4.Genetic Algorithms

Thursday, February 18, 2021 1:51 PM

- **Individual -** Any possible solution
- **Population -** Group of all individuals
- **Fitness** – Target function that we are optimizing (each individual has a fitness)
- **Trait -** Possible aspect (features) of an individual
- **Genome** - Collection of all chromosomes (traits) for an individual.

Fitness wheel (roulette wheel)
Crossover
Mutations
Iterate till you reach goal criteria

GA Operators

1. Methods of Representation
2. Methods of Selection (roulette wheel)
3. Methods of Reproduction (single point, two (multi) point, uniform crossover, mutations)

Traveling salesman problem

- Salesman has to visit each city once while minimizing distance

Encode information
Crossover
Mutate
Randomly generate populations (through iterations) and find an optimal solution
Younger generations are only picked up if they have better performance

1. How many genes in a chromosome of each individual if we have 10 cities:
2. How many genes in the alphabet of the algorithm: (how many chromosomes)

- Each city connected to another
- 10*9/2 = 45

Suppose a genetic algorithm uses chromosomes of the form $x = abcdefgh$ with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as:

$$f(x) = (a+b) - (c+d) + (e+f) - (g+h) ,$$

Chromosome has 8 genes
Each digit can be between 0 and 9
Fitness function given

1. Evaluate fitness of each individual

$$
\begin{aligned}
x_1 &= 65413532 \\
x_2 &= 87126601 \\
x_3 &= 23921285 \\
x_4 &= 41852094
\end{aligned}
$$

Individual	Fitness
X1	9
X2	23
X3	-16
X4	-19

X2>X1>X3>X4

Perform crossover operations:

i) Cross the fittest two individuals using one–point crossover at the middle point.

8712**6601**		87123532
6541**3532**		65416601

ii) Cross the second and third fittest individuals using a two–point crossover (points b and f).

X1	65	**4135**	32	O3	65	**9212**	32
X2	23	**9212**	85	O4	23	**4135**	85

iii) Cross the first and third fittest individuals (ranked 1st and 3rd) using a uniform crossover.

Random exchange between two parents
Eg swap genes at a,d,f

$$
\begin{aligned}
x_2 &= \underline{8}\,7\,1\,\underline{2}\,6\,\underline{6}\,0\,1 \\
x_3 &= \underline{2}\,3\,9\,\underline{2}\,1\,\underline{2}\,8\,5
\end{aligned}
\Rightarrow
\begin{aligned}
O_5 &= 2\,7\,1\,2\,6\,2\,0\,1 \\
O_6 &= 8\,3\,9\,2\,1\,6\,8\,5
\end{aligned}
$$

c) Suppose the new population consists of the six offspring individuals received by the crossover operations in the above question. Evaluate the fitness of the new population, showing all your workings. Has the overall fitness improved?

$$
\begin{aligned}
f(O_1) &= (8+7)-(1+2)+(3+5)-(3+2)=15\\
f(O_2) &= (6+5)-(4+1)+(6+6)-(0+1)=17\\
f(O_3) &= (6+5)-(9+2)+(1+2)-(3+2)=-2\\
f(O_4) &= (2+3)-(4+1)+(3+5)-(8+5)=-5\\
f(O_5) &= (2+7)-(1+2)+(6+2)-(0+1)=13\\
f(O_6) &= (8+3)-(9+2)+(1+6)-(8+5)=-6
\end{aligned}
$$

Average fitness is improved

d) By looking at the fitness function and considering that genes can only be digits between 0 and 9 find the chromosome representing the optimal solution (i.e. with the maximum fitness). Find the value of the maximum fitness.

(Xoptimal) = 99009900
f(Xoptimal) = 36

e) By looking at the initial population of the algorithm can you say whether it will be able to reach the optimal solution without the mutation operator?

Not possible