Optimization using Binary coded Genetic Algorithm

By

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- Optimization Problem

Minimize the given Objective Function, $f(x_1, x_2) = x_1 + x_2 - 2 * {x_1}^2 - {x_2}^2 + x_1 x_2$

In the range of $0.0 \leq x_1, x_2 \leq 0.5$

- Results

The given problem has two minima points in the given range. One point is $(0,0)$ and second point is $(0.5,0)$.

Predefined values:

Number of variable = 2

Maximum value of variables = 0.5

Minimum value of variables = 0.0

Population size = 6

Crossover probability = 0.9

Mutation probability = 0.1

Fitness Value is calculated by: $FV = \frac{1}{1+OFV}$, where OFV = Objective Function Value

Here, two results are shown below:

1. Result-1:

Initial population:

0	1	1	1	1	1	0	1	0	0	1	1
1	0	1	0	0	1	1	1	1	0	1	0
0	0	0	1	0	1	0	0	0	0	1	0
1	0	0	1	1	1	1	0	0	0	0	1
1	1	1	0	0	0	0	1	1	0	0	1
0	0	0	1	1	1	0	0	1	1	1	0

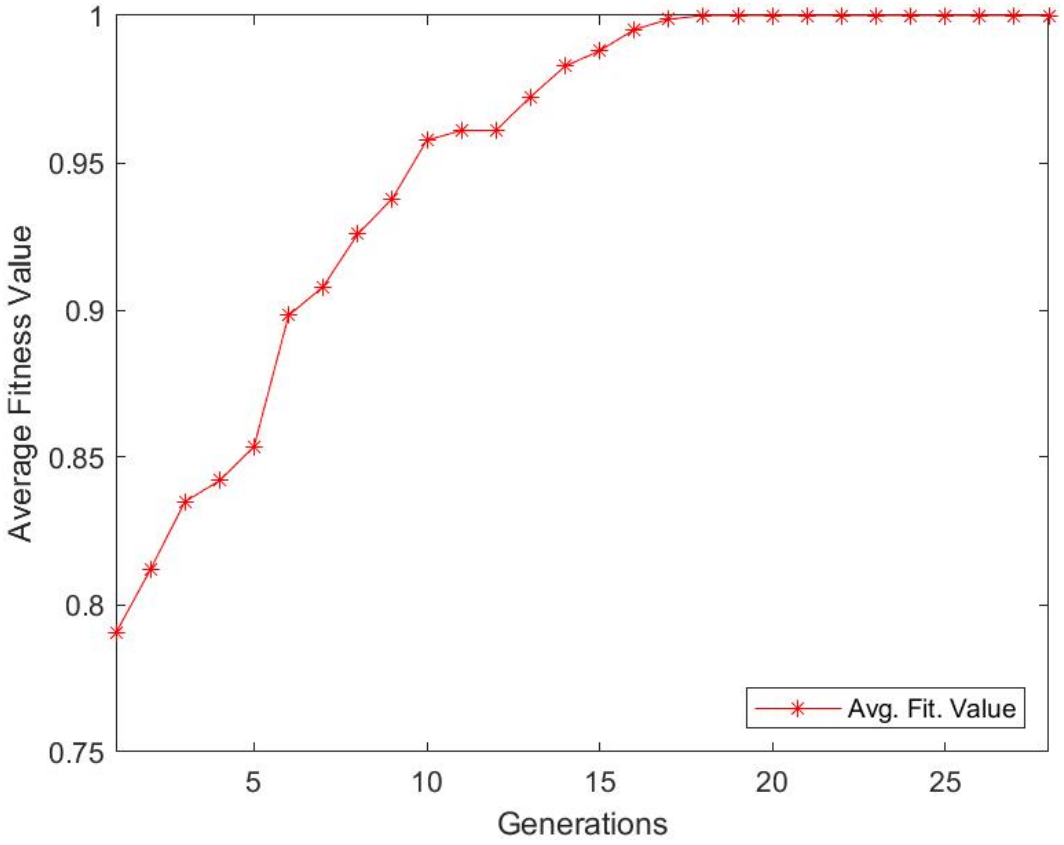
Initial X-values and fitness values:

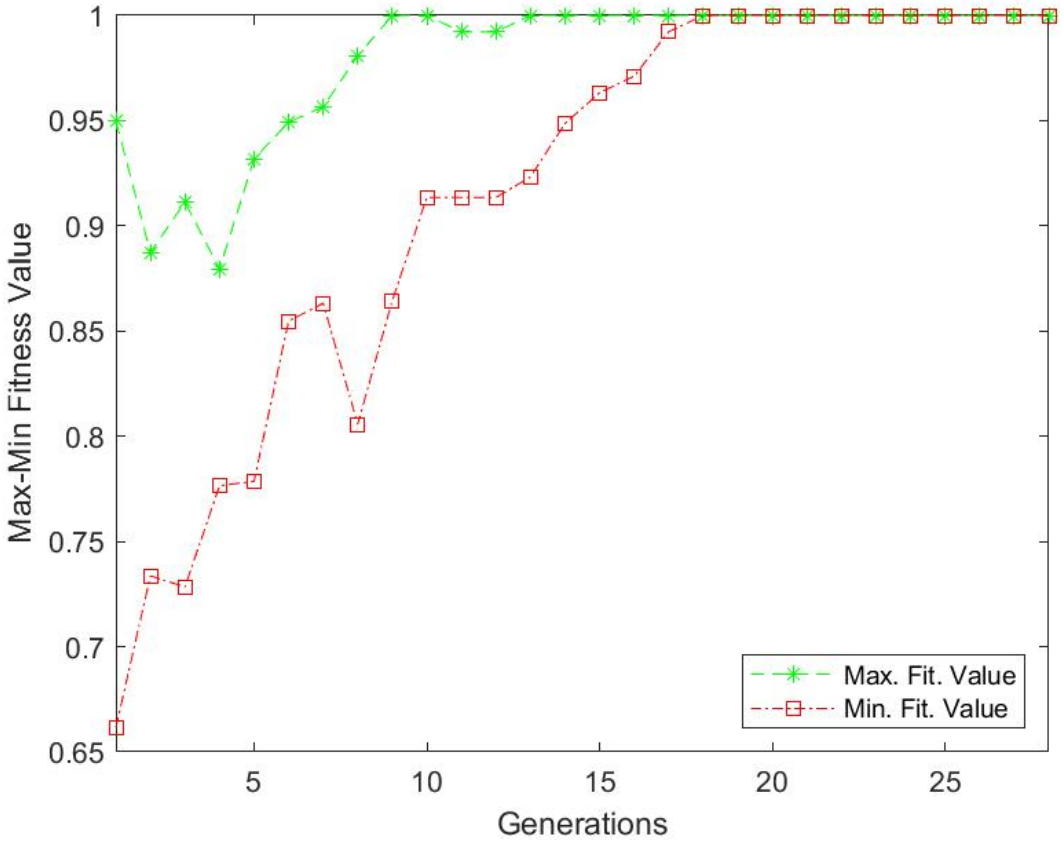
x_1	x_2	Fitness Value	Objective Function Value
0.2460	0.1508	0.7751	0.2901
0.3254	0.4603	0.6614	0.5118
0.0397	0.0159	0.9499	0.0528
0.3095	0.2619	0.7182	0.3923
0.4444	0.1984	0.771	0.2966
0.0556	0.1111	0.8663	0.1543

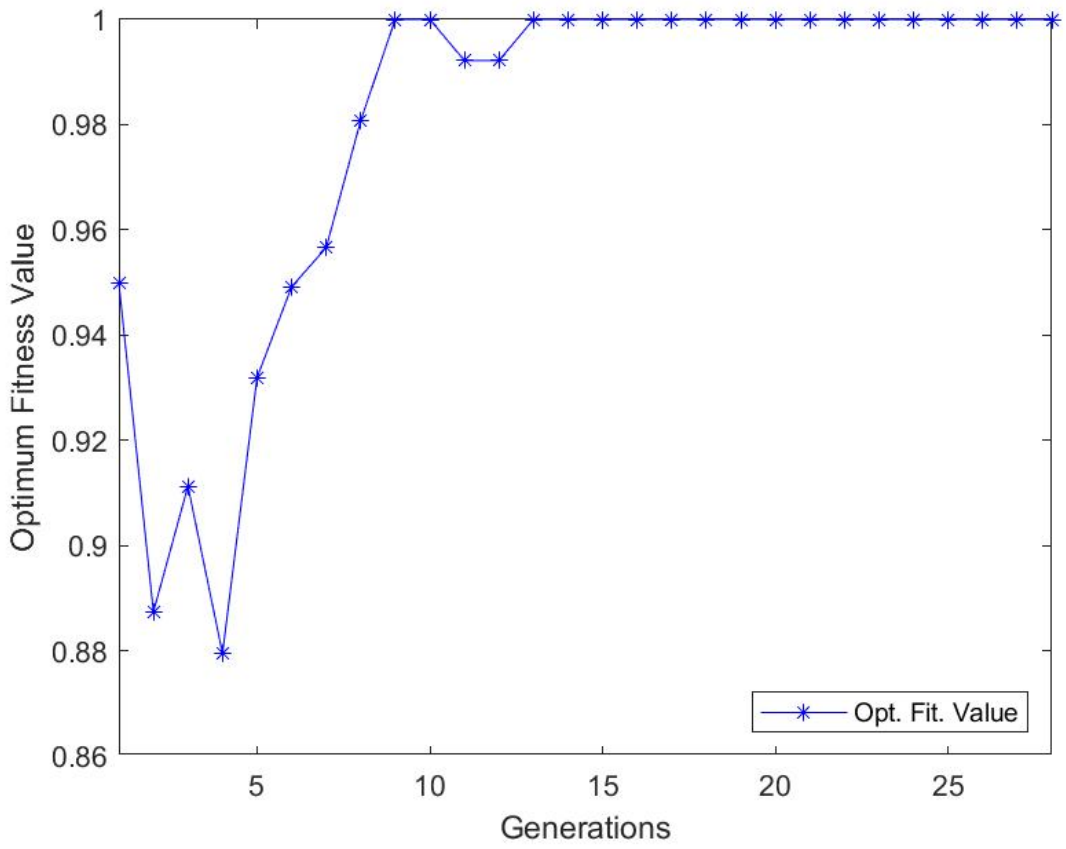
No. Generation taken to reach at optimum solution $(0,0)$ = 28 (considering initial as generation = 1)

x_1	x_2	Fitness Value	Objective Function Value
0	0	1	0

Below, three graphs for the above run are shown:


Average Fitness Value
Generations
Avg. Fit. Value
1
0.95
0.9
0.85
0.8
0.75
5
10
15
20
25


Max-Min Fitness Value
Generations
Max. Fit. Value
Min. Fit. Value
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
5
10
15
20
25



2. Result-2:

Initial population:

0	1	1	1	1	0	0	1	0	0	0	1
0	1	0	1	1	0	1	0	0	1	0	1
0	0	1	1	1	1	0	1	0	1	0	1
0	1	1	0	1	1	1	0	0	0	1	1
1	0	0	1	1	0	0	0	1	1	1	0
0	1	1	0	0	0	1	1	0	0	1	0

Initial X-values and fitness values:

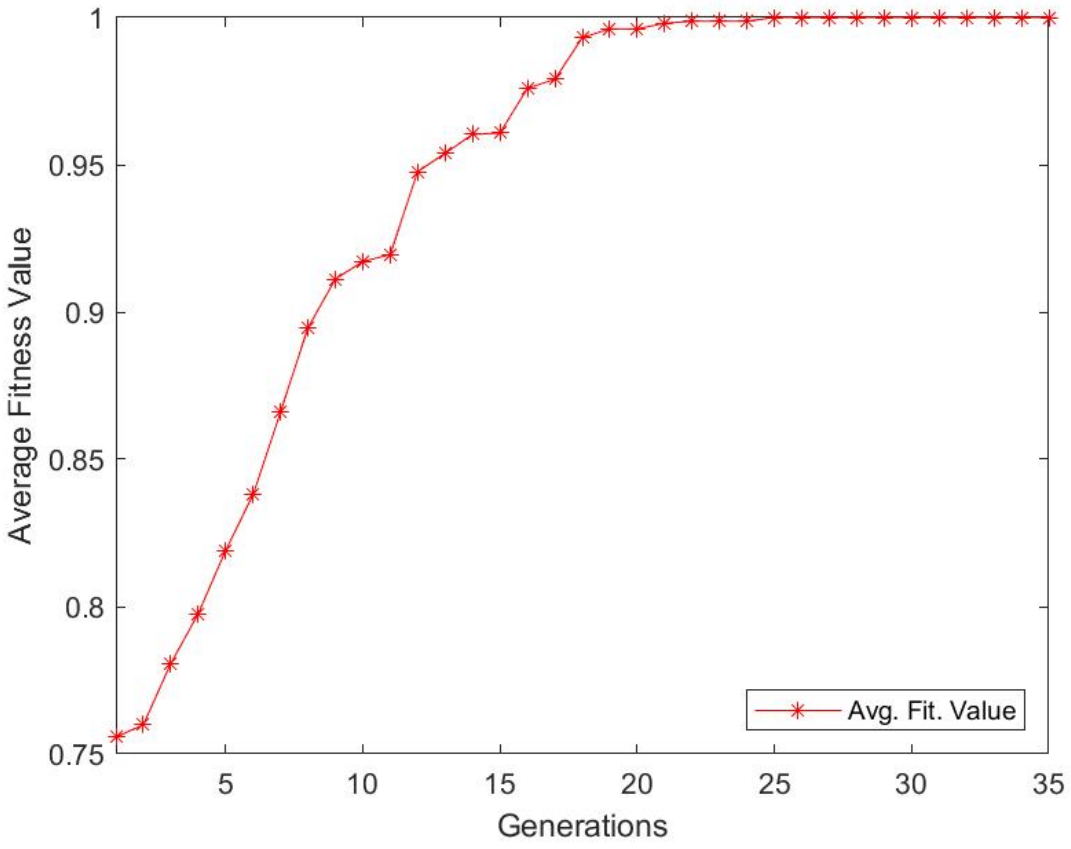
x_1	x_2	Fitness Value	Objective Function Value
0.2381	0.1349	0.7852	0.2736
0.1746	0.2937	0.7287	0.3723
0.1190	0.1667	0.8004	0.2494
0.2143	0.2778	0.7233	0.3826
0.3016	0.1111	0.7988	0.2519

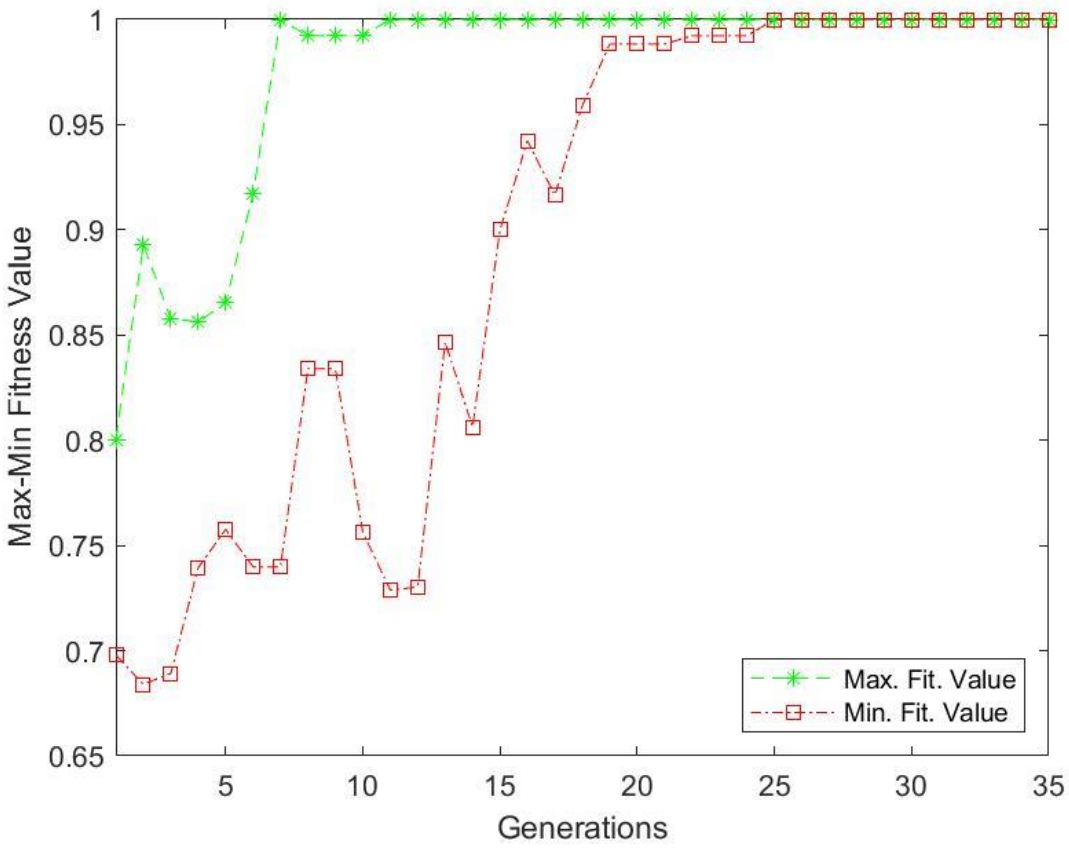
0.1905	0.3968	0.6979	0.4329

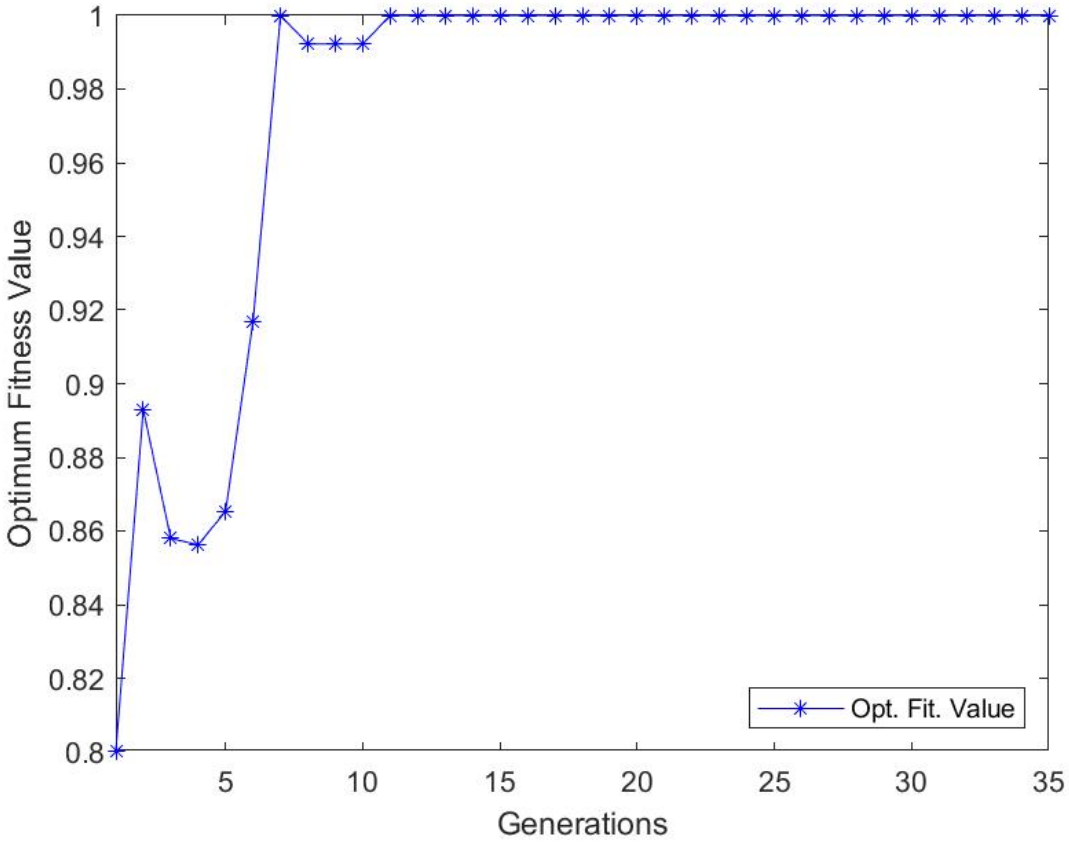
No. Generation taken to reach at optimum solution $(0,0)$ = 28 (considering initial as generation = 1)

x_1	x_2	Fitness Value	Objective Function Value
0.5	0	1	0

Below, three graphs for the above run are shown:




Max-Min Fitness Value
Generations
Max. Fit. Value
Min. Fit. Value
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
5
10
15
20
25
30
35


Optimum Fitness Value
Generations
Opt. Fit. Value
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
5
10
15
20
25
30
35

- Important Points:
    1. In the given code, after calculation of mutation step if average fitness value of that solution comes greater than average fitness value of previous generation solution, then that solution will be taken as present generation solution (if this condition is not put then we might have optimum solution at one point, but due to not satisfying terminating conditions, it will continue to run until last and we lose our optimum solution). So, this code will run for few iterations within one generation, to get optimum value.
    2. Two termination conditions are taken in present code. Those are, one termination condition is that, if generation number goes beyond maximum generation number given by user, then code will be terminated. Second termination condition is that, if average fitness value of present generation is equal to average fitness value before 10 generations, then in this case also code will be terminated.