A Simulation of Evolved Autotrophic Reproduction

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Project Goals

Innately creative embedded systems would have many uses in manufacturing, agriculture, and exploration. In this project we evolve a reproductive behaviour for a simulated manipulator cart. Our long term goal is to produce a robust behaviour that can reproduce by an assembly process in an artificial ecosystem where emergent complexity generates evolutionary pressure. To this end we use a fitness function that reflects reproductive fidelity.

Background

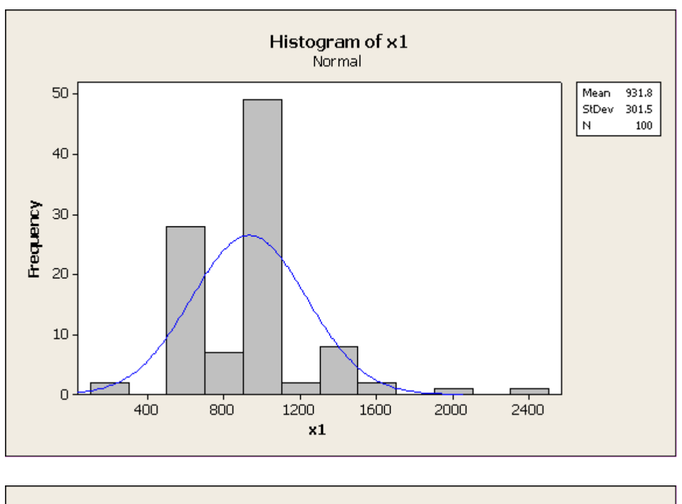
-Circumstance has demonstrated that creative intelligence can emerge when capabilities for manipulation, communication, learning, abstraction, and prediction are present in a reproductive system that is subject to complex pressures.
-In Chalmers' 1991 paper on evolving learning algorithms he demonstrated that generalization capability can be produced by subjecting an algorithm to a variety of tasks during trials.
-Tom Ray characterized ecosystems as unfolding fitness landscapes.
-The only fitness criteria in such a system is reproduction.
-Valentino Braitenberg's *Vehicles: Experiments in Synthetic Psychology* showed us that simple mobile agents can tell us about control and the way neurons achieve it.
-Jon Von Neumann and Freeman Dyson envisioned self replicators exploring the depths of space; we envision such systems exploring the domains of physical and conceptual production.

Research Methodology

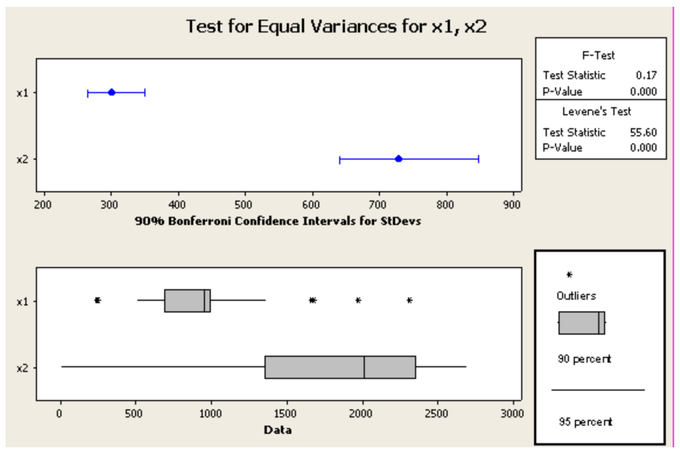
-Simulated using Jon Klein's *breve* A-life engine.
-On an eight node cluster computer.
-We conducted an initial study with a single armed manipulator to confirm that a simulated assembly scenario would be a suitable trial for evolving a neural network controlled vehicle.
-Subsequent tests explored epigenetic variation of the control network by a second network in hopes of detecting the Baldwin effect and contrasting Lamarkian evolution against pure Darwinian.
-In pursuit of greater dexterity we now use two arm vehicles.
-The results presented in this paper were achieved using a tournament style GA operating on a 376 node fully connected neural network controlling a vehicle with 40 input channels and 17 degrees of freedom.

Results

We demonstrated the possibility of evolving reproductive behaviours for this scenario by comparing the variance and mean of two samples consisting of the first 100 trials (x1) and the last 100 trials (x2) of a series of 16,400.



Results continued...



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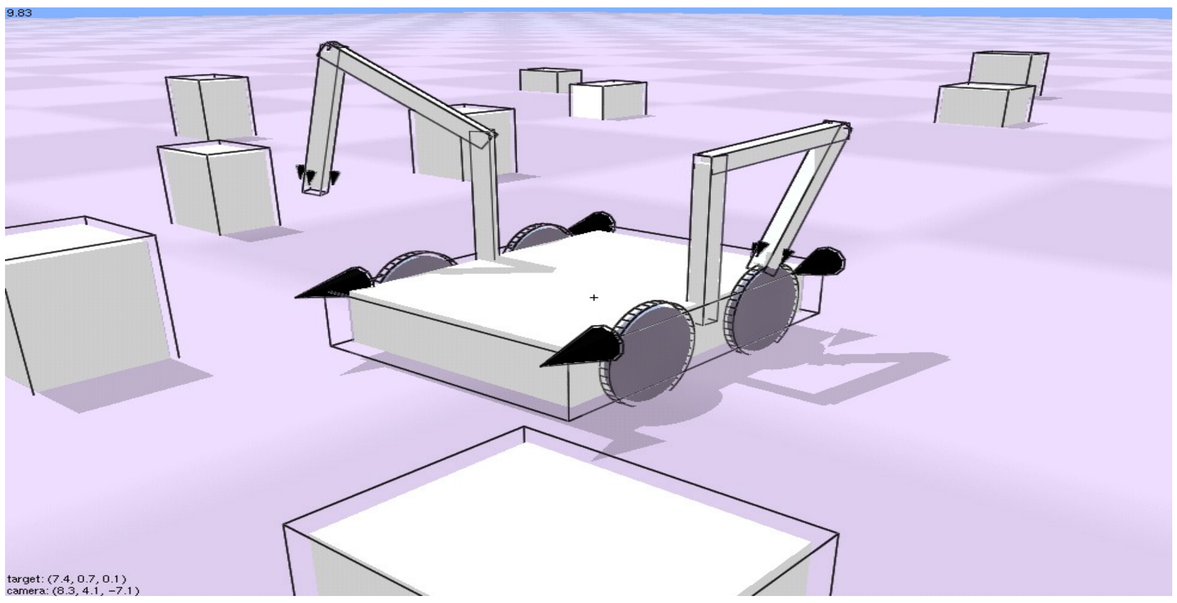
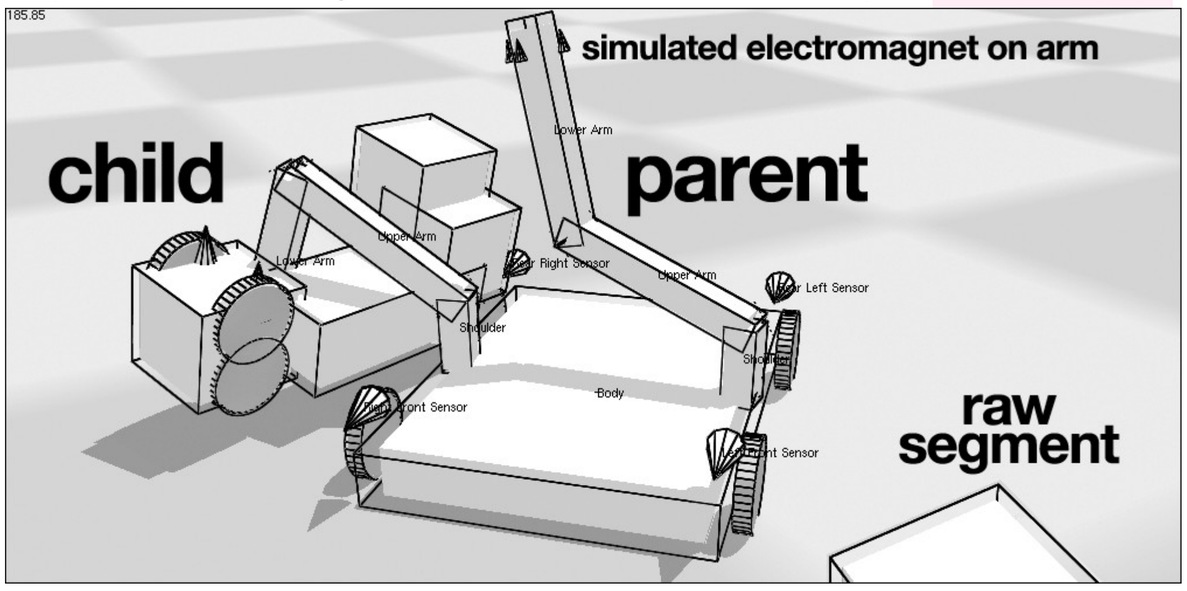
Assembly Scenario

A trial starts with a vehicle situated in a field of raw materials.



A parent vehicle is given ten seconds of simulation per added element.



Future implementations of the code base:

-Artificial farming and husbandry by Heterotrophic Reproductive Vehicles.
-Scenarios where inter-agent communication is a demand.
-Testing behaviours for reproductive continuity in an artificial ecosystem.
-Testing a Simultaneous Locating and Mapping Radial Dissipation Map (SLAM/RDM) based on the von der Malsburg SOM.

Conclusions

While evolving complex simulated reproductive agents is clearly possible, it is extremely expensive. Truly deployable designs might be evolved with a combination of higher resolution physical simulations, evolving physical morphologies, and large cluster computers.

Acknowledgements

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References

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[2] Sipper, M., Sanchez, E., Mange, Tomassini, D., Pérez-Uribe, A. and Stauffer, A. A Phylogenetic, Ontogenetic, and Epigenetic View of Bio-Inspired Hardware Systems. *IEEE Transactions on Evolutionary Computation*, Vol. 1, No. 1, pages 83-97, April 1997.