Applying Evolutionary Computation to Robotics

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Outline

The big picture

- Robots are faced with difficult problems
- Evolutionary computation is a process which can can solve difficul t problems in programming
- Since a robot interacts with the physical world, EC is slower by s everal magnitudes
- It is possible to use EC to evolve robots

Bluedrakon
http://tr.im/pWUi

Outline

Evolutionary Computation

- Evolutionary Computation (EC) is a problem solving technique which mimics natural selection

Evolutionary Computation: Requirements

- A population of candidates
- A fitness function

Evolutionary Computation: Process

- Candidates are evaluated
- The best performing candidates are selected
  - Two candidates cross-over with one another
  - Some candidates are subject to mutation
- This process repeats until the population is recreated

Genetic Algorithm

- Genetic Algorithms are a type of EC
- Candidates are represented as bit strings

Genetic Algorithm: Cross-over

- A Cross-over point is selected from two candidates. All bits are swapped beyond the point, creating two new candidates.

- Before:

$C_1 = [1, 0, 1, 0, |0, 0, 1, 0, 0, 1]$

$C_2 = [0, 0, 1, 1, |0, 1, 1, 0, 1, 0]$

- After:

$[1, 0, 1, 0, 0, 1, 1, 0, 1, 0]$

$[0, 0, 1, 1, 0, 0, 1, 0, 0, 1]$

Genetic Algorithm: Candidate Manipulation

- Mutation:

$$[1, 0, 1, 0, 0, 0, 1, 0, 1, 1]$$

$$[1, 0, 1, 0, 0, 0, 1, 0, 0, 1]$$

Example: “One Max”

$$p \begin{cases} [1,\ 0,\ 1,\ 1,\ 0,\ 1,\ 0,\ 1,\ \cdots\ 1] \\ [1,\ 0,\ 1,\ 0,\ 1,\ 1,\ 1,\ 0,\ \cdots\ 0] \\ \qquad\qquad\qquad \cdots \\ [0,\ 0,\ 1,\ 1,\ 0,\ 1,\ 0,\ 0,\ \cdots\ 0] \end{cases}$$

Artificial Neural Networks

Outline

Swimming Robot

Walking Robot

Coordinate Tracking Robot

Outline

Swimming Robot: Simulation

Walking Robot: Simulation

Coordinate Tracking Robot: Simulation

Coordinate Tracking Robot

Outline

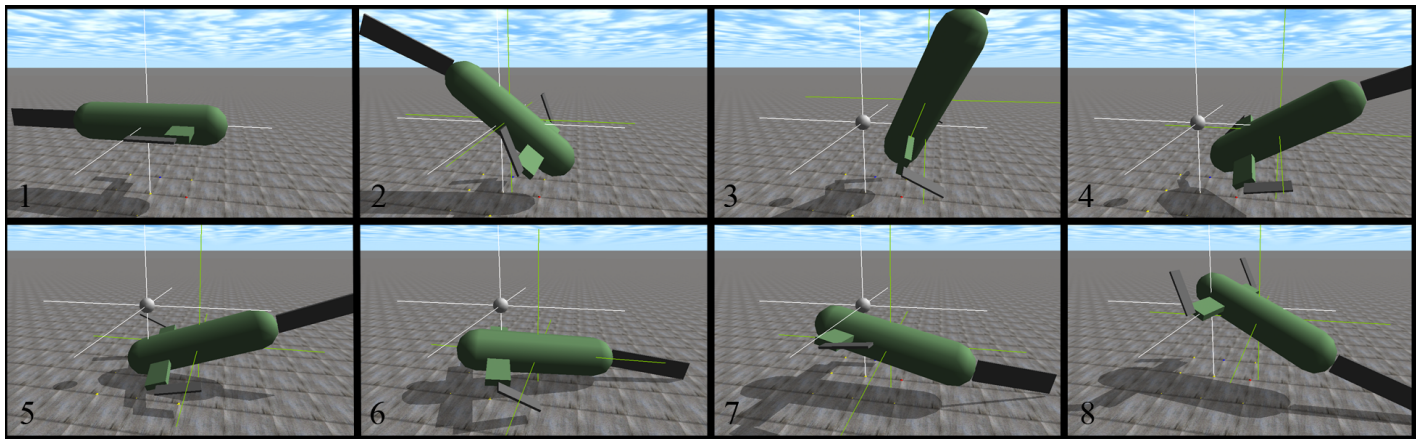
Swimming Robot: Evolutionary Process

Walking Robot: Simulation

Coordinate Tracking Robot: Simulation

Outline

Station Keeping Robot: Results



Moore et al.

- Each trial had a candidate which successfully maintained the position
- When the flow was coming from behind, the evolved candidate would flip end-over-head to orient itself (http://y2u.be/UufbnEGFwV4)

Results Robot: Results

Coordinate Tracking Robot: Results

Outline

Any Questions?

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