CoEvolution

- Definition
  - Interactive evolution
  - External influences
  - Can be more than one population
  - One population influences the other
  - Can deal with subjective fitness functions
- Motivation
  - In nature fitness of an organism depends on environmental niche
  - A species and the area seen on the solution space depends on interaction with other species
  - Types of interaction
    - Mutualism/symbiosis (positive species enhancement)
    - Predation/parasitism (negative effects of species)

Examples:

Ability of a rabbit to run at 30kph depends on the top speed of a fox that preys on it

Ability of a plant to pollinate depends bees to pick up and spread the pollen

<u>Exercise:</u> find out about the Iterated prisoner's dilemma used to evolve game-playing strategies

Cooperative CoEvolution

- Model
  - Set of different species
  - Each represent part of the problem
  - Must cooperate to solve a larger problem
- Computational Examples
  - Job shop scheduling
  - High-dimensional function optimisation
- Advantage
  - Allows function decomposition
  - But requires user to provide a partitioning of problem
- Real world example
  - Endosymbiosis where two species physically linked
  - e.g. gut bacteria that has to live inside hosts body.
- Computing
  - A parts of a problem cannot be separated.
  - Use linkage flags to show which solutions for different populations should stay together
- Genetic programming
  - Use the idea of automatically defined functions
  - GP can call functions which are themselves being evolved.

Competitive CoEvolution

- Model
  - Populations compete against each other
  - Grab fitness or parts of fitness landscape at the expense of each other
- Iterated prisoner's dilemma
  - Simplest scheme 2 players
  - Each decides whether to cooperate or defect
  - Reward is decided by a payoff matrix
  - Evolve a strategy where player can only see the last three strategies of opponent
  - Best strategy Tit-for-Tat
- Hillis Sorting networks
  - Used two species (population)
  - Task to evolve the best sorting networks
  - Fitness determined by how many examples were sorted correctly
  - Found better networks than previously known
- Pairing
  - As population's evolve can pair up to cooperate
  - If competition occurs in single pop use fitness and ranking to choose members
  - Between populations requires competitive fitness evaluation

CoEvolution in constraint problems

- Here have a number of constraints
  - Each constraint must be satisfied to get high fitness
- Two populations
  - Can measure fitness of one by ability to solve problem
  - Can measure second by its ability to frustrate the first population
- Choice of populations
  - Pop 1: individuals try to satisfy the problem
  - Pop 2: are constraints
- Frustration
  - A candidate s in pop1 frustrates a candidate c in pop2 if it satisfies the constraint represented by c
  - A candidate c if pop 2 frustrates a candidate s in pop 1 if constraint c makes s fail
- Mutual frustration
  - Taking repeated cycles evolve pop1 which has a high fitness in frustrating pop2 (i.e satifies constraints)
  - Pop2 remains static – cannot evolve constraints (usually know at design-time)

Interactive Evolution

- Method
  - User becomes part of evolutionary system
  - Usually in determining the fitness of individuals
- Example: agricultural breeding
  - Selective breeding by man
  - Creates better cattle, faster horses, different types of dogs
- User's influence
  - Subjective (user chooses best)
  - Aesthetic (used in context of evolutionary art)
- Application
  - Situations where no clear fitness function exists
  - To improve search ability, when method gets stuck in area of search space
  - To increase exploration and diversity of population
- Disadvantages
  - Slow compared with automated execution
  - Inconsistency: humans change their mind as to what is 'best'
  - Limited coverage: humans only concentrate for a limited time or for small populations