MRS

Domain of variable {0 — 6}, Smaller values are favourable, must be tried first.

L {1 — 4} Can't be 0, Can't generate Carry

A {1 — 6} Can't be 0.

T, E {0 — 6} Can be any value.

MRV → L

Let L = 1

So this will limit

A = 2

or Incase of Carry A = 3.

So Domain

Choice → Let first try A = 2

mean E is less than 5 otherwise A = 3.

~~So By MRV.~~

So Reduced ~~Domain~~ Domains

$E = \{0 — 4\}$.

$T = \{0 — 6\}$.

By MRV we ~~choose~~ choose. E

$E = 0$ and $C_1 = 1$

other wise there is no feasible value for E.

~~So that~~ $R = 1$.

Domain of $T = \{0 — 6\}$ and $E = 0$

So we do not have any valid assignment.

we will back track.

So the last choice was $A = 2$

we can make $A = 3$.

$A = 3$ mean there is a carry

$C_2 = 1$ which mean E

is 5 or 6.

MRS

lets try with E = 5 (1)

$$\begin{array}{cccc} 1 & L & E & T \\ 1 & L & E & E \\ \hline 3 & A & L & L \\ & & 1 & \end{array}$$

5 is only feasible if there is a carry $C_1 = 1$ otherwise no sol.

so lets ~~change for~~ keep E=5 and we expect a carry

$$\begin{array}{cccc} & 1 & 1 & \\ 1 & L & 5\,E & T \\ 1 & L & 5\,E & E\,5 \\ \hline 3 & A & 1\,L & L\,1 \end{array}$$

So what value of T such that T + 5 = 11 so T = 6.

MRS

1 1

LET 156

LEE 155

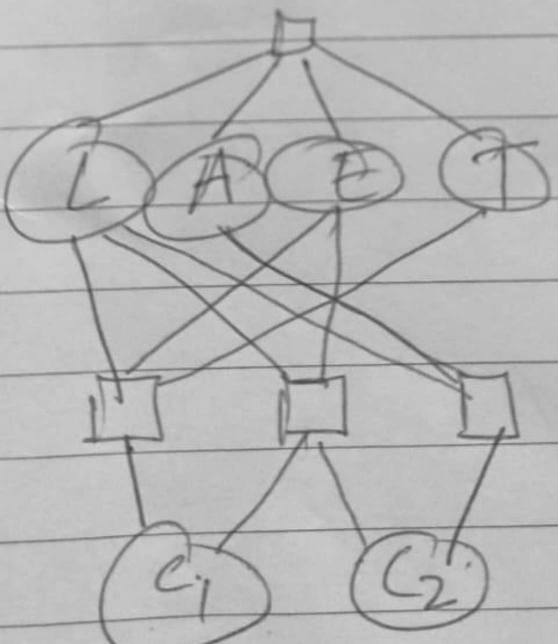
- ALL 311

$$
\begin{array}{r}
LET \\
LEE \\
\hline
ALL
\end{array}
$$

$$T + E = L + 10 C_1$$

$$C_1 + E + E = L + 10 C_2$$

$$C_2 + L + L = A$$



Q2: 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:

$$f(x) = (a - b) + (c + d)^2 - (e + f)^2 - (g + h)$$

and let the initial population consist of four individuals with the following chromosomes:

$$x_1 = 89362037$$

$$x_2 = 09151323$$

$$x_3 = 34790619$$

$$x_4 = 25904237$$

1. Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.

   Answer:

   $f(x_1) = (8-9) + (3+6)^2 – (2+0)^2 − (3+7) = -1 + 81 – 4 – 10 = 66$

   $f(x_2) = (0-9) + (1+5)^2 – (1+3)^2 − (2+3) = -9 + 36 – 16 – 5 = 6$

   $f(x_3) = (3-4) + (7+9)^2 – (0+6)^2 − (1+9) = -1 + 256 – 36 – 10 = 209$

   $f(x_4) = (2-5) + (9+0)^2 – (4+2)^2 − (3+7)= -3 + 81 – 36 – 10 = 32$

   The order is x_3, x_1, x_4, and x_2.

2. Cross the fittest two individuals using one–point crossover between c and d, and calculate the fitness of the offsprings:

   x_3 = **3 4 7** | **9 0 6 1 9** $\qquad$ O_1 = **3 4 7** 6 2 0 3 7

   ➔

   x_1 = 8 9 3 | 6 2 0 3 7 $\qquad$ O_2 = 8 9 3 **9 0 6 1 9**

   $f(O_1) = (3-4) + (7+6)^2 - (2+0)^2 − (3+7) = -1 + 169 - 4 – 10 = 154$

   $f(O_2) = (8-9) + (3+9)^2 - (0+6)^2 – (1+9) = -1 + 144 - 36 - 10 = 97$

3. Cross the second and third fitted individuals using a two-point crossover (points b and g). Calculate the fitness of the offsprings.

x_1 = **8 9** | **3 6 2 0 3** | **7** $\rightarrow$ O_3 = **8 9** 9 0 4 2 3 **7**

x_4 = 2 5 | 9 0 4 2 3 | 7 O_4 = 2 5 **3 6 2 0 3** 7

$f(O_3) = (8-9) + (3+6)^2 - (2+0)^2 – (3+7) = -1 + 81 – 4 - 10 = 66$

$f(O_4) = (2-5) + (9+0)^2 - (4+2)^2 – (3+7) = -3 + 81 - 36 - 10 = 32$

4. Suppose the new population consists of the four offsprings individuals received by the crossover operations in the previous parts. Evaluate the average fitness of the new population. Has the overall fitness improved, as compared to initial population?

   Fitness of old population ($x_1 – x_4$) = (66 + 6 + 209 + 32) / 4 = 78.25

   Fitness of new population ($O_1 – O_4$) = (154 + 97 + 66 + 32) / 4 = 87.25

   Yes, overall fitness has improved.

5. By looking at the fitness function and considering that the gene 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.

   $\max f(x) = \max [(a - b) + (c + d)^2 - (e + f)^2 - (g + h)]$

   Optimal solution should be:

   $x_{optimal}$ = 9 0 9 9 0 0 0 0

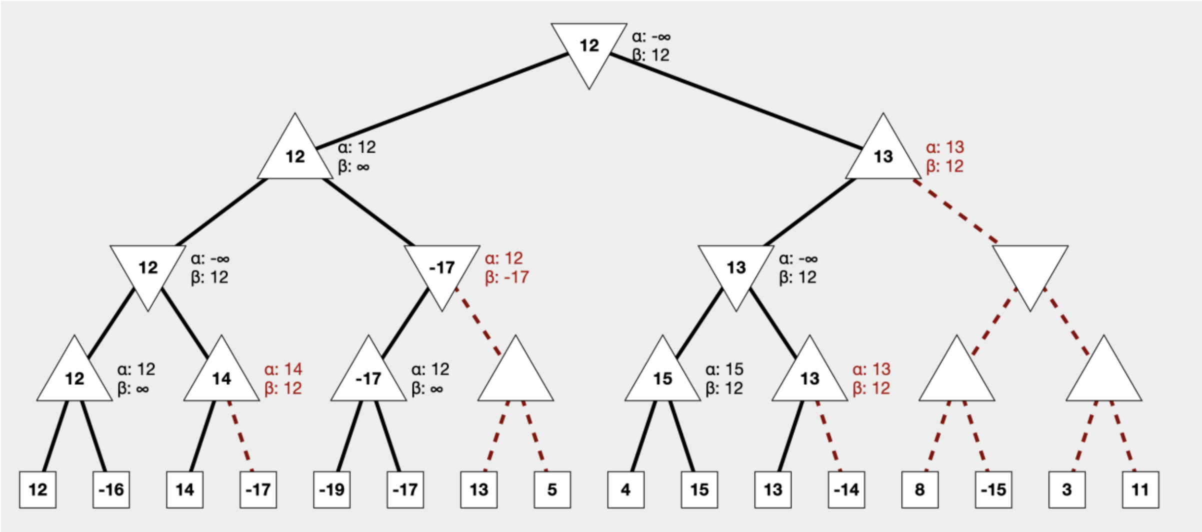
   Maximum fitness:

   $f(x_{optimal}) = (9 + 0) + (9 + 9)^2 - (0 + 0)^2 – (0 + 0) = 9 + 324 = 333$

6. Looking at the population, briefly explain if the optimal solution can be reached without using the mutation operation?

   Without mutation, the algorithm will never reach the optimal solution

Question 3



12
α: -∞
β: 12
12
α: 12
β: ∞
13
α: 13
β: 12
12
α: -∞
β: 12
-17
α: 12
β: -17
13
α: -∞
β: 12
12
α: 12
β: ∞
14
α: 14
β: 12
-17
α: 12
β: ∞
15
α: 15
β: 12
13
α: 13
β: 12
12
-16
14
-17
-19
-17
13
5
4
15
13
-14
8
-15
3
11