Genetic Algorithms

Idea: learning based on simulated evolution

- Maintain population of competing hypotheses
- Evolve successor generations by recombining most fit, replacing least fit
- Terminate when sufficiently fit hypothesis obtained

Motivation:

- Biological evolution is robust, successful method
- Appropriate for complex hypotheses with many interacting parts
- Easily parallelized

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Typical Genenetic Algorithm

GA(Fitness, Acceptable-Fitness, p, r, m)

p: the number of hypotheses to be included in the population.

r: the fraction of the population to be replaced at each step.

m: the mutation rate.

Initialize population: P $\leftarrow$ Generate *p* hypotheses
Evaluate: for each h in P, compute Fitness(h)

While [MAX_hFitness(h) < Acceptable-Fitness] do

1. *Select:* $P_s \leftarrow$ the $(1-r)p$ members of P according to their fitness
2. *Crossover:* Randomly select $r \times p$ pairs of hypotheses from P_s, favoring those with highest fitness. For each pair, h_1, h_2, produce offspring by applying recombination operators. Add each offspring to P_s.
3. *Mutate:* For m percent of the members of P_s, flip one randomly selected bit in its representation.
4. *Update:* P $\leftarrow$ P_s
5. *Evaluate:* for each h in P, compute Fitness(h)

Return the hypothesis h from P that has the highest fitness.

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Fitness Determines Probability of Survival

Probability of selecting hypothesis h from current population:

$$\frac{Fitness(h_i)}{\sum_{j=1}^{p} Fitness(h_j)}$$

- Increases with fitness of h_i
- Decreases with fitness of its competitors

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Encoding Hypotheses as Bitstrings

Encoding a condition as a string:

Attribute a1 has possible values v1,...,v8

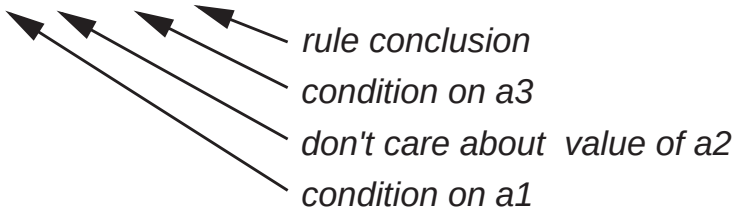
0 011 encodes "a1=v3"

1 10# encodes "a1 does NOT equal v4 or v5"

Encoding a rule as a string:

Assume rule can use 8-valued attritubte a1, and boolean attributes a2, a3
Assume rule concludes one of four conclusions, c1,...,c4

1011 ## 01 11 encodes "IF a1 does not equal v3, AND a3=v1, THEN c3"



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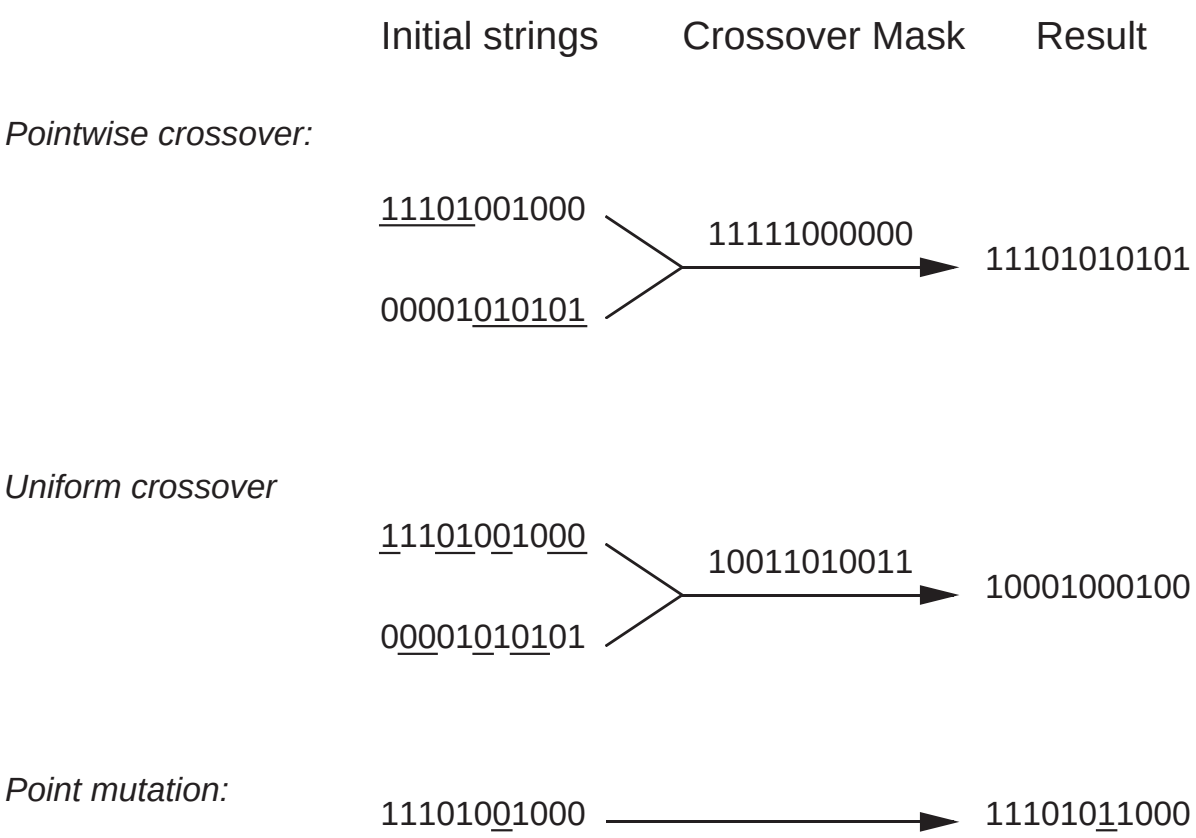
Common Recombination Operators



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An Example: COGIN

Task: Learn disjunctive set of rules

Approach:

- Population of bitsting/rules.
- Total population = disjunctive hypothesis
- Generation of successors is random
- Replacement within population is by competition, and considers total coverage of population

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COGIN Fitness Function

$$Fitness(R) = Info(R) + Lex(R)$$

$$Info(R) = Ent(S) - \frac{|Matched| Ent(Matched) + |Unmatched| Ent(Unmatched)}{|S|}$$

$$Lex(R) = \lceil \frac{N}{i} \rceil - \lceil \frac{Misclass(R)}{i} \rceil$$

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Generation of Successors

- Generate candidates: Old rules plus recombinations of all pairs.
- Recombination rule is randomly selected pointwise crossover
- Evaluate fitness of each rule
- Loop: Take the best, and subtract examples it classifies correctly

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More on GOGIN

See the following paper for the additional slides on COGIN

Green and Smith, "Competition Based Induction of Decision Models from Examples", *Machine Learning*, 13, Kluwer Academic Press, pp. 229- 257, November 1993.

Various Slides on Genetic Programming

sorry, I don’t have these online yet.

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