

Evolving "Brains" from Basic Elements

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The Problem: Evolution has produced complex systems such as brains and nervous systems out of basic elements, the neurons. We want to investigate what systems we can obtain out of basic elements such as NAND gates and operational amplifiers.

Motivation: Neurons are the basic elements that, when organized, yield brains and nervous systems. Currently, we do not understand the principles of this organization, but this organization is a product of evolution.

In a similar way, we intend to build robots whose "brains" are the result of artificial evolution. In this case, the basic elements used for evolution are NAND gates, operational amplifiers or any other device that will be used to implement an actual "brain" of a robot.

A similar approach is used in evolutionary neural networks where, artificial evolution is applied to computational models of neurons to investigate different topologies or organizations.

In our case, basic elements, instead of computational models of neurons, are used because we want to take advantage of the natural dynamics of these elements.

We would also like to analyze the organizational differences between systems obtained by artificial evolution and those by human design. For example, digital and analog computers are models of comparison for organization of NAND and operational amplifiers respectively.

Previous Work: One of the goals of evolutionary neural networks [2] is to find topologies adequate for a given task. However, the basic elements are computational models of neurons and not actual elements with its own dynamics. Artificial evolution has also been applied to different basic elements such as transistors, resistor, capacitors and inductors. However, the goal has been to optimize hardware. A review of this work is presented in [1].

Approach: The experiment described above will be implemented in hardware using, for example, analog and digital FPGA's to control a robot. This will allow us to take advantage of the dynamic characteristics of the basic elements of the FPGA and the robot's environment.

Impact: This work will help us to explore and understand the organization that arises from evolutionary algorithms.

Future Work: Using digital gates comprises the initial stage of the work. Subsequently, we plan to exchange the digital elements (NAND gates) for analog elements i.e. operational amplifiers.

References:

- [1] John Koza, Forrest Bennett III, David Andre, and Martin Keane. *Genetic Programming III; Darwinian Invention and Problem Solving*. Morgan Kaufmann Publishers, 1999.
- [2] Yao. Evolving artificial neural networks. *PIEEE: Proceedings of the IEEE*, 87, 1999.