Modern Robots: Evolutionary Robotics

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What do you want robots for?
What skills will they need?
Robotics is Limited by AI
Why do you want to build robots?
What robots have you built?
Current Robots
Evolve Artificially Intelligent Robots
Evolve Artificially Intelligent Robots
Evolve Artificially Intelligent Robots

create evolutionary processes in computers that evolve complex forms
Motivation

• Understand by building
• Engineering applications
Other Robotics Approaches We Won’t Cover

• GOFAI: Good old fashioned AI
  • logic, symbols, rules (expert systems), theorem proving, deduction, etc.
  • still in use, though not cool at the moment

• Statistical Machine Learning
  • Bayesian statistics, deep learning, support vector machines
  • Current “favorite son”
  • Very impressive results
  • Some biological motivation

• Reinforcement Learning

Note: These distinctions are debatable, and not comprehensive
Evolutionary Algorithms (EAs)

1. Encode Problem
2. Generate Population
   - mutation and/or recombination
3. Select Parents
4. Score Population

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Mutation and/or recombination

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Why use Evolution for robotics?
Why Evolution?

- Biological motivation
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• Biological motivation
• We know it works! Most impressive engineer known
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• Robust
• Often outperforms engineers
• Often best-in-class algorithm
• Creative!
Class Mechanics

- Survey of Evolutionary Robotics
  - History through cutting edge
- Scientific Training
  - Learn by doing
  - Work towards a publication!
Acknowledgments

• Course based on one designed by Josh Bongard, University of Vermont

• Josh sent me his course materials. I have adapted them to various degrees.
Syllabus

• On course website:
  • http://jeffclune.com/courses/evolutionaryrobotics.html

• All of the following info (and more) is on the syllabus

• Read every word. A few times

• It is your responsibility to know the syllabus
  • after introductions, I will do a high-level summary.
  • but the details are in the syllabus!
Brief Intro to Me: Professional
Evolving Artificial Intelligence Lab

• Goal: robots that rival animals
  • Evolutionary computation
  • Evolutionary robotics
  • Deep learning
  • Neural networks
  • Computational evolutionary biology
  • etc.

• Join in and do fun, fascinating research
Introductions: Your Turn

• Some introductions, then course mechanics as time permits
  • pair up
  • learn
    - name
    - from
    - academic interests
    - non-academic passions
    - some fun fact
    - etc…
Course Mechanics

• First we’ll learn evolutionary computation
• Then we’ll apply it to simulated robotics
• All work done in simulation
  • possibility for real robot work via lab robots
Textbook

- BAI on syllabus
Readings

- Reading assignments posted on syllabus
- Read before class
- Some from book, some original papers from literature
Paper Reactions

- Graduate students: 10% of grade
- Undergraduates: 10% extra credit (optional)
- Due Friday (including this Friday!)
- 1/2 to 1 page (see syllabus)
- opinions, ideas, criticisms, or some other interesting reaction
- show you’ve thought about it deeply
- not a summary!
Piazza

• Online forum
• Wikipedia in spirit
• Counts towards participation
• Ask and answer good questions
  • see syllabus
• First test: let’s pick a test question
  • enter your name / answer
  • note: aside from this, no need for your name
You will build your own evolutionary robotics platform
Series of 10 homework programming assignments
Due every Monday
  • If no class, due following class
Homework Assignments

- Assignment 1: Create an Optimizer.
- Assignment 2: Create a Neural Network.
- Assignment 3: Evolve Neural Networks.
- Assignment 4: Place objects in the physics engine.
- Assignment 5: Add joints to the physics engine.
- Assignment 6: Add motors to the physics engine.
- Assignment 7: Add sensors to the physics engine.
- Assignment 8: Add the neural network to the physics engine.
- Assignment 9: Evolve the neural network in the physics engine.
- Assignment 10: Evolve behaviors in the physics engine.