Evolving Insect Locomotion using Non-uniform Cellular Automata

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Abstract

We present a model for the evolution of locomotion behavior in a simulated insect. In our model, locomotion is defined over a discrete state space using non-uniform cellular automata. We use a genetic algorithm to evolve the dynamical law of the system. The model was capable of evolving several commonly observed gaits of insects. In addition, the evolutionary process yielded periodic attractors which are invariant from the initial conditions.

1 SUMMARY

Research in autonomous agents has focused for many years on the design of computational models capable of synthesizing agent behaviors. Pfeifer and Scheier (1999) argue in favor of parsimony when modeling agents: if there are a number of competing models, the more parsimonious ones are to be preferred. Cellular automata are general and simple (Sipper, 1997). In addition, they provide a formal framework for understanding the emergent and dynamical properties of agent behaviors.

Some insect inspired locomotion models suggest that locomotion may be viewed as an emergent property of local interactions between the mechanisms responsible for the control of individual legs (Ferrell, 1995). These models share several properties with cellular automata: parallelism, locality of interactions and simplicity of components.

In this work, we demostrate the application of non-uniform cellular automata to the synthesis of locomotion behavior on a simulated insect (Beer, 1990). The architecture of our model is inspired from the distributed model for leg coordination proposed by Cruse (1990). We use a genetic algorithm to evolve the cellular rules of the system. The model was capable of evolving several commonly observed gaits of insects, including those resulting from amputation.

When we explore the generality of the solutions, the evolutionary process yielded periodic attractors which are invariant from the initial conditions. The indentification of attractors and their corresponding basins of attraction sets can be very important when modeling agents for which the conditions of the environment are uncertain. These behaviors are invariant to perturbations.

The focus of this study has been on the evolution of locomotion behavior. An immediate extension of this work is the consideration of other agent behaviors. Other extensions include a formal analysis of the behavior of the system using tools provided by the theory of dynamical systems. These studies will provide insights for understanding the emergent and dynamical properties of agent behaviors.

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