Applications of Evolutionary Algorithms

Michael J. Watts

http://mike.watts.net.nz

Lecture Outline

- Advantages of EA
- EA Application areas
- Scheduling
- Load balancing
- Engineering
- Path Planning

Advantages of EA

- Efficient investigation of large search spaces
  - quickly investigates a problem with a large number of possible solutions
- Problem independence
  - can be applied to many different problems
- Best suited to difficult combinatorial problems

Applying EA

- Two major requirements for applying an EA
  - fitness (objective) function
  - representation schema
- Fitness function must be deterministic
  - same individual should have same fitness each time

Applying EA

- Representation schema must be capable of
  - being decoded / transformed into a problem solution
  - having reproduction operations performed on it
- EA should not be used when an efficient method of solving the problem already exists

EA Application Areas

- Scheduling
  - optimising time allocation
- Load balancing
  - optimising load placed on different entities
- Engineering
  - optimise structural strength / weight
  - designing hardware
    - where to place components?
    - Rock crushers

EA Application Areas

- Path planning
  - select shortest / easiest path

Scheduling

- Take for example the scheduling of lectures in a university
- Problem is:
  - when a class is run
  - where it is run
  - who takes it

Scheduling

- Want to maximise
  - number of people in a room
  - number of rooms in use at once
- Want to minimise
  - number of streams
- Other constraints
  - need to provide sufficient space between labs for staff to clean-up

Scheduling

- Information available
  - number of timetable slots
  - number of students enrolled in course
- Given the large number of variables, an EA can be the most efficient way of finding a solution

Scheduling

- EA examines possible solutions
- Evaluates each solution according to
  - number of rooms in use at one time
  - how much space is wasted
  - number of streams
  - number of collisions
  - how well it satisfies other constraints

Load Balancing

- Consider the example of a factory
- Factory has
  - set number of different speed machines
  - set number of operators
- Goals are:
  - maximise number of machines in use
  - minimise time taken for each machine to complete each task

Load Balancing

- Information available
  - speed of each machine
- EA scores each candidate solution according to:
  - number of machines in use at each time
  - total time each machine is working
  - productivity of the factory as a whole
  - number of operators needed

Engineering

- Consider the example of designing the floor of a train carriage
- Want to
  - maximise strength
    - loads falling through floor onto rails is A Bad Thing
  - minimise weight
    - less weight of structure = more freight = more money

Engineering

- Use EA to evolve the layout of floor beams and plates
- Candidates scored by
  - total weight of floor
  - strength of floor

Designing Hardware

- The problem is placing components on a circuit board
- Want to minimise
  - size of circuit board
  - amount of waste space on circuit board
  - distance between components

Designing Hardware

- Encoding represents position of each component
- Each attempt scored according to
  - amount of board used
  - size of board
  - distance between components

Designing Hardware

- Rock crushers
- Ore must be crushed into pieces of uniform size
- Power used by crusher must be minimised
- Amount of ore flowing through the crusher must be maximised

Designing Hardware

- Problem is usually attempted intuitively
- Used an evolution strategy
- Optimised shapes and relative angles of parts
- Individuals simulated
- Fitness based on
  - size and uniformity of product
  - Capacity

Path Planning

- This is a minimisation problem
- Example: the Travelling Salesman Problem
  - also known as Hamiltonian Path
- Given n cities, what is the shortest route to each city, visiting each city exactly once
- Want to minimise total distance travelled
- Also must obey the "Visit Once" constraint

Path Planning

- Encoding represents the order of cities to visit
- Candidates scored by total distance travelled

Lecture Summary

- EA can solve many complex problems
- Have been successfully applied to
  - Scheduling
    - maximises use of resources / minimises costs
  - Load balancing
    - maximises use of resources

Lecture Summary

- Applied to (cont.)
  - Engineering
    - minimise material use / maximise strength
    - maximise capacity / minimise variance
  - Path planning
    - minimise distance / difficulty