Investigations of evolutionary phenomena with Framsticks

Walter de Back Maciej Komosinski

www.framsticks.com

This presentation
describes research ideas of
the team led by Walter de Back
Department of Philosophy
and Robotics Lab
Institute for Computing Sciences
Utrecht University

Evolutionary Psychology

- perspective for examination of behavior, cognition, intelligence etc.
- grounded in cognitive psychology, evolutionary biology, neuro-psychology, anthropology and sociobiology
- examines how Darwinian evolution could have produced the mental faculties which are exhibited by humans today
- hypotheses about the human mind derived from the general natural selection theory are only **hypotheses** until empirical testing can be conducted

Evolutionary Psychology

- Evolutionary psychology = evolutionary biology + cognitive psychology (Dylan Evans and Oscar Zarate: "Introducing Evolutionary Psychology")
- goal: to discover and understand the design of the human mind
- *mind* as a set of information-processing machines designed by natural selection to solve adaptive problems
- or: how (ancient) environmental, social and other evolutionary forces has shaped the human brain, to which we can ascribe mental states, to become a human mind

Synthetic Evolutionary Psychology

- SEP = Evolutionary Psychology + Synthetic Psychology
- use of computer simulations and autonomous (evolutionary) robotics to investigate the history and structure of the brain and mind
- synthesizing creatures, evolutionary forces and brains.

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synthetic methods (e.g. game theory): constructing artificial systems to provide useful models for evolving minds and evolutionary histories. Provides evolutionary psychologists with additional means to test their hypotheses about mental structure and evolutionary trajectories.

- Best known example of computer simulation used in evolutionary psychology is the Prisoner's Dilemma (PD)
- A game-theoretical approach to the emergence of cooperation and altruism – social behaviors.
- Do animals play Tit-for-Tat? no. . . their behavior depends on the environment! they are *situated* and *embodied*. Thus in late 80's – critics: minds are always situated in bodies and worlds, and cannot be understood apart from them.
- Investigating the origins of behavior from a game theoretical perspective is much like studying chess in order to investigate intelligence!
- This is why SEP is needed.

Endogenous evolution

- All animal behaviours are solutions to the problems of survival and reproduction. In order to investigate the evolutionary origins by artificial life simulation, the model must include these selective forces.
- They are incorporated by using endogenous selection scheme in which creatures are born, survive by consuming food, are able to reproduce with conspecifics by colliding, and die when energy is low, or killed.
- Contrary to traditional artificial evolution, this model contains no predefined fitness functions and selection mechanisms.

Sympatric speciation

- Many examples of speciation are found in nature. In some cases this is caused by a physical barrier which forces a population to diverge into two different species (allopatric speciation).
- However, speciation without physical isolation can also occur in nature (sympatric speciation). Speciation within Framsticks can result from one gene pool and one population without a geological barrier.
- Starting with a population of intermediate individuals varying in artificial trait X, that is not geographically isolated and on whom disruptive selection is working, evolutionary branching into two different biospecies will occur, without the use of explicit fitness rules.

Sexual selection

- Sexual selection is the theory that competition for mates between individuals of the same sex drives the evolution of certain traits
  (one of such traits is the preference of females to mate with older males)
- In this project, a certain species is modeled to find out whether evolution can lead to such behaviour.

Semiotics

- Natural ecosystems are interlocked by many sign-processes between species and between individuals of the same species. A sign comes to existence when a signal gains value: when it triggers behaviour in another individual. Sign processes are evolved through a process of co-evolution.
- In this project, the establishment of signs is investigated, through the co-evolution of a small predator-prey ecology.

Evolution of flocking

- Reynolds' BOIDS clearly demonstrated that the complex animal behaviour known as flocking is the result of very simple local rules. What is less clear, however, is how these rules may be implemented in the sensorimotor mechanisms of these animals. Moreover, it is not at all understood what evolutionary pressures (=environmental conditions) lead many species to adopt such strategies.
- This project aims to get understanding of the evolutionary history that lead to the emergence of flocking by using a spontaneous evolution scheme.

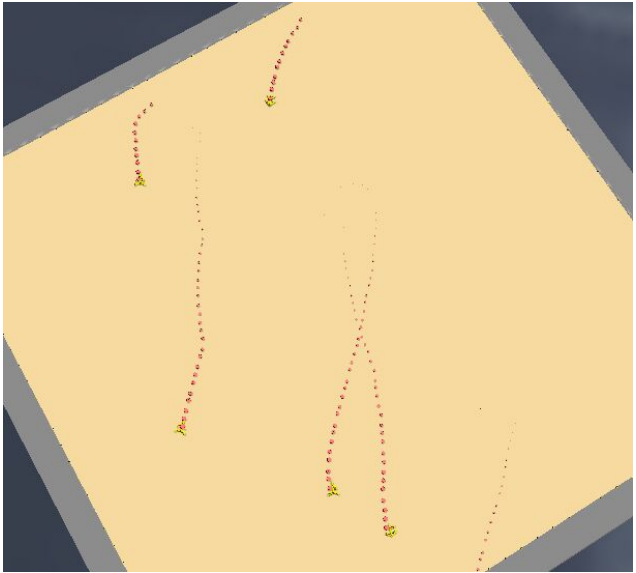
Endogenous Neuro-evolution of Augmented Neural Net Topologies

- Co-evolutionary 'arms races' are wiedely held responsible for complexification of behaviour. However, complex behaviour should be facilitated by complexification of neural network topologies.
- In this project, we incorporate a variety of the NEAT methdology in the Framsticks simulator. Other than NEAT, we show that complexification is not only possible in fitness optimisation evolution, but also emerges from endogenous evolution.

Diploid genetics

- In normal genetic algorithms (GAs) all information is encoded on one string (haploid). In nature, genetic encoding is pairwise. There are two copies of every gene in the genome. When these pairs are not identical (due to mutation), the decision which gene to express in the phenotype is done by associated genes that describe the dominance / recessivity.
- Diploid GAs in (simulated) autonomous robotics promise greater diversity, better peak performance and better and faster adaptivity to changing environments.

Sample implementation: pheromones and stigmergy



Sample implementation: predator–prey dynamics