Automated Algorithm Design VIP

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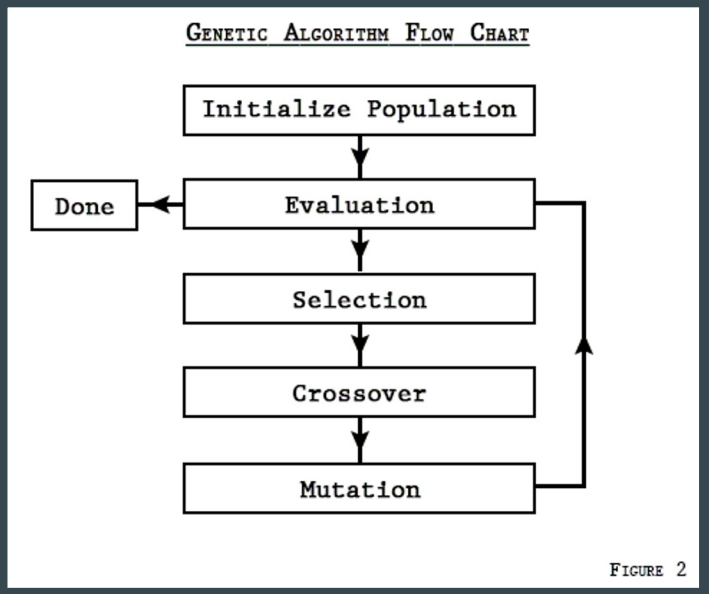
Part 1 - Genetic Algorithm

Vertically Integrated Projects
Program

Georgia Tech Research Institute

Concept

With genetic algorithms, each new generation is created through mating/mutation of individuals in the previous population (then their fitness is evaluated). Through numerous operations of this process, it will eventually produce the best individual - one whose fitness is better than everyone else's in the population and cannot get any better.



Genetic Algorithm - Keywords

- Individual
- Population
- Objective
- Fitness
- Evaluate
- Selection
- Mate / Crossover
- Mutate
- Algorithms (various evolutionary algorithms)

Genetic Algorithm - Keywords (cont.)

Individual: one specific candidate in the population (with properties such as DNA)

Population: group of individuals whose properties will be altered

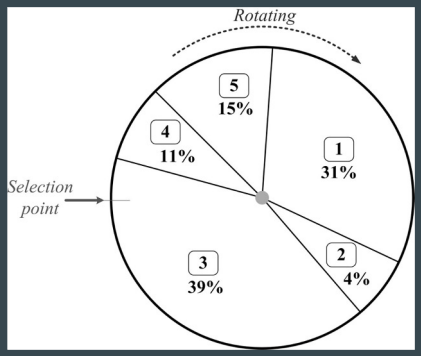
Objective: a value used to characterize individuals that you are trying to maximize or minimize (usually the goal is to increase objective through the evolutionary algorithm)

Fitness: relative comparison to other individuals; how well does the individual accomplish a task relative to the rest of the population?

Evaluation: a function that computes the objective of an individual

Genetic Algorithm - Keywords (cont.)

Selection: represents ‘survival of the fittest’; gives preference to better individuals, therefore allowing them to pass on their genes

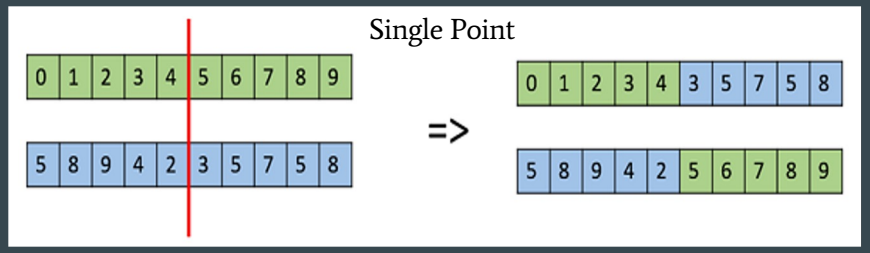


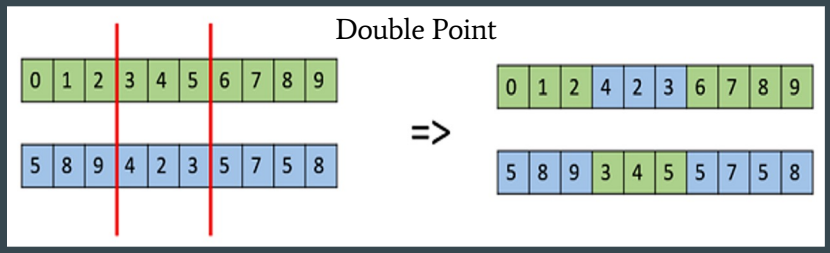
- Fitness Proportionate: the greater the fitness value, the higher the probability of being selected for mating

- Tournament: several tournaments among individuals (number of individuals in each tournament is dependent on tournament size); winners are selected for mating

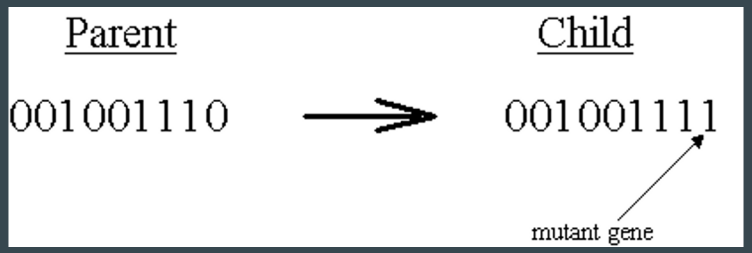
Genetic Algorithm - Keywords (cont.)

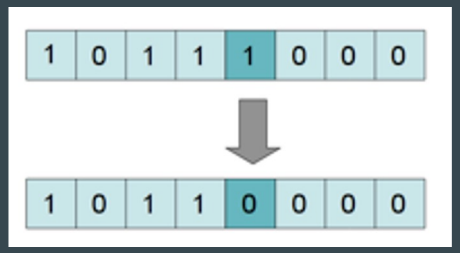
Mate/Crossover: represents mating between individuals



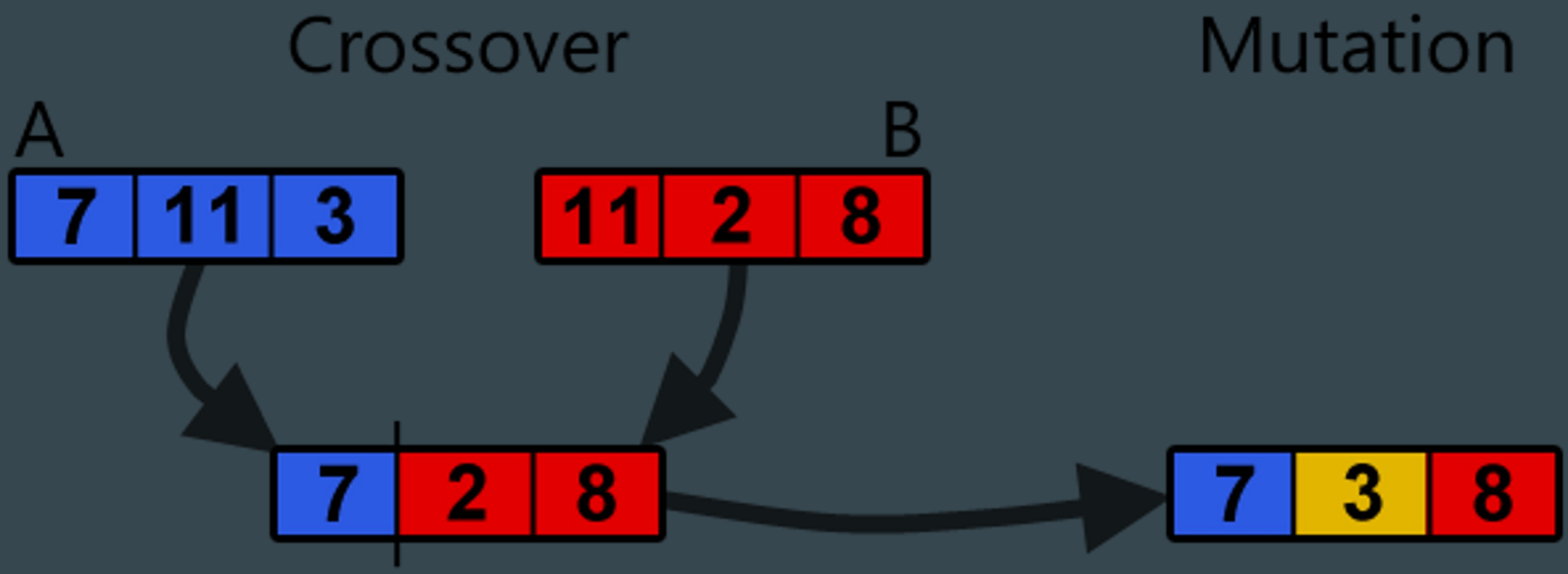


Mutate: introduces random modifications; purpose is to maintain diversity





Genetic Algorithm - Keywords (cont.)



Genetic Algorithm - Keywords (cont.)

Algorithms: various evolutionary algorithms to create a solution or best individual

1. Randomly initialize population
2. Determine fitness of population
3. Repeat...
    1. select parents from population
    2. perform crossover on parents creating population
    3. perform mutation of population
    4. determine fitness of population

... until best individual is good enough.

*https://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol1/hmw/article1.html

One Max Problem - Example

- This problem begins with individuals that each has a list of one hundred values that are either 0 or 1.

  [0, 0, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 0, 0, 1, 1] (68.0) = 68 one's = objective value

- The goal is to eventually produce an individual whose list contains ALL one's.

  [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1] (100.0) = 100 one's = objective value

One Max Problem - Example Output

--- *Generation 3* ---

Evaluated 167 individuals
Min. 47.0
Max. 71.0
Avg. 62.96
Std. 2.907

Best individual is [1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1,
0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1,
1, 0, 1, 1, 1, 1, 1, 1] (71.0)

--- *Generation 7* ---

Evaluated 171 individuals
Min. 62.0
Max. 76.0
Avg. 70.89
Std. 2.446

Best individual is [1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1,
0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1,
1, 0, 1, 1, 1, 1, 1, 1] (76.0)

--- *Generation 11* ---

Evaluated 171 individuals
Min. 69.0
Max. 84.0
Avg. 77.18
Std. 2.558

Best individual is [1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1,
0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1,
0, 1, 1, 1, 1, 1, 1] (84.0)

--- *Generation 15* ---

Evaluated 163 individuals
Min. 74.0
Max. 88.0
Avg. 82.68
Std. 2.225

Best individual is [1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0,
1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1,
1, 1, 1, 1, 1, 0] (88.0)

--- *Generation 22* ---

Evaluated 187 individuals
Min. 80.0
Max. 92.0
Avg. 88.37
Std. 2.201

Best individual is [1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0,
1, 1, 1, 1, 1, 1] (92.0)

--- *Generation 39* ---

Evaluated 180 individuals
Min. 90.0
Max. 100.0
Avg. 98.83
Std. 2.110

Best individual is [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1] (100.0)

Next Steps - Genetic Programming