7CCSMDBIM
Nature-Inspired Learning Algorithms

Assignment 1

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1 Binary Genetic Algorithm by Hand

a) Forming numbers:

The first 7 digits of the student number: 2011337
Creating an 8-digit number, with two digits denoting date of birth: 01133731

b) Cost function:

$$f(x, y) = \text{-}(0 + 1)x^2 + (1 + 3)xy \text{ - } (3 + 7)y^2 \text{ - } (3 + 1)$$

c) Population initialisation:

n	**Chromosome**	**Decoded x, y**	**Cost**
1	0000000001	0,1	-14
2	0000100011	1,3	-83
3	0001100111	3,7	-419
4	0001100001	3,1	-11
5	0000100000	1,0	-5
6	0001100001	3,1	-11
7	0011100011	7,3	-59
8	0000100011	1,3	-83

d) The *ranked* population, after *natural selection*:

n	**Chromosome**	**Decoded x, y**	**Cost**
1	0001100111	3,7	-419
2	0000100011	1,3	-83
3	0000100011	1,3	-83
4	0011100011	7,3	-59
$N_{keep} = 4$			
5	0000000001	0,1	-14
6	0001100001	3,1	-11
7	0001100001	3,1	-11
8	0000100000	1,0	-5

e) Probability table:

n	**Chromosome**	**Decoded x, y**	**Cost**	$C_n = c_c - c_{Nkeep+1}$	P_n	$\Sigma_{i=1}^{n} Pn$
1	0001100111	3,7	-419	5866	0.4	0.4
2	0000100011	1,3	-83	1162	0.3	0.7
3	0000100011	1,3	-83	1162	0.2	0.9
4	0011100011	7,3	-59	826	0.1	1.0

f) Single point crossover:

The first pair of parents chosen according to the random numbers resulted in the pair (0,1). Since there is no value n = 0, zero indexing was assumed and the first pair was comprised of (1,2) and the second pair (3,4) accordingly.

Pair	**Parents**	**Crossover point**	**Children**
(1,2)	(0001100111, 0000100011)	1	(0000100011, 0001100111)
(3,4)	(0000100011, 0011100011)	2	(0011100011, 0000100011)

g) Mutation:

The value $\mu = 0.25$
Number of bits to be mutated: 0.25(8-1)10 = 17.5 $\approx$ 18

n	**Chromosome**	**Chromosome after mutation**	**Decoded x, y**	**Cost**
1	0001100111	0001101011	(3,11)	-1091
2	0000100011	0001100110	(3,6)	-301
3	0000100011	0101101011	(11,11)	-851
4	0011100011	0001101001	(3,9)	-715
5	0000100011	0000101001	(1,9)	-779
6	0001100111	0100110011	(9,19)	-3011
7	0011100011	0011100011	(7,3)	-59
8	0000100011	0000000011	(0,3)	-94

2 Question 2

a) Calculation for R_1:

R_1= remainder of $\frac{s_2+s_3+s_4}{9}$

$\frac{0+1+1}{9} = 0$ **R** 2

R_1= 2

b) Determining the number of bits for binary decoding:

$$\frac{x_{hi} - x_{lo}}{10^{-d}}$$

x_{hi} = -20, x_{lo} = 20, d = 4

Solution:

$\frac{20-(-20)}{10^{-4}} \leq 2^m - 1 \Rightarrow 400001 \leq 2^m \Rightarrow m = 18.6096 \approx 19$ bits

c) Running the binary genetic algorithm:

"Run" Number	$p = 10$ $\mu = 0.1$	$p = 10$ $\mu = 0.5$	$p = 10$ $\mu = 0.9$	$p = 50$ $\mu = 0.1$	$p = 50$ $\mu = 0.5$	$p = 50$ $\mu = 0.9$	$p = 100$ $\mu = 0.1$	$p = 100$ $\mu = 0.5$	$p = 100$ $\mu = 0.9$
1	75.096	14.443	13.221	3.9289	23.758	10.019	15.571	18.064	28.73
2	75.098	14.443	13.221	2.9828	23.758	10.019	15.571	17.909	28.73
3	75.098	14.443	13.221	2.9828	15.639	10.019	8.477	15.333	23.575
4	51.38	8.8751	13.221	2.9828	5.6188	10.019	5.8064	15.333	1.1733
5	8.2619	8.8751	13.221	2.9761	5.6188	10.019	0.1136	15.333	1.1733
6	8.2619	8.8751	13.221	2.9761	5.6188	10.019	0.1136	14.81	1.1733
7	8.2619	8.8751	13.221	2.9761	5.6188	10.019	0.1136	14.81	1.1733
8	8.2619	8.8751	13.221	2.9761	5.6188	10.019	0.1136	14.81	1.1733
9	8.2619	8.8751	13.221	2.9761	5.6188	10.019	0.1136	14.81	1.1733
10	7.238	8.8751	13.221	1.1929	5.6188	10.019	0.1136	14.81	1.1733
Mean	32.522	10.5455	13.221	2.89507	10.2487	10.019	4.6107	15.6022	8.9248
Standard Deviation	30.6197	2.5515	0	3.3867	7.3764	0	6.148	1.214	11.9152
Best Cost	7.238	8.8751	13.221	1.1929	5.6188	10.019	0.1136	14.81	1.1733
Worst Cost	75.096	14.443	13.221	3.9289	23.758	10.019	15.571	18.064	28.73

Mean of "Mean"	12.0654
Standard deviation of "mean"	8.1079
Mean of "Standard Deviation"	7.0235
Standard deviation of "Standard Deviation"	9.1119
Mean of "Best Cost"	6.918
Standard Deviation "Best Cost"	5.0478
Mean of "Worst Cost"	22.5368
Standard Deviation "Worst Cost"	19.7936

d) Findings:

The results suggest that from the population size (p) and mutation rate (μ) pairs tested, the optimal results where found with the pair, p=100 and $\mu = 0.1$; returning a "best cost" of 0.1136, 6.8044 less than the mean of best costs. We are able to infer that the binary genetic algorithm is sensitive to parameter changes with smaller population sizes. The range of the standard deviation for $p = 10$ and μ in the range 0.1 to 0.5 was 30.6197. Despite this the sensitivity over all the tested parameters was low with a mean of standard deviation of 7.0235 and a standard deviation of "standard deviation" of 9.1119. At higher rates of mutation the algorithm performed unreliably. The algorithm converged to local minima at higher mutation rates, demonstrated in the results for pairs $p = 10$, $\mu = 0.9$ and $p = 50$, $\mu = 0.9$. The lower mutation rates reliably produced the "best cost" in 100% of the tested pairs.