Optimisation and Heuristic Methods Project (IM39003)
Term Project

Using Genetic Algorithm and Simulated Annealing to determine the Lending decision in a Bank

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Problem Statement

There is a Bank which Lends Loans to people. When a person asks for a Loan, the bank has a set of characteristics or features regarding the person and the loan on the basis of which it'll decide whether to give or not give the Loan to the person.

Some of the characteristics in regards with the loan are as follows

1. Loan Size : The Amount ($ or Rupees) the person is asking for loan.
2. Loan Interest : How much Interest can the Bank get from the person after the Loan is given.
3. Expected Loan Loss : It is the loss expected when the loan defaults.
4. Financial Institution's Deposit : It is the Amount that the Financial Institution has in its money Reserve.
5. Required Reserve Ratio : It is the minimum amount that the Financial Institution should have in it's Reserve after Giving Loans.
6. Cost of Demand Deposit : It is the cost of maintaining the Deposits that were maintained by other customers in the bank. Interest needs to be payed to the customers by the bank on the money deposited.

And many more like Loan Age, Loan Type etc.

Problem

Calculate the best lending decision when

- ➔ Financial Institution's Deposit (D) = 60
- ➔ Required Reserve Ratio (K) = 0.15

Loan Size	10	25	4	11	18	3	17	15	9	10
Interest	0.021	0.022	0.021	0.027	0.025	0.026	0.023	0.021	0.028	0.022
Rating	AAA	BB	A	AA	BBB	AAA	BB	AAA	A	A
Loss ()	0.0002	0.0058	0.0001	0.0003	0.0024	0.0002	0.0058	0.0002	0.001	0.001

Using Genetic Algorithm

Defining Chromosome and Genes

Each Gene is a Lending Decision, containing each **10** chromosomes. Each Chromosome contains a **1** or **0** which means the following

0 -> Loan is not Granted **1** -> Loan is granted

A Sample Gene [0 0 1 0 1 1 0 1 1 1] is given below.

Lending Decision ->	0	0	1	0	1	1	0	1	1	1
Loan Size	10	25	4	11	18	3	17	15	9	10
Interest	0.021	0.022	0.021	0.027	0.025	0.026	0.023	0.021	0.028	0.022
Rating	AAA	BB	A	AA	BBB	AAA	BB	AAA	A	A
Loss ()	0.0002	0.0058	0.0001	0.0003	0.0024	0.0002	0.0058	0.0002	0.001	0.001

Using Genetic Algorithm (cont..)

$$\text{Fitness Function}\,(F_x) = \vartheta + \varpi - \beta - \sum_{i=0}^{n} \lambda$$

$$\text{Loan Revenue}(\vartheta) = \sum_{i=0}^{n} (r_L L - \lambda)$$

$$\text{Transaction Cost}(T) = (1-K)D - L \text{[K=Required Reserve Ratio ; D=Financial Institution's Deposit]}$$

$$\text{Total Transaction Cost}\,(\varpi) = \sum_{i=0}^{n} (r_T T)$$

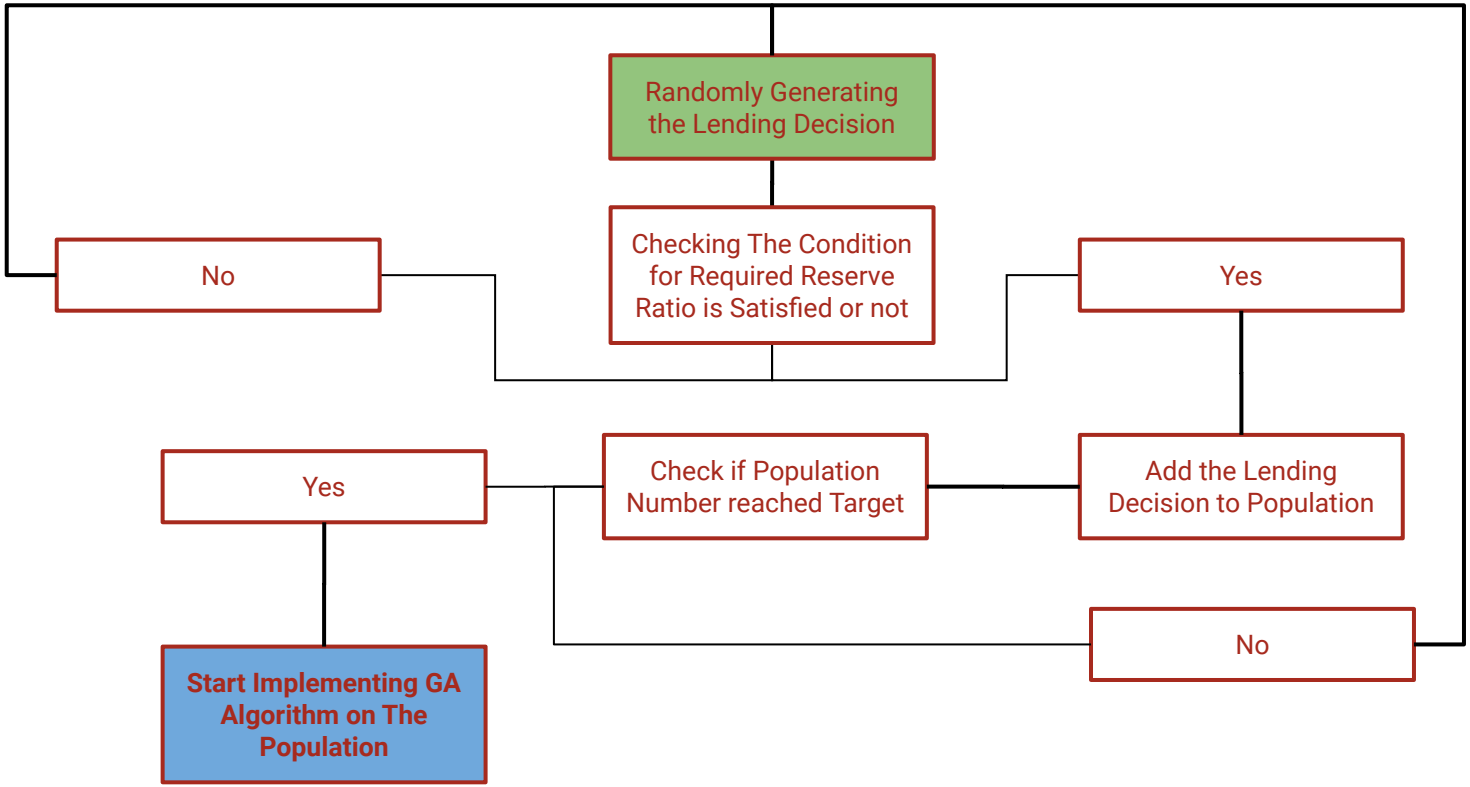
$$\text{Cost of Demand}\,(\beta) = r_D D$$

$$\text{Loan Size}\,(\text{L}) = [10 \quad 25 \quad 4 \quad 11 \quad 18 \quad 3 \quad 17 \quad 15 \quad 9 \quad 10]$$
$$\text{Interest}\,(r_L) = [0.021 \quad 0.022 \quad 0.021 \quad 0.027 \quad 0.025 \quad 0.026 \quad 0.023 \quad 0.021 \quad 0.028 \quad 0.022]$$
$$\text{Loss}\,(\lambda) = [0.0002 \quad 0.0058 \quad 0.0001 \quad 0.0003 \quad 0.0024 \quad 0.0002 \quad 0.0058 \quad 0.0002 \quad 0.001 \quad 0.001]$$
$$\text{Lending Decision}\,(X) = [0 \quad 1 \quad 0 \quad 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 \quad 1]$$
$$D = 60\,;\; K = 0.15\,;\; r_T = 0.01\,;\; r_D = 0.009$$
$$\text{Fitness}\,(F_x) = [(r_L).*(L) + (r_T) * ((1-K) * D - L) - \lambda] * X' - r_D * D$$

Note : For every Lending Decision generated at random the following condition should be satisfied

$(1-K) * D - (L * X.') \geq 0$ [Required Reserve Ratio Condition]

Using Genetic Algorithm (cont..)



Using Genetic Algorithm (cont..)

Parameters taken while Implementing Genetic Algorithm

- Initial Population Number = 60
- Parent Pool Population = 60 pairs
- Number of Generations = 60
- Crossover Probability = 0.8
- Mutation Probability = 0.06
- Parent Pool Selection Method = Roulette Wheel Selection

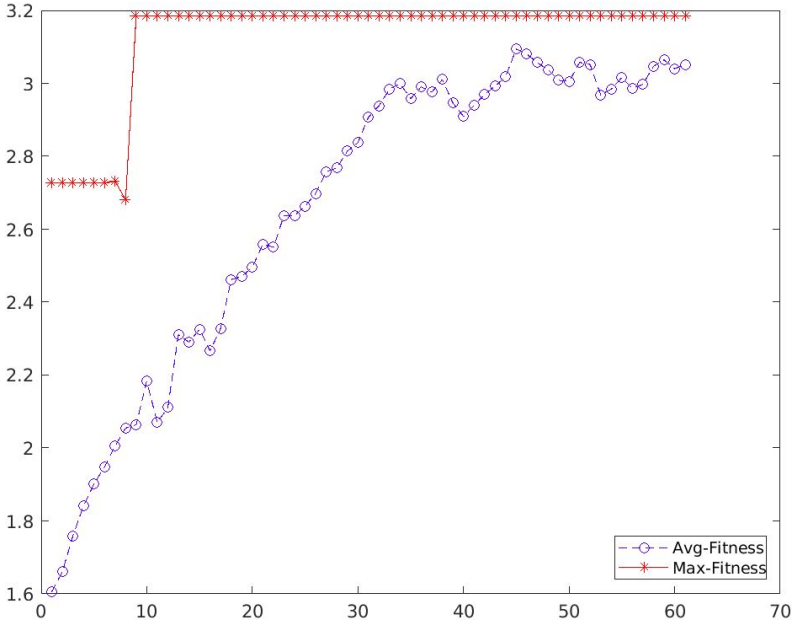
Remarks

- After Children are generated, they too need to be checked for the condition regarding the Required Reserve Ratio and if satisfied then only need to be added to the children pool.
- For Generating Initial Population randomly generate an Integer from 1 to 2^10-1 and convert it into binary.

Results

```
Result - Final Lending Decision
     1     0     1     1     0     1     0     0     1     1

    "Result Fitness"    "3.1854"

    "Total Loan Amount"    "47"

    "Total Loan Revenue"    "1.1382"

Elapsed time is 0.667649 seconds.
```

Lending Decision ->	1	0	1	1	0	1	0	0	1	1
Loan Size	10	25	4	11	18	3	17	15	9	10



Using Simulated Annealing

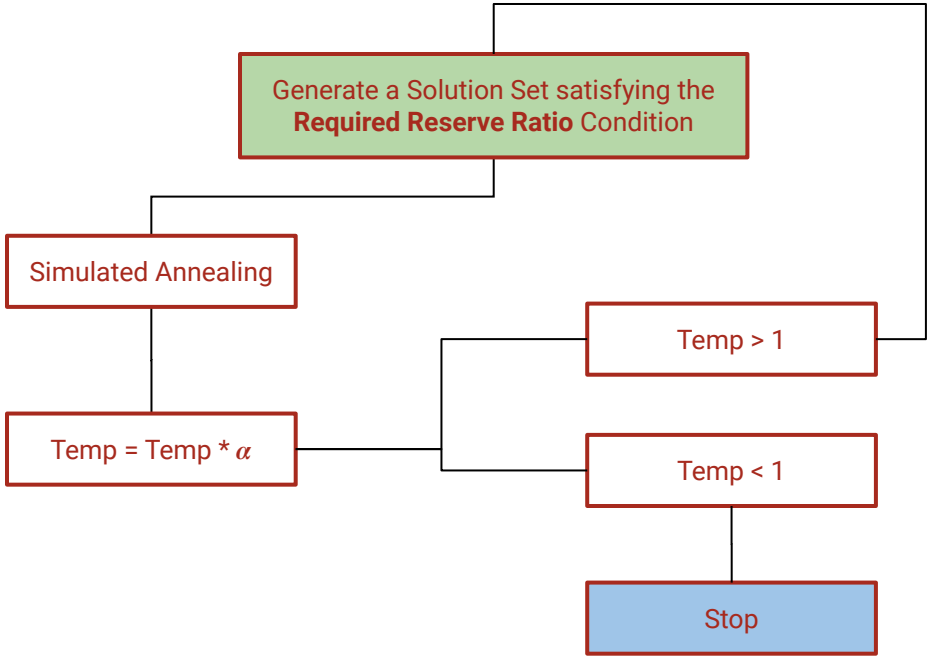
Solution Set is generated in the same way as in the case of Genetic Algorithms. Objective Function is **-ve (Fitness Function)** from Genetic Algorithm. We use Simulated Annealing to Minimize the Obj Function.

Parameters

- Number of Solutions in the Solution Set = 60
- Initial Temperature = 1000
- Cooling Rate (α) = 0.9 *[T_new = α*T_old]*
- Stopping Criteria : stops when Temp<1

Remarks

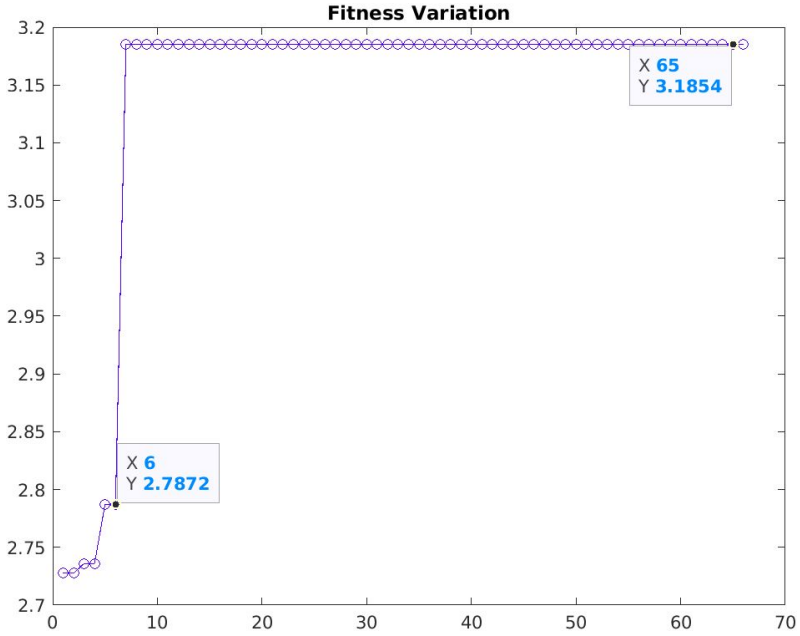
- In the graph we Plot -ve of Objective Function which is Fitness Function.



Results

```
Final Lending Decision (Best Solution)
     1     0     1     1     0     1     0     0     1     1

Fitness of Best Solution
    3.1854

Total Loan Amount
    47

Total Loan Revenue
    1.1382

Elapsed time is 0.325902 seconds.
```

Lending Decision ->	1	0	1	1	0	1	0	0	1	1
Loan Size	10	25	4	11	18	3	17	15	9	10



Comparisons and Inference

- Now as we see from the plots in both implementations the optimal is reached after around 10 iterations.
- But from the results we can see that Genetic Algorithm takes more time when compared to Simulated Annealing.

- As there are other solutions whose fitness is close to the Optimal Value there is a chance that GA might not give it as a result rather than the optimal value. A particular case is shown below.

```
Result - Final Lending Decision
     1     0     1     0     0     1     0     1     1     1

    "Result Fitness"    "3.1636"

    "Total Loan Amount"    "51"

    "Total Loan Revenue"    "1.1563"

Elapsed time is 0.698910 seconds.
```