# Machine Intelligence

## Full Example of Genetic Algorithm

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# MACHINE INTELLIGENCE

## Full Example of Genetic algorithm

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# A Solved Example of GA

Consider the following optimization problem:

$$Min.\, f(x) = x \sin 10\pi x + 1.0$$
$$s.t.$$
$$-1 \leq x \leq 2$$

Let crossover rate be 0.5 and mutation rate be 0.1. Consider one generation with a population of 10 chromosomes.

# A Solved Example of GA

**Step 1: Initialization and Evaluation of the population**

Let the initial population be :

**-0.4691, 0.1572, -0.5914, 0.6454, 0.7796, 1.0580, 0.0991, 0.2772, 0.5605, 1.6327**

Compute the cost ( value of f(x)) corresponding to each initial value of x( initial chromosome in the population)

| x | y=f(x) |
|---|---|
| -0.4691 | 1.3872 |
| 0.1572 | 0.8468 |
| -0.5914 | 0.8422 |
| 0.6454 | 1.6387 |
| 0.7796 | 0.5339 |
| 1.0580 | 2.0248 |
| 0.0991 | 1.0028 |
| 0.2772 | 1.1820 |
| 0.5605 | 0.4697 |
| 1.6327 | 2.3962 |

# A Solved Example of GA

Sort the values of f(x) in ascending order.
Min f(x)=0.4697 for x=0.5605

| x | y=f(x) | Normalized |
|---|---|---|
| 0.5605 | 0.4697 | 0.1000 |
| 0.7796 | 0.5339 | 0.1269 |
| -0.5914 | 0.8422 | 0.2584 |
| 0.1572 | 0.8468 | 0.2566 |
| 0.0991 | 1.0028 | 0.3213 |
| 0.2772 | 1.1820 | 0.3958 |
| -0.4691 | 1.3872 | 0.4808 |
| 0.6454 | 1.6387 | 0.5855 |
| 1.0580 | 2.0248 | 0.7458 |
| 1.6327 | 2.3962 | 0.9000 |

## Step 2: Selection ( Roulette Wheel)

Normalizing the values of f(x) between 0.1 and 0.9.
Lets normalize using

$$f(x) = \frac{(max.range - \min.\ range)(f(x) - min.f(x))}{max.f(x) - \min f(x)} + \min.range$$

Here min. range=0.1, max. range=0.9
$f(x_1)$=0.4697( this is also min cost)
$f(x_2)$=2.3962( max cost)

# GA Example contd....

For selection,

Probability of $i^{th}$ chromosome to be selected in the pool of population of size n for crossover operation is

$$Prob. = \sum_{i=1}^{n} \frac{normalized\ cost\ of\ individual\ chromosome}{sum\ of\ all\ the\ normalized\ costs}$$

Finally we'll *flip these probabilities* so that best chromosome gets the highest probability.

The best chromosome is the one with the minimum cost and should have highest probability of selection.

| x | Normalized f(x) | Prob. | Flipped Prob. |
|---|---|---|---|
| 0.5605 | 0.1000 | 0.02339 | 0.2159 |
| 0.7796 | 0.1269 | 0.03045 | 0.1789 |
| -0.5914 | 0.2584 | 0.06114 | 0.1405 |
| 0.1572 | 0.2566 | 0.06157 | 0.1154 |
| 0.0991 | 0.3213 | 0.0771 | 0.0950 |
| 0.2772 | 0.3958 | 0.0950 | 0.0771 |
| -0.4691 | 0.4808 | 0.1154 | 0.06157 |
| 0.6454 | 0.5855 | 0.1405 | 0.06114 |
| 1.0580 | 0.7458 | 0.1789 | .03045 |
| 1.6327 | 0.9000 | 0.2159 | 0.02339 |

# GA Example contd.....

| Chromo. | Cost in ascending order | Normalized | Prob. | flipped Prob. | Cumulative Prob. | Random Values generated for selection. |
|---|---|---|---|---|---|---|
| 0.5605 | 0.4697 | 0.1000 | 0.2159 | 0.2159 | 0.2160 | 0.6777 |
| 0.7796 | 0.5344 | 0.1269 | 0.03045 | 0.1789 | 0.3949 | 0.2345 |
| 0.5914 | 0.8424 | 0.2584 | 0.06114 | 0.1405 | 0.5354 | 0.6190 |
| 0.1572 | 0.8468 | 0.2566 | 0.06157 | 0.1154 | 0.6508 | 0.1389 |
| 0.0991 | 1.0027 | 0.3213 | 0.0771 | 0.0950 | 0.7458 | 0.8430 |
| 0.2772 | 1.1820 | 0.3958 | 0.0950 | 0.0771 | 0.8229 | 0.0579 |
| 0.4691 | 1.3868 | 0.4808 | 0.1154 | 0.06157 | 0.8844 | 0.9805 |
| 0.6454 | 1.6389 | 0.5855 | 0.1405 | 0.06114 | 0.9456 | 0.7784 |
| 1.0580 | 2.0249 | 0.7458 | 0.1789 | 0.03045 | 0.9760 | 0.4111 |
| 1.6327 | 2.3962 | 0.9000 | 0.2159 | 0.2339 | 1.000 | 0.2513 |

For Roulette Wheel Selection Process,
Consider a random no. say 0.6777 and this random no. fits between 0.6508 and 0.7458
Therefore, 5$^{th}$chromosome ie 0.0991 is selected.

# GA Example contd....

So, consider another random number=0.2345

It fits between 0.2160 and 0.3949

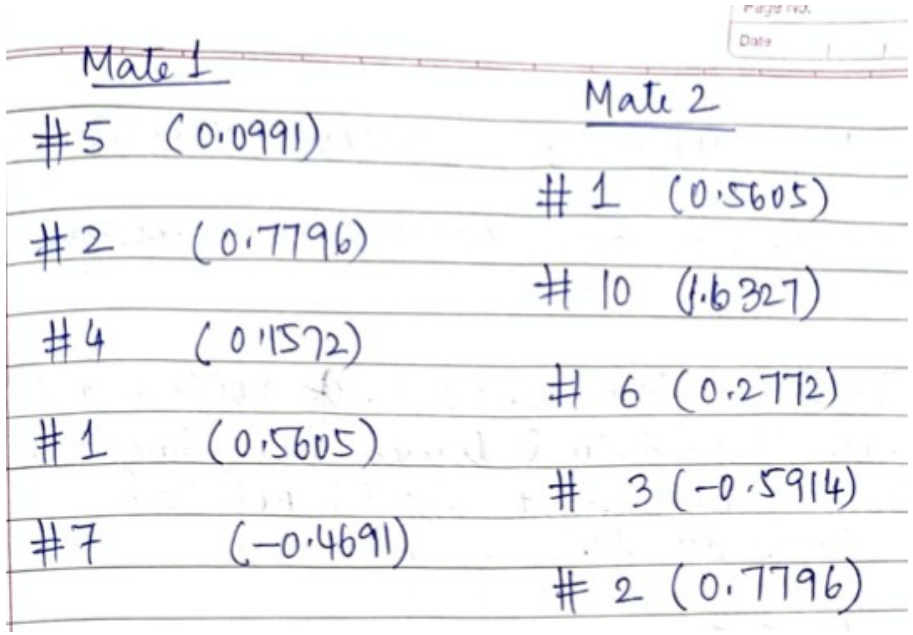
Therefore, Chromosome corresponding to 0.3949 ie 2nd chromosome( 0.7796) is selected.

For this problem the random nos. considered are 0.6190 (4th Chrom),

0.1389(1st Chro), 0.8430(7th Chrom), 0.0579(1st Chro), 0.9805(10th Chrom), 0.7784(6th), 0.4111(3rd), 0.2513 (2nd) are selected.

Like this, 10 chromosomes that are best fit are selected.

Lets divide the pool of 10 chromosomes into 2 subsets of 5 chromo each.



# GA Example contd....

## Step 3: Crossover

As crossover rate =0.5
Therefore, # of crossovers=5
And # of mutations =1

Crossover operator used is Directional crossover given as follows:

$C_1$=P1+R(P2-P1)

$C_2$=P2+R(P1-P2)

Where R is a random number

( The random nos. considered for crossover step are 0.3451,0.4539,0.8674,0.1004,0.7801)

# GA Example contd....

| Selection of Chromosome for mating | | Random number for Directional X | Crossover Operator |
|---|---|---|---|
| 5th ( 0.0991) | 1st (0.5605) | 0.3451 | $C_5$: 0.0991+0.3451(0.5605-0.0991)=0.2583<br>$C_1$: 0.5605+0.3451(0.0991-0.5605)=0.4013 |
| 2nd (0.7796) | 10th ( 1.6327) | 0.1004 | $C_2$: 0.7796+0.4539(1.6327-0.7796)=1.1668<br>$C_{10}$: 1.6327+0.4539(0.7796-1.6327)=1.2454 |
| 4th (0.1572) | 6th ( 0.2772) | 0.4539 | $C_4$: 0.1572+0.8674(0.2772-0.1572)=0.2613<br>$C_6$: 0.2772+0.8674(0.1572-0.2772)=0.1731 |
| 1st (0.5605) (0.4013) | 3rd ( -0.5914) | 0.7801 | $C_1$: 0.4013+0.1004(-0.5914-0.4013)=0.3016<br>$C_3$: -0.5914+0.1004(0.4013+0.5914)= -0.4917 |
| 7th (-0.4691) | 2nd (0.7796) (1.1668) | 0.8674 | $C_7$: 0.8071<br>$C_2$: -0.1094 |

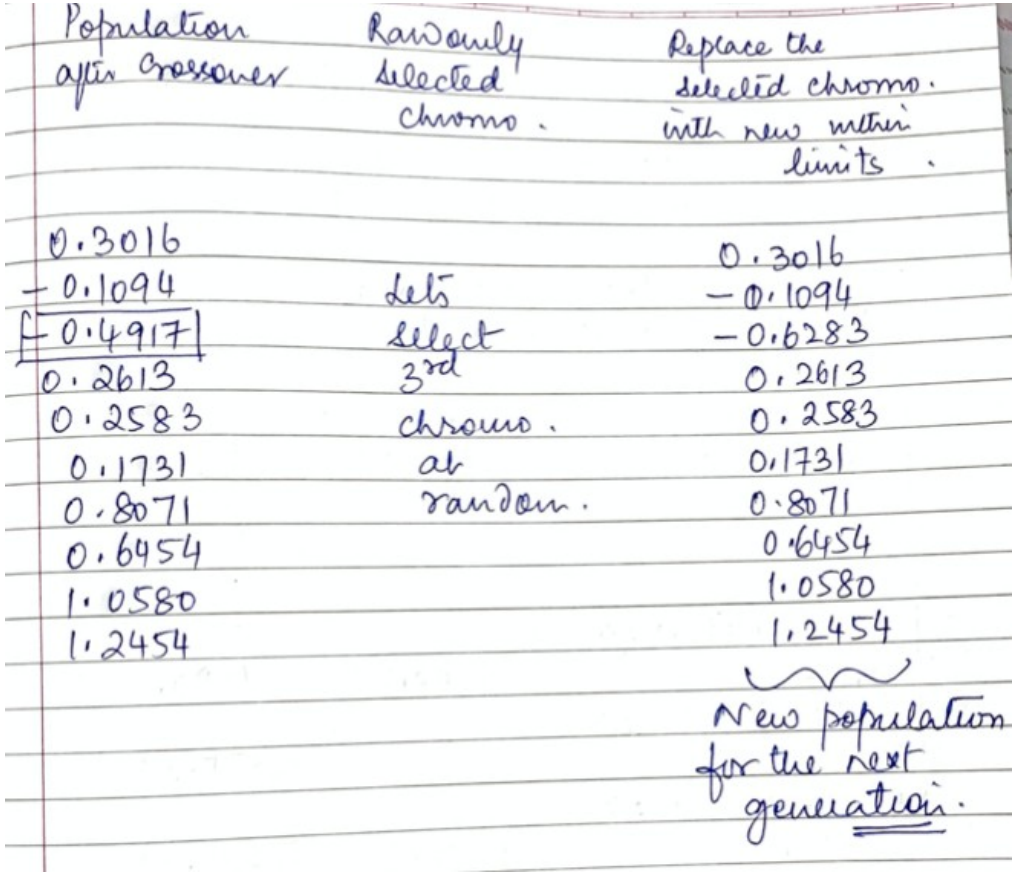
The new chromosomes so obtained will be looked into for whether they lie within the boundary limits of -1 and 2 , if not then parent chromosome will not be replaced by the new offspring.

# GA Example contd....

## Mutation

Lets select 3rd chromosome( offspring) randomly.

Replace it by a new random no. between -1 and 2.




## Step 5: Termination

Depending on how many generations or any other criteria for stopping the algorithm.


# THANK YOU

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