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C1.

Fitness Function

$Y = w_1x_1^2 + w_2x_2^3 + w_3x_3 + w_4x_4 + w_5x_5 + w_6x_6$

$(x_1, x_2, x_3, x_4, x_5, x_6) = (4, -2, 7, -5, 11, 1)$

Optimum = Maximizing the equation = Maximum Y value

$P_c = 0.8$ = Probability of Crossover
$P_M = 0.1$ = Probability of Mutation

Generation 0

Population

1. Random weights are created between -100 to 100.

   C10 = Weight = Gene of a chromosome

   C10 = RANDBETWEEN(-100,100)

   It is repeated for 6 genes (6 columns) [C10:H10]
   and 8 chromosomes (8 rows) [C10:C17].

Chromosome\Gene	w1	w2	w3	w4	w5	w6
1	18	-1	-30	80	-98	-35
2	36	-16	7	-66	25	-39
3	32	-99	42	97	63	-84
4	-72	-48	23	-6	-82	-35
5	93	-12	60	8	-98	59
6	-69	42	34	44	-58	31
7	-84	-83	17	-94	-43	-21
8	7	45	-76	-68	-31	-22

2. Fitness function is used to solve for ‘Y’.

   C5, D5, E5, F5, G5, H5 = x values
   C10, D10, E10, F10, G10, H10 = weights = genes of one chromosome
   J10 = Y value for current chromosome

   J10 =
   (C10*POWER($C$5,2))+(D10*POWER($D$5,3))+(E10*$E$5)+(F10*$F$5)+(G10*$G$5)
   +(H10*$H$5)

   This is repeated for all 8 chromosomes [J10:J17].
   The values are also ranked.

   K10 = RANK(J10,$J$10:$J$17,0)

Y	Rank
-1427	6
1319	2
1722	1
-1514	7
945	3
-2029	8
-585	4
-803	5

Crossing-Over

3. To create Roulette Wheel, the range is required. Since I have negative Y values, I would use the summation of the absolute values of Y as the full range of the wheel.

   J10, J11, J12, J13, J14, J15, J16, J17 = Y values
   J18 = Full range

   J18 = ABS(J10)+ABS(J11)+ABS(J12)+ABS(J13)+ABS(J14)+ABS(J15)+ABS(J16)+ABS(J17)

4. The ranges for every chromosome are defined.

   J10 = Y value of current chromosome
   J18 = Full range
   N10 = Range of current chromosome

   N10 = ABS(J10)/$J$18

   It is repeated for 8 chromosomes (8 rows) [N10:N17].

5. The sections for every chromosome are defined.

   N10 = Range of current section
   O10 = Ending point for previous section / Beginning point for current section
   P10 = Ending point for current section

   P10 = SUM(N10:O10)

   It is repeated for 8 chromosomes (8 rows) [P10:P17].

Roulette Wheel			
		From	To
Chance for 1	0.13795437	0	0.13795437
Chance for 2	0.12751353	0.13795437	0.2654679
Chance for 3	0.16647332	0.2654679	0.43194122
Chance for 4	0.14636504	0.43194122	0.57830626
Chance for 5	0.09135731	0.57830626	0.66966357
Chance for 6	0.19615236	0.66966357	0.86581593
Chance for 7	0.05655452	0.86581593	0.92237046
Chance for 8	0.07762954	0.92237046	1

6. A value for each chromosome is randomly determined between 0 and 1 [S10:S17].

   S10 = RAND()

   Such value is considered as the roulette result for current chromosome.
   Such result is used to determine the partner for crossover [U10:U17].

Pick for 1	0.59527901	Pair for 1	5
Pick for 2	0.8175986	Pair for 2	6
Pick for 3	0.58708681	Pair for 3	5
Pick for 4	0.97216385	Pair for 4	8
Pick for 5	0.27247025	Pair for 5	3
Pick for 6	0.73616066	Pair for 6	6
Pick for 7	0.43465324	Pair for 7	4
Pick for 8	0.46157552	Pair for 8	4

7. The probability for crossover is defined as 0.8.
   Pairs with values less than 0.8 will become parents.
   A value for each pair is randomly determined between 0 and 1 [W10:W17].

   W10 = RAND()

   7 pairs will become parents.

8. We would apply ‘Single point crossover’.
   A crossover point for each pair is randomly determined between 1 and 5 [Column Y].

0.8		
Probability of Crossover	Y/N	Point of Crossover
0.632732735	Y	4
0.182672336	Y	4
0.717279123	Y	2
0.489114293	Y	2
0.621409062	Y	5
0.613887359	Y	3
0.316367521	Y	3
0.949365971	N	

9. Parents are crossed over at crossover points to create children.
   A pair of parents would create two children.

Parents		Child	w1	w2	w3	w4	w5	w6
1	5	1	18	-1	-30	80	-98	59
5	1	2	93	-12	60	8	-98	-35
2	6	3	36	-16	7	-66	-58	31
6	2	4	-69	42	34	44	25	-39
3	5	5	32	-99	60	8	-98	59
5	3	6	93	-12	42	97	63	-84
4	8	7	-72	-48	-76	-68	-31	-22
8	4	8	7	45	23	-6	-82	-35
5	3	9	93	-12	60	8	-98	-84
3	5	10	32	-99	42	97	63	59
6	6	11	-69	42	34	44	-58	31
6	6	12	-69	42	34	44	-58	31
7	4	13	-84	-83	17	-6	-82	-35
4	7	14	-72	-48	23	-94	-43	-21

Mutation

10. Both all parents and all children will be considered for mutation.

		w1	w2	w3	w4	w5	w6
Parents	1	18	-1	-30	80	-98	-35
	2	36	-16	7	-66	25	-39
	3	32	-99	42	97	63	-84
	4	-72	-48	23	-6	-82	-35
	5	93	-12	60	8	-98	59
	6	-69	42	34	44	-58	31
	7	-84	-83	17	-94	-43	-21
	8	7	45	-76	-68	-31	-22
Children	1	18	-1	-30	80	-98	59
	2	93	-12	60	8	-98	-35
	3	36	-16	7	-66	-58	31
	4	-69	42	34	44	25	-39
	5	32	-99	60	8	-98	59
	6	93	-12	42	97	63	-84
	7	-72	-48	-76	-68	-31	-22
	8	7	45	23	-6	-82	-35
	9	93	-12	60	8	-98	-84
	10	32	-99	42	97	63	59
	11	-69	42	34	44	-58	31
	12	-69	42	34	44	-58	31
	13	-84	-83	17	-6	-82	-35
	14	-72	-48	23	-94	-43	-21

11. The probability for mutation is defined as 0.1.
    Genes with values less than 0.1 will be mutated.
    A value for each gene is randomly determined between 0 and 1 [
    AT10:AY10:AT31:AY31].

    AT10 = RAND()

12. The new population is created.
    By mutation, the new gene will be randomized between -100 and 100.

    BC10 = Gene of the chromosome
    AT10 = Random probability for mutation of each gene
    AM10 = Original gene of current chromosome

    BC10 = IF(AT10<0.1,RANDBETWEEN(-100,100),AM10)

    It is repeated for 6 genes (6 columns) [BC10:BH10]
    and 22 chromosomes (22 rows) [BC10:BC31].

Mutated							
		w1	w2	w3	w4	w5	w6
Parents	1	18	-1	-30	80	-98	-35
	2	36	-16	7	-66	25	-39
	3	48	-62	42	97	63	-84
	4	-72	-48	23	-6	-82	-35
	5	93	-12	-54	8	-98	59
	6	-69	42	34	44	-58	31
	7	-84	-83	17	-94	-43	-21
	8	7	45	-76	-68	-31	-22
Children	1	18	-1	-30	86	33	59
	2	93	-12	60	8	-98	-35
	3	36	-16	7	66	-58	31
	4	-69	42	34	44	25	-39
	5	32	-99	60	8	-98	59
	6	93	-12	42	97	63	-84
	7	-72	-48	-76	-68	-31	-13
	8	7	45	23	-6	-82	-35
	9	-41	-12	60	8	-98	-84
	10	32	-99	42	97	63	-54
	11	-69	42	34	44	-58	31
	12	-69	42	34	44	-58	31
	13	-84	-83	17	-2	-82	-35
	14	-72	-48	23	-94	-43	-21

Generation 1

Population

1. The population from previous generation (after bring crossed over and mutated) will be carried over as the population.

Population	Chromosome\Gene	w1	w2	w3	w4	w5	w6
Parents	1	18	-1	-30	80	-98	-35
	2	36	-16	7	-66	25	-39
	3	48	-62	42	97	63	-84
	4	-72	-48	23	-6	-82	-35
	5	93	-12	-54	8	-98	59
	6	-69	42	34	44	-58	31
	7	-84	-83	17	-94	-43	-21
	8	7	45	-76	-68	-31	-22
Children	1	18	-1	-30	86	33	59
	2	93	-12	60	8	-98	-35
	3	36	-16	7	66	-58	31
	4	-69	42	34	44	25	-39
	5	32	-99	60	8	-98	59
	6	93	-12	42	97	63	-84
	7	-72	-48	-76	-68	-31	-13
	8	7	45	23	-6	-82	-35
	9	-41	-12	60	8	-98	-84
	10	32	-99	42	97	63	-54
	11	-69	42	34	44	-58	31
	12	-69	42	34	44	-58	31
	13	-84	-83	17	-2	-82	-35
	14	-72	-48	23	-94	-43	-21

2. Fitness function is used to solve for ‘Y’.

   C5, D5, E5, F5, G5, H5 = x values
   C10, D10, E10, F10, G10, H10 = weights = genes of one chromosome
   J10 = Y value for current chromosome

   J10 =
   (C10*POWER($C$5,2))+(D10*POWER($D$5,3))+(E10*$E$5)+(F10*$F$5)+(G10*$G$5)
   +(H10*$H$5)

   This is repeated for all 22 chromosomes [J10:J31].

Y	Rank
-1427	17
1319	4
1682	3
-1514	19
147	7
-2029	20
-585	10
-803	12
78	8
851	5
-184	9
-1186	14
665	6
2002	1
-1314	15
-994	13
-1342	16
1752	2
-2029	20
-2029	20
-1488	18
-631	11

3. Chromosomes with optimum 'Y' (Maximum 'Y') values are considered best performers.

   K10 = RANK(J10,$J$10:$J$31,0)

   Best 8 chromosomes are selected.
   The less performing chromosomes are eliminated.

   These 8 chromosomes are the new population for this current generation.

Rank	New Population	Chromosome\Gene	w1	w2	w3	w4	w5	w6
1		1	93	-12	42	97	63	-84
2		2	32	-99	42	97	63	-54
3		3	48	-62	42	97	63	-84
4		4	36	-16	7	-66	25	-39
5		5	93	-12	60	8	-98	-35
6		6	32	-99	60	8	-98	59
7		7	93	-12	-54	8	-98	59
8		8	18	-1	-30	86	33	59

4. Fitness function is used to solve for ‘Y’.

   C5, D5, E5, F5, G5, H5 = x values
   P10, Q10, R10, S10, T10, U10 = weights = genes of one chromosome
   W10 = Y value for current chromosome

   W10 =
   (P10*POWER($C$5,2))+(Q10*POWER($D$5,3))+(R10*$E$5)+(S10*$F$5)+(T10*$G$5)
   +(U10*$H$5)

   This is repeated for all 8 chromosomes [W10:W17].

Y
2002
1752
1682
1319
851
665
147
78

Crossing Over

Step 3 to 9 from Generation 0 is repeated.

5. Roulette Wheel

Roulette Wheel			
		From	To
Chance for 1	0.2356403	0	0.2356403
Chance for 2	0.20621469	0.2356403	0.44185499
Chance for 3	0.19797552	0.44185499	0.63983051
Chance for 4	0.15524953	0.63983051	0.79508004
Chance for 5	0.10016478	0.79508004	0.89524482
Chance for 6	0.07827213	0.89524482	0.97351695
Chance for 7	0.01730226	0.97351695	0.99081921
Chance for 8	0.00918079	0.99081921	1

6. Determining partner

Pick for 1	0.32562234	Pair for 1	2
Pick for 2	0.02979477	Pair for 2	1
Pick for 3	0.38718555	Pair for 3	2
Pick for 4	0.19229919	Pair for 4	1
Pick for 5	0.1462218	Pair for 5	1
Pick for 6	0.06245055	Pair for 6	1
Pick for 7	0.91356942	Pair for 7	6
Pick for 8	0.71745523	Pair for 8	4

7. Probability of Crossover

0.8

Probability of Crossover	Y/N	Point of Crossover
0.350751242	Y	4
0.102506566	Y	3
0.559165346	Y	4
0.838536535	N	2
0.692576562	Y	4
0.894207245	N	1
0.720806471	Y	3
0.614793848	Y	1

Mutation

Generation 10 to 12 from Generation 0 will be repeated.

8. Populations considered for mutation

		w1	w2	w3	w4	w5	w6
Parents	1	93	-12	42	97	63	-84
	2	32	-99	42	97	63	-54
	3	48	-62	42	97	63	-84
	4	36	-16	7	-66	25	-39
	5	93	-12	60	8	-98	-35
	6	32	-99	60	8	-98	59
	7	93	-12	-54	8	-98	59
	8	18	-1	-30	86	33	59
Children	1	93	-12	42	97	63	-54
	2	32	-99	42	97	63	-84
	3	32	-99	42	97	63	-84
	4	93	-12	42	97	63	-54
	5	48	-62	42	97	63	-54
	6	32	-99	42	97	63	-84
	7	93	-12	60	8	63	-84
	8	93	-12	42	97	-98	-35
	9	93	-12	-54	8	-98	59
	10	32	-99	60	8	-98	59
	11	18	-16	7	-66	25	-39
	12	36	-1	-30	86	33	59

9. Mutated Population

Mutated							
		w1	w2	w3	w4	w5	w6
Parents	1	93	40	42	97	63	-84
	2	32	-99	42	-9	63	-54
	3	48	-62	42	97	63	31
	4	36	-16	7	-66	25	-39
	5	93	-12	60	8	-98	-35
	6	32	-99	60	8	-98	59
	7	93	-12	-54	8	-98	59
	8	18	-1	-74	86	33	59
Children	1	93	-12	42	97	63	-54
	2	32	-99	42	97	63	-84
	3	32	-99	42	97	63	-84
	4	93	-91	42	97	-15	13
	5	48	-62	42	97	63	-54
	6	32	-99	42	97	63	-84
	7	93	-12	-41	8	63	-84
	8	93	-12	42	97	-98	-35
	9	93	-12	-54	8	-98	59
	10	32	-99	89	8	-98	59
	11	18	-16	5	-66	25	84
	12	36	-1	-30	86	33	59

Generation 2

Population

Step 1 and 2 from Generation 1 will be repeated.

1. Previous population

Population	Chromosome\Gene	w1	w2	w3	w4	w5	w6		Y	Rank
Parents	1	93	40	42	97	63	-84		1586	10
	2	32	-99	42	-9	63	-54		2282	1
	3	48	-62	42	97	63	31		1797	5
	4	36	-16	7	-66	25	-39		1319	11
	5	93	-12	60	8	-98	-35		851	14
	6	32	-99	60	8	-98	59		665	15
	7	93	-12	-54	8	-98	59		147	18
	8	18	-1	-74	86	33	59		-230	20
Children	1	93	-12	42	97	63	-54		2032	2
	2	32	-99	42	97	63	-84		1722	6
	3	32	-99	42	97	63	-84		1722	6
	4	93	-91	42	97	-15	13		1873	3
	5	48	-62	42	97	63	-54		1712	9
	6	32	-99	42	97	63	-84		1722	6
	7	93	-12	-41	8	63	-84		1866	4
	8	93	-12	42	97	-98	-35		280	17
	9	93	-12	-54	8	-98	59		147	18
	10	32	-99	89	8	-98	59		868	13
	11	18	-16	5	-66	25	84		1140	12
	12	36	-1	-30	86	33	59		366	16

2. Best performing population

Rank	New Population	Chromosome\Gene	w1	w2	w3	w4	w5	w6		Y
1		1	32	-99	42	-9	63	-54		2282
2		2	93	-12	42	97	63	-54		2032
3		3	93	-91	42	97	-15	13		1873
4		4	93	-12	-41	8	63	-84		1866
5		5	48	-62	42	97	63	31		1797
6		6	32	-99	42	97	63	-84		1722
6		7	32	-99	42	97	63	-84		1722
6		8	32	-99	42	97	63	-84		1722
									Range	15016

Crossing Over

Step 3 to 9 from Generation 0 is repeated.

3. Roulette Wheel

Roulette Wheel			
		From	To
Chance for 1	0.15197123	0	0.15197123
Chance for 2	0.13532232	0.15197123	0.28729355
Chance for 3	0.12473362	0.28729355	0.41202717
Chance for 4	0.12426745	0.41202717	0.53629462
Chance for 5	0.11967235	0.53629462	0.65596697
Chance for 6	0.11467768	0.65596697	0.77064465
Chance for 7	0.11467768	0.77064465	0.88532232
Chance for 8	0.11467768	0.88532232	1

4. Determining Partner

Pick for 1	0.63663136	Pair for 1	5
Pick for 2	0.20766264	Pair for 2	2
Pick for 3	0.86281809	Pair for 3	7
Pick for 4	0.11394012	Pair for 4	1
Pick for 5	0.83196629	Pair for 5	7
Pick for 6	0.1451848	Pair for 6	1
Pick for 7	0.01521171	Pair for 7	1
Pick for 8	0.73920039	Pair for 8	6

5. Probability of crossover

Probability of Crossover	Y/N	Point of Crossover
0.172599289	Y	2
0.387283346	Y	3
0.547068449	Y	4
0.28046118	Y	5
0.258805598	Y	3
0.91480628	N	
0.353495327	Y	5
0.67081675	Y	2

Mutation

Generation 10 to 12 from Generation 0 will be repeated.

6. Populations considered for mutation

		w1	w2	w3	w4	w5	w6
Parents	1	32	-99	42	-9	63	-54
	2	93	-12	42	97	63	-54
	3	93	-91	42	97	-15	13
	4	93	-12	-41	8	63	-84
	5	48	-62	42	97	63	31
	6	32	-99	42	97	63	-84
	7	32	-99	42	97	63	-84
	8	32	-99	42	97	63	-84
Children	1	32	-99	42	97	63	31
	2	48	-62	42	-9	63	-54
	3	93	-12	42	97	63	-54
	4	93	-12	42	97	63	-54
	5	93	-91	42	97	63	-84
	6	32	-99	42	97	-15	13
	7	93	-12	-41	8	63	-54
	8	32	-99	42	-9	63	-84
	9	48	-62	42	97	63	-84
	10	32	-99	42	97	63	31
	11	32	-99	42	97	63	-54
	12	32	-99	42	-9	63	-84
	13	32	-99	42	97	63	-84
	14	32	-99	42	97	63	-84

7. Mutated Population

Mutated							
		w1	w2	w3	w4	w5	w6
Parents	1	-15	-99	-17	-9	63	-54
	2	93	-12	42	97	63	-54
	3	93	18	42	97	-15	13
	4	63	-12	-41	8	63	-84
	5	48	-62	42	97	63	31
	6	32	-99	42	97	63	-84
	7	32	-99	-5	3	24	-84
	8	32	-99	42	97	63	-84
Children	1	32	-99	42	97	63	31
	2	48	-62	42	-9	63	-54
	3	93	-12	42	97	63	-54
	4	93	-12	42	97	63	-54
	5	93	-91	42	97	63	-84
	6	32	-99	42	97	-72	13
	7	93	5	-41	8	63	-38
	8	32	-99	42	-9	63	-84
	9	48	-62	42	92	63	-84
	10	32	-99	42	97	-6	31
	11	32	-99	42	97	63	-54
	12	32	-99	42	-9	63	-84
	13	32	-99	42	97	63	-84
	14	32	31	-91	97	63	-84

Conclusion

The final population is used to solve for Y value. They are ranked and the best performing chromosome is chosen. The genes of the best performing chromosome are the best weights at Generation 2.

Population	Chromosome\Gene	w1	w2	w3	w4	w5	w6		Y	Rank
Parents	1	-15	-99	-17	-9	63	-54		1117	18
	2	93	-12	42	97	63	-54		2032	5
	3	93	18	42	97	-15	13		1001	20
	4	63	-12	-41	8	63	-84		1386	17
	5	48	-62	42	97	63	31		1797	9
	6	32	-99	42	97	63	-84		1722	12
	7	32	-99	-5	3	24	-84		1434	16
	8	32	-99	42	97	63	-84		1722	12
Children	1	32	-99	42	97	63	31		1837	8
	2	48	-62	42	-9	63	-54		2242	4
	3	93	-12	42	97	63	-54		2032	5
	4	93	-12	42	97	63	-54		2032	5
	5	93	-91	42	97	63	-84		2634	1
	6	32	-99	42	97	-72	13		334	21
	7	93	5	-41	8	63	-38		1776	10
	8	32	-99	42	-9	63	-84		2252	2
	9	48	-62	42	92	63	-84		1707	15
	10	32	-99	42	97	-6	31		1078	19
	11	32	-99	42	97	63	-54		1752	11
	12	32	-99	42	-9	63	-84		2252	2
	13	32	-99	42	97	63	-84		1722	12
	14	32	31	-91	97	63	-84		-249	22

Best Weights at Generation 2	
w1	93
w2	-91
w3	42
w4	97
w5	63
w6	-84

C2.

Number of Chromosomes = 50
Number of Genes = 6
Number of Generations = 1000

C2A

The coding for C2A follows the step of C1.

Initial Weights – Randomized between -100 to 100
My coding took too long for me so, I only could finish until 100 for this type.

Best Weights at Generation 100	
w1	97
w2	-76
w3	97
w4	-83
w5	99
w6	99
Optimum Y score	2822

C2B

Instead, this is for
Half the population with optimum fitness always become parents.
The chromosomes always crossover at halfway.
Number of genes mutating = The number of children chromosomes
Mutation = Increasing or decreasing a random value between 1 and. -1 from a gene

Initial Weights – Randomized between -150 to 150

Best Weights at Generation 1000	
w1	141
w2	-104
w3	35
w4	-22
w5	141
w6	73
Optimum Y score	5067