CSCI 446: Artificial Intelligence

Genetic Algorithms

Genetic Algorithms

- Basic concept is Darwin's theory of evolution
  - Evolution is the process of a species adapting to and surviving in a given environment
  - The more able to survive (the fittest) are also the more likely to reproduce, thus improving the gene pool over time

Genetic Algorithms

- Rattlesnake example
  - Some rattlesnakes don't have rattles
  - In AZ? NM? This percentage has been increasing.
  - The theory is that if people hear the rattle, the snake is more likely to get killed, so snakes without rattles are more likely to mate and reproduce and their offspring are more likely not to have rattles

Genetic Algorithms

- Two main issues of simulating evolutionary behavior
  - Encoding – how do we represent a problem as a chromosome containing a string of genes
  - Evaluation – how do we tell which individuals (chromosomes) are more fit than others, and therefore allowed to reproduce

The Development Process

- Step 1:
  - Represent the domain as a chromosome
  - Choose population size N
  - Choose crossover probability Pc
  - Choose mutation probability Pm

The Development Process

- Step 2:
  - Define fitness function to evaluate the “goodness” of a particular solution
- Step 3:
  - Randomly generate initial population of N chromosomes
- Step 4:
  - Calculate the fitness of each chromosome

The Development Process

- Step 5:
  - Select a pair of chromosomes for mating
    - Base selection on both their fitness and a probability function
- Step 6:
  - Create offspring by applying crossover and mutation operators
- Step 7:
  - Put new offspring in the population
- Step 8:
  - Repeat. Go back to step 5 until new population is of size N

The Development Process

- Step 9:
  - Replace parent population with child population
- Step 10:
  - Go to step 4 and repeat process until termination criterion is reached

Comparison to Traditional Optimization and Search

- GAs work with an encoding of the parameter set, not the parameters themselves
- GAs search from a population of points, not a single point
- GAs use a payoff / objective function, not derivatives of other auxiliary knowledge
- GAs use probabilistic transition rules, not deterministic rules

Genetic Operators

- Selection / Reproduction
  - Cloning a chromosome to put in the mating pool
  - Recall that one of the main issues in evolutionary computing is how to represent the problem parameters as a chromosome / the eventual solution
  - The second main issue is how to evaluate the goodness, or fitness, of that chromosome / solution
  - When you have these two things, you can then see how operators work
  - In reproduction, each chromosome is evaluated according to a fitness function
  - The value of its fitness influences its probability of being chosen for reproduction, that is, carrying its genes to the next generation

Genetic Operators

- Example

Number	String	Fitness	% of Total
1	01101	169	14.4
2	11000	576	49.2
3	01000	64	5.5
4	10011	361	30.9
Total		1170	100.0

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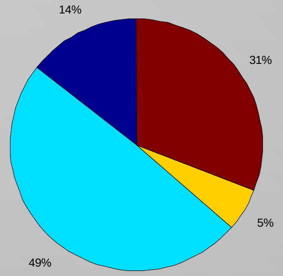
  - 2^{nd} one has a greater chance of being chosen for reproduction
  - Can visualize this as a roulette wheel selection



Genetic Operators

- Crossover
  - Proceeds in two steps
    - Members of the mating pool are mated at random
    - Each pair of strings / chromosomes is crossed
      - Choose an integer position k
        - Uniform choice between 1 and ℓ-1 where ℓ is the length of the chromosome
      - Create two more strings by swapping all genes / characters from k+1 to ℓ inclusively
      - e.g. choose k=4 (position 4)

A1 = 01101 → A1' = 011000

A2 = 11000 → A2' = 11001

Genetic Operators

- Mutation
  - Actually plays a minor role
  - Needed because sometimes good genetic material is lost, but most of the time, mutation has a degrading effect on the fitness
  - Mutation is the occasional (small probability) random alteration of the value of a string position
  - Frequency of mutation usually on the order of 1 per 1000 bit transfers
    - Actually even smaller probability in natural populations

Genetic Algorithms

- Where is this used?
  - Nathan Fortier’s Open Song Composer