Evolving Behaviors for Simulated Kinematic Self Replicators.

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In this study we compare three classic variations on evolution: Darwinian, Lamarkian, and Baldwinian in the role of improving a behavior-generating neural network. Kinematic self-replication was selected as the problem domain because it represents a rich set of constraints, possibilities, and implications.

In the past fifty years numerous techniques have been developed to improve the performance of behavior-generating artificial neural networks. Neuroevolution is a technique of improvement by means of variation and selection based on the theories advanced by Charles Darwin. It differs from many improvement models based on the phenomena of ontogenic learning in that it does not attempt to assign credit to a locus in the tissue but rather to an individual that is a host of a set of behaviors. Systems that exhibit natural evolution are best classified as exhibiting unsupervised improvement (to borrow a term from neural network learning theory). In this model an environment produces and reinforces a characteristic over a series of generations; in contrast, many improvement theories rely on an explicitly defined goal or model of successful behavior and a predetermined algorithm for modifying the neural network to produce that behavior. In the pursuit of artificial intelligence it is important to recognize if we knew exactly what we wanted we could probably get it. This research is based on the premise that we can only afford to describe a small subset of the possible behaviors that demonstrate intelligence; thus we are reliant on the possibility of limited supervision improvement models. Genetic Algorithms as they have been implemented to this point still utilize an explicit goal in the form of a fitness function. This can be thought of as a molecular form of the atomic supervised learning theories. In contrast artificial self-replicating systems immersed in an environment approximate the phenomena of natural evolution in that success is demonstrated by existence and supervision (if you can call it that) is provided by the environment. In the context of these experiments we attempt to use a genetic algorithm with an explicitly defined fitness function to evolve a behavior-generating neural network capable of guiding a simulated mobile robot with a set of manipulation capabilities to assemble a similar robot, in an attempt "jump start" a process of implicitly guided evolution. Further we examine the applicability of variations of evolution that involve self supervised adaptation, which we achieve by means of a meta-network with the capability to sense the activation state of the behavior-generating network and alter the value of the inter-weights.

Background players:

Jean Baptiste Pierre Antoine de Monet, Chevalier de Lamarck proposed the largely discredited theory that individuals in a population could pass on traits that were acquired during their lifetime to their offspring. Whereas few examples of this exist in the natural world (notably immunological) it is not a bad model for improving the members of population.

James Mark Baldwin proposed the idea that an evolving population of adaptable individuals can eventually exhibit characteristics that were once only achieved by a process of individual adaptation, without individual adaptation. In recent years we have come to value his contribution as leading us to a valuable synergy between artificial learning and evolution.

Michael I. Jordan and Jurgen Schmidhuber have utilized artificial neural networks to improve other artificial neural networks.

Tom Ray has described scenarios wherein agents self replicate in a common environment as an unfolding fitness landscape.

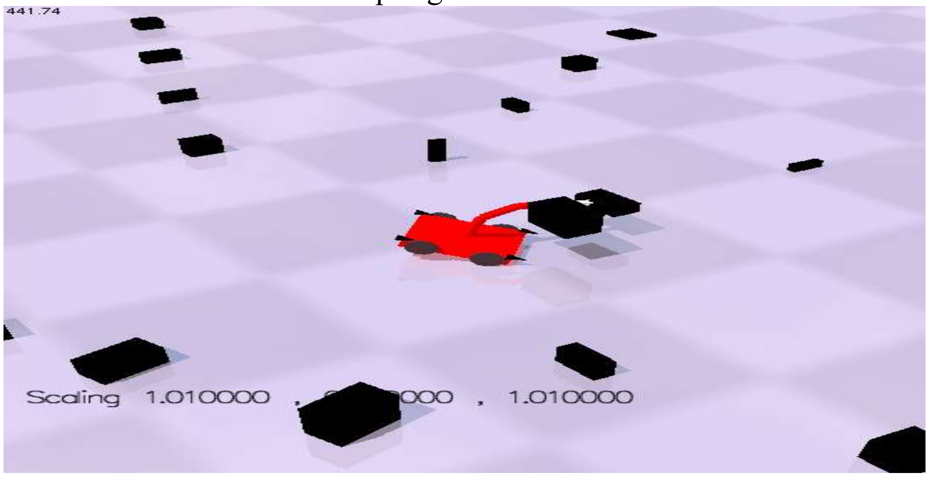
David Chalmers pioneered efforts to evolve learning algorithms and observed that the more diverse the set of training tasks the more robust and broadly applicable the resulting learning algorithm is.

Jon Klein has developed the breve simulation engine with a broad set of capabilities appropriate for alife simulations.

Valentino Braitenberg proposed that even if Occam's Razor does not apply to neurobiology it is easy to use simple known neurological mechanisms to produce complex behaviors.

The Manipulator Robots:

One arm...with unfinished offspring



Two arm...with unfinished offspring