RoboGen™

Robot generation through artificial evolution

*Evolutionary Robotics Course Project*

Co-evolving robot bodies and brains

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Co-evolution of Robot Bodies and Brains
Early work

Sims, 1994

Lipson & Pollack, 2000

Bongard & Pfeifer, 2001

The Golem Project
More recently

Auerbach & Bongard, 2012

Cheney et al., 2013
Co-evolution of Robot Bodies andBrains

Phase 1: Simulation

- Genetic Encoding
- Variation Operators
- EA Parameters
- Simulation Parameters
- Scenario (fitness fn)

Evolutionary Algorithm

Evaluations in Physics Simulator

Phase 2: Reality

- Pre-printed kit of building blocks
- 3D Print parametric parts

Robot Assembly

Microcontroller Programming

Real World Validation
Physics-based Simulation

Physics – described by geometric primitives (cubes, cylinders, etc), constraints (joints) and masses

Rendering – described by meshes from STL files (these are in the model/ dir of the software).
Physics-based Simulation
**Evolve Robots**

Configurable scenarios: goal-directed navigation, racing, custom …
Configurable environments (obstacles, friction, …)
Flexibility of evolutionary algorithm, neural network model, …
Transfer to reality.
Mechanical Design
Types of Components

- Core
- Joints
- Parametric joint
- Connection elements
- Sensors
3D printing
Electronics

Core processor: Arduino with Atmel processors

Sensors: gyroscopes, accelerometers, light, distance

Servo-motors

Li-Po battery
Educational Goal

Practice course material on:

- Evolutionary algorithms
- Neural networks
- Co-evolution of morphology and control
- Physics-based simulations
- 3D printing
- Experimental methods
Last year examples
Project

3-4 students/group

This should not be the case.

Final report should state the contribution of each team member
Schedule

29 March: Basics of Robogen
- Evolve the brain of cart robot
- Project & Group Formation

5 April: Evolving morphologies using Robogen
- Learn to evolve body + brain
- Project group should be finalized

12 April: Information on Robot fabrication

26 April: Project Hands-on (1 hour)
- Projects discussion with course assistants
- Continue working on projects out of class

10 May: Intermediate Presentation
Project Requirements

You will be evolving complete robots to perform a task of your choosing.

You will need to create a robotic task scenario and define the parameters of the evolutionary process:

- environment (obstacles, light sources, terrain, etc.)
- fitness function (important to design a good one!)
- evaluation procedure (length of evaluation, number of trials, presence of noise, etc.)
- Evolutionary Algorithm parameters
- neural network structure

You should make a systematic study of one or more of the above aspects in order to achieve good results.
Evaluation

Intermediate Presentation on May 10
At this time you should be able to demonstrate what you have accomplished so far including a demonstration of your best evolved robot(s) in simulation.

Final Report
Report should document your work, your methods, your results and analysis (Hint: performing repetitions of your experiments in order to conduct a statistical analysis is strongly encouraged!)

Final Presentation
A live demo of your evolved robot with 3D printed robot.

The results you obtain + creativity + task difficulty + demonstration of a rigorous scientific approach + clarity and completeness of your report and presentations will all influence your final grade.

Grade
Robogen Resources

Robogen Website

YouTube Channel

Robogen Online Edition