Comp 6731 Pattern Recognition

Assignment 2

Submitted By Pazim Goyal and Mridul Pathak

40069412 & 40078157

Values Used

Initial Population Count: - 4

Chromosome Size: -4 i.e. [1 0 0 1]

Crossover Probability: 75%

Mutation Probability: - 1%

The Data Used is Array Lists Of 4 elements those are binary variables i.e. either 0 or 1 hence are chromosome if made up of 4 binary digits [x1, x2, x3, x4] where (x1, x2, x3, x4 € (0,1))

Initial Population Generation:

Initially we would generate a population of random chromosomes. This population would be unique and follow our constraint of maximum investment per year. Is any chromosome does not follow the constraint or repeats it is discarded and new chromosome is randomly generated.

Initially_Population is generated in following steps-

1. Start loop
2. Generate a chromosome with random genes of size 4
3. Check the chromosome for constraint of maximum investment budget per year i.e.
   Constraints: $0.5x_1 + 1.0x_2 + 1.5x_3 + 0.1x_4 \leq 3.1; 0.3x_1 + 0.8x_2 + 1.5x_3 + 0.4x_4 \leq 2.5; 0.2x_1 + 0.2x_2 + 0.3x_3 + 0.1x_4 \leq 0.4.$
4. If value is true for all and chromosome doesn't already exist in population:
   I. Add chromosome to population
   II. Go to step 2
5. Else if value is false or the chromosome already exists in population:
   a) Discard the chromosome
   b) Go to step 2

6. Stop when population size is equal to predefined population size

Fitness Function Used*:*

Fitness Function is function used to determine the fitness of chromosomes i.e. how good is our result according to the problem. We call fitness function for every chromosome and select the chromosomes with best fitness in every generation

Fitness Function Used –

Maximize $\square(x_1, x_2, x_3, x_4) = 0.2\ x_1+0.3\ x_{2+}0.5\ x_{3+}0.1\ x_4$

Parent Selection:

Parent Selection is technique used to select parents from population for creation of children. This could be done is several ways e.g. Selecting the Fittest Parents or Roulette Wheel selection.

In my code I have implemented (*coding for both the methods*) both the methods but Fittest Parent is used for selection.

Selection technique used is Chromosomes with highest fitness in pairs**.** In our scenario selection is used as following: -

1. Start loop with count=0
2. Sort the population according to fitness value
3. Select two parents at position count and count+1
4. Send the parent values to crossover function
5. Count=count+2
6. Stop when count = PopulationSize/2

The crossover mechanism used:

Crossover is technique of creating children from selected parents. It is inspired from biological crossover i.e. genes of both parent chromosomes mix up to make two new child chromosomes. These Child chromosomes may or may not different then parent chromosomes and could result in better fitness value but not always.

Crossover Probability: 75%

Crossover probability (P_c) is whether the crossover would occur or not

We now have two parents

Crossover is done as following: -

1. Generate a random variable between 0 and 4, say its n

2. From the nth index interchange the genes of both parent chromosomes

Mutation Mechanism:

As term describes Mutation happens in children after crossover. This happens very rare i.e. probability of mutation is very less. In this any gene of child is flipped randomly resulting in new gene structure of child. This may result in better fitness but not always.

Mutation Probability: - 1%

Mutation probability (P_m) is whether the mutation would occur or not

1. Select a child From Crossover mechanism
2. Generate a random variable between 0 and 4, say its n
3. Inverse nth gene of child i.e. if nth gene is zero inverse to one and vice versa
   (Only one gene is changed if mutation occurs)

The stopping criteria:

Stopping Criteria is the condition where we stop our algorithm for making new generations and finally receive a output.

We may use several stopping criteria such as when we keep on receiving similar output or we may predefine a fitness value and ask the algorithm to stop when it reaches that fitness level

We may say that we can stop when we receive max fitness of every generation for more then five times

OUTPUT :

We generally receive an chromosome with fitness level of 0.6 or 0.5 in some cases. And chromosome is either 0011 or 1100 respectively.

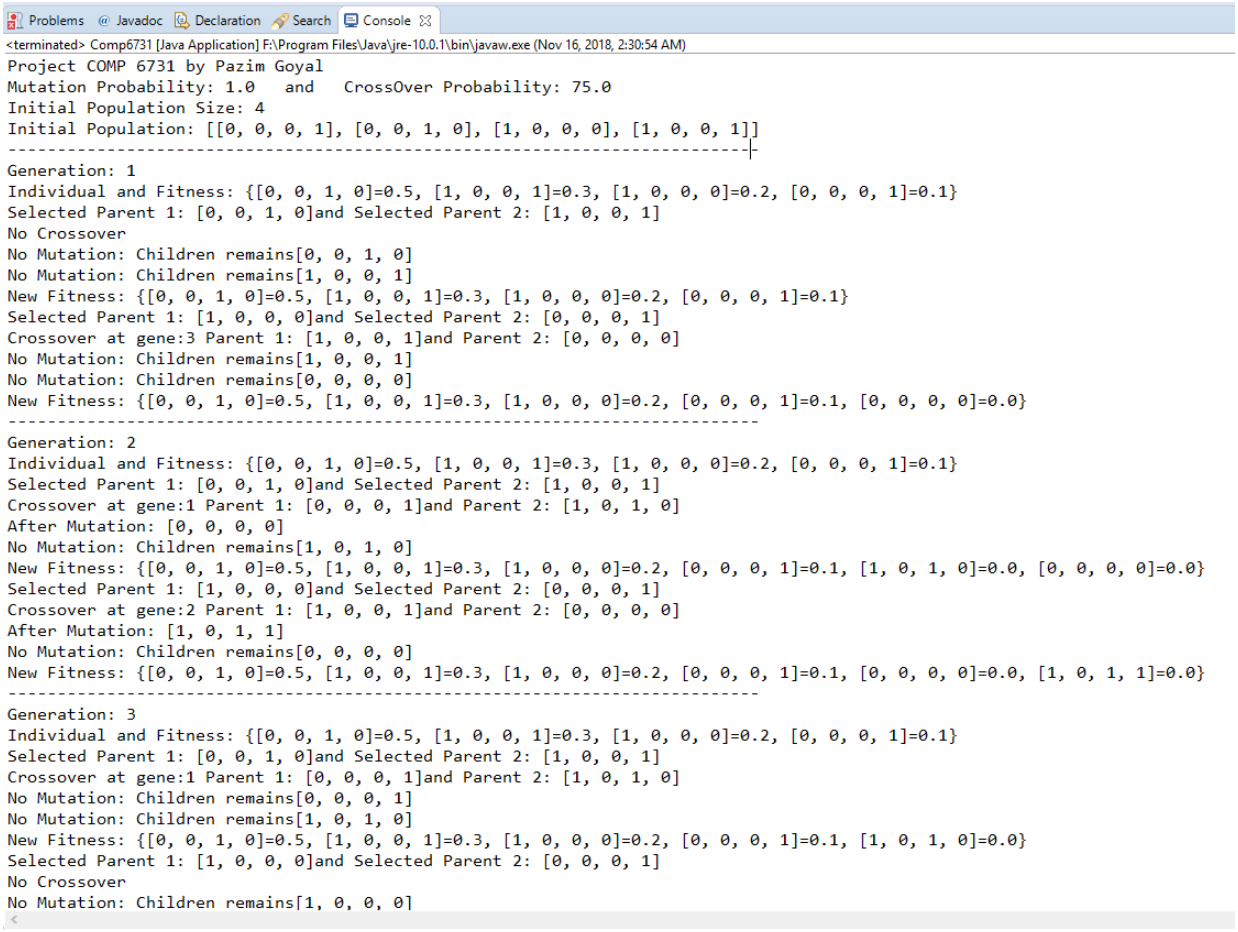
Final Output: -
Chromosome Selected: [0, 0, 1, 1] with Fitness Value: 0.6000000238418579

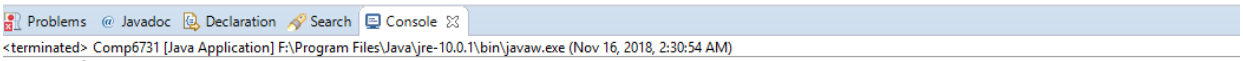
Output of each generation (E.g. how each generation looks): -

```
Generation: 2
Individual and Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [1, 0, 0, 1]
Crossover at gene:1 Parent 1: [0, 0, 0, 1]and Parent 2: [1, 0, 1, 0]
After Mutation: [0, 0, 0, 0]
No Mutation: Children remains[1, 0, 1, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [1, 0, 1, 0]=0.0,
[0, 0, 0, 0]=0.0}
Selected Parent 1: [1, 0, 0, 0]and Selected Parent 2: [0, 0, 0, 1]
```

Crossover at gene:2 Parent 1: [1, 0, 0, 1]and Parent 2: [0, 0, 0, 0]
After Mutation: [1, 0, 1, 1]
No Mutation: Children remains[0, 0, 0, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [0, 0, 0, 0]=0.0, [1, 0, 1, 1]=0.0}

Output Screen Shots:






```
<terminated> Comp6731 [Java Application] F:\Program Files\Java\jre-10.0.1\bin\javaw.exe (Nov 16, 2018, 2:30:54 AM)
Generation: 5
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
No Mutation: Children remains[0, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
No Crossover
No Mutation: Children remains[1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
--------------------------------------------------------------------------------
Generation: 6
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
No Mutation: Children remains[0, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
Crossover at gene:2 Parent 1: [1, 0, 0, 0]and Parent 2: [1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
--------------------------------------------------------------------------------
Generation: 7
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
After Mutation: [1, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [1, 0, 1, 1]=0.0}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
Crossover at gene:1 Parent 1: [1, 0, 0, 0]and Parent 2: [1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
------------------------------------------------------------
Chromosome Selected: [0, 0, 1, 1]  with Fitness Value: 0.6000000238418579
```

JAVA COMPILER OUTPUT (as text)

```
Project COMP 6731 by Pazim Goyal
Mutation Probability: 1.0   and   CrossOver Probability: 75.0
Initial Population Size: 4
Initial Population: [[0, 1, 0, 1], [0, 0, 1, 0], [0, 0, 0, 0], [1, 0, 0, 1]]
---------------------------------------------------------------------------
Generation: 1
Individual and Fitness: {[0, 0, 1, 0]=0.5, [0, 1, 0, 1]=0.4, [1, 0, 0, 1]=0.3, [0, 0, 0, 0]=0.0}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [0, 1, 0, 1]
Project COMP 6731 by Pazim Goyal
Mutation Probability: 1.0   and   CrossOver Probability: 75.0
Initial Population Size: 4
Initial Population: [[0, 0, 0, 1], [0, 0, 1, 0], [1, 0, 0, 0], [1, 0, 0, 1]]
---------------------------------------------------------------------------
Generation: 1
Individual and Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [1, 0, 0, 1]
No Crossover
No Mutation: Children remains[0, 0, 1, 0]
No Mutation: Children remains[1, 0, 0, 1]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [1, 0, 0, 0]and Selected Parent 2: [0, 0, 0, 1]
Crossover at gene:3 Parent 1: [1, 0, 0, 1]and Parent 2: [0, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
No Mutation: Children remains[0, 0, 0, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [0, 0, 0, 0]=0.0}
---------------------------------------------------------------------------
Generation: 2
Individual and Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [1, 0, 0, 1]
Crossover at gene:1 Parent 1: [0, 0, 0, 1]and Parent 2: [1, 0, 1, 0]
After Mutation: [0, 0, 0, 0]
No Mutation: Children remains[1, 0, 1, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [1, 0, 1, 0]=0.0,
[0, 0, 0, 0]=0.0}
Selected Parent 1: [1, 0, 0, 0]and Selected Parent 2: [0, 0, 0, 1]
Crossover at gene:2 Parent 1: [1, 0, 0, 1]and Parent 2: [0, 0, 0, 0]
After Mutation: [1, 0, 1, 1]
No Mutation: Children remains[0, 0, 0, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [0, 0, 0, 0]=0.0,
[1, 0, 1, 1]=0.0}
---------------------------------------------------------------------------
Generation: 3
Individual and Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [1, 0, 0, 1]
Crossover at gene:1 Parent 1: [0, 0, 0, 1]and Parent 2: [1, 0, 1, 0]
No Mutation: Children remains[0, 0, 0, 1]
No Mutation: Children remains[1, 0, 1, 0]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1, [1, 0, 1, 0]=0.0}
Selected Parent 1: [1, 0, 0, 0]and Selected Parent 2: [0, 0, 0, 1]
No Crossover
No Mutation: Children remains[1, 0, 0, 0]
No Mutation: Children remains[0, 0, 0, 1]
New Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
---------------------------------------------------------------------------
Generation: 4
Individual and Fitness: {[0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [0, 0, 1, 0]and Selected Parent 2: [1, 0, 0, 1]
Crossover at gene:3 Parent 1: [0, 0, 1, 1]and Parent 2: [1, 0, 0, 0]
No Mutation: Children remains[0, 0, 1, 1]
No Mutation: Children remains[1, 0, 0, 0]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 1]=0.1}
Selected Parent 1: [1, 0, 0, 0]and Selected Parent 2: [0, 0, 0, 1]
Crossover at gene:1 Parent 1: [1, 0, 0, 1]and Parent 2: [0, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
No Mutation: Children remains[0, 0, 0, 0]
```

```
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [0, 0, 0, 0]=0.0}
--------------------------------------------------------------------------------
Generation: 5
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
No Mutation: Children remains[0, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
No Crossover
No Mutation: Children remains[1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
--------------------------------------------------------------------------------
Generation: 6
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
No Mutation: Children remains[0, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
Crossover at gene:2 Parent 1: [1, 0, 0, 0]and Parent 2: [1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
--------------------------------------------------------------------------------
Generation: 7
Individual and Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
Selected Parent 1: [0, 0, 1, 1]and Selected Parent 2: [0, 0, 1, 0]
Crossover at gene:3 Parent 1: [0, 0, 1, 0]and Parent 2: [0, 0, 1, 1]
No Mutation: Children remains[0, 0, 1, 0]
After Mutation: [1, 0, 1, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2, [1, 0, 1, 1]=0.0}
Selected Parent 1: [1, 0, 0, 1]and Selected Parent 2: [1, 0, 0, 0]
Crossover at gene:1 Parent 1: [1, 0, 0, 0]and Parent 2: [1, 0, 0, 1]
No Mutation: Children remains[1, 0, 0, 0]
No Mutation: Children remains[1, 0, 0, 1]
New Fitness: {[0, 0, 1, 1]=0.6, [0, 0, 1, 0]=0.5, [1, 0, 0, 1]=0.3, [1, 0, 0, 0]=0.2}
--------------------------------------------------------------
Chromosome Selected: [0, 0, 1, 1]  with Fitness Value: 0.6000000238418579
```