer window.
- A two-layer mutual inhibition behavioral network is proposed as a possible decision architecture for crayfish models and autonomous robots. As shown in Figure 2, the "behavioral state" layer allows the model animal to adopt one of several different "behavioral states" according to the prevailing external and internal environmental conditions. Each state will correspond to a particular pattern of inhibitory coefficients in the mutual inhibitory behavior network at the behavior layer.
- The two-layer architecture has been applied to a multi-robot dynamic team formation system, where robots search for their partners and eventually form a large single team in a line formation. Figure 3 shows four snapshots from a simulation of the team formation process.



(a) Model viewer (b) Simulation viewer

Figure 1: The *BehaviorSim* Simulation Environment

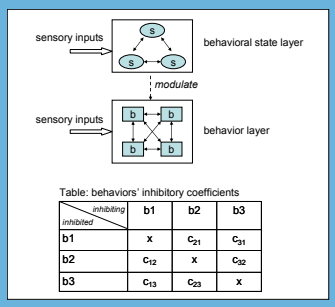


Table: behaviors' inhibitory coefficients

inhibiting / inhibited	b1	b2	b3
b1	x	c_{21}	c_{31}
b2	c_{12}	x	c_{32}
b3	c_{13}	c_{23}	x

Figure 2: The Two-layer Mutual Inhibition Behavior Network Architecture

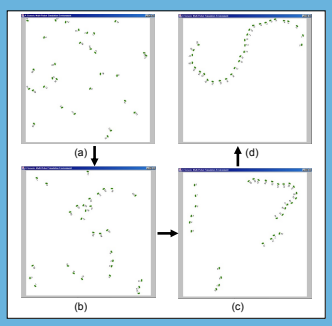


Figure 3: A Multi-robot Dynamic Team Formation System

Plans for the Next Stage

- Continue the development of *BehaviorSim* to make it useful for a set of biological problems. The ultimate goal is to have a modeling and simulation environment that allows crayfish models (composed from behavior models and neural circuits) to be easily constructed and configured. We foresee an iterative process where models and the simulation environment are continuously updated.
- Determine whether the two layer model can account for the change in social dominance interactions that occurs among small groups of juvenile crayfish as the hierarchy matures. Results will be validated by comparing with real crayfish experiments.
- Continue development of the two layer architecture and apply it to both simulated agents and robotic systems. Real robots will also be employed to test and demonstrate the architecture.

Reference

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