Modern Robots:
Evolutionary Robotics

Jeff Clune
Assistant Professor
Evolving Artificial Intelligence Laboratory

University of Wyoming
Diversity

• Hugely important issue in EC
• Long history, many techniques
• Major breakthroughs recently
Novelty Search

- Lehman & Stanley 2011
- Search only for novel behaviors
- Need “novelty metric”
  - here: distance b/t ending points
  - rewards going where no org has gone before
- What controls would you use?
Novelty Search: Results

Final location of each org in 4 example runs:

(a) Medium Map Novelty
(b) Hard Map Novelty
(c) Medium Map Fitness
(d) Hard Map Fitness
Novelty Search: Biped

• Is NS suited well only to the maze?

• Try it on a harder problem: biped locomotion
  • probably has even more local optima
  • but also more dimensionality (true?)
  • initial gradients are bad
    - e.g. oscillation is good, but not rewarded if the robot still falls
    - classic problem is robots that fall far

• previous work
  - reward oscillation
  - enforce regularity (e.g. symmetry)
  - provide crutches, etc.
Novelty Search: Biped

• Objective: speed
• Behavioral measure: center of mass each second
• Novelty metric: squared distance in behavioral measure
Novelty Search: Biped Results

- NS best: 13.7 meters
- Fit best: 6.8 meters
- NS genome: 87 connections
- Fit genome: 272 connections*

*p < 0.001
Novelty Search: Biped
Novelty Search: Discussion

• Why is NS better than random?
• What does it learn?
• Roby’s Work
Novelty Search: Discussion

• Why are its genomes smaller?
Novelty Search: Discussion

• Shows that target-based objectives may be the problem
  • Why assume that the path to what you want is straight (think about the maze)

• With NS, you get infinite stepping stones to nowhere
  • But a more expansive search that eventually finds the goal is better than one that never finds it at all

• Is this what happens in nature?
  • for: new niches are created and exploited because of a lack of competition
  • against: but orgs still have to survive, reproduce, not dissolve, etc.