OPTIMIZING BANK LENDING DECISIONS USING METAHEURISTICS

OHM TERM PROJECT IM39003

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CONTENTS

GENETIC ALGORITHM BASED MODEL FOR OPTIMIZING BANK LENDING DECISIONS

Introduction

The heart of the any financial crisis is whether and how did the banking sector managed to distribute the limited credit available in a way that maximizes their profits in the time of crisis.Therefore, there is a need to set an optimal mechanism of bank lending decisions that will maximize the bank profit in a timely manner.

Bank lending decision has become a primary tool for financial institutions to increase profit, reduce possible risks, and make managerial decisions.

Benefit of Genetic Algorithm Model

The problem of bank lending decision in a credit crunch environment- where all applicable customers are eligible to get the desired loan is an NP-hard optimization problem that can be solved using meta-heuristic algorithms such as evolutionary algorithms.

The main focus of the GA model is two-fold:

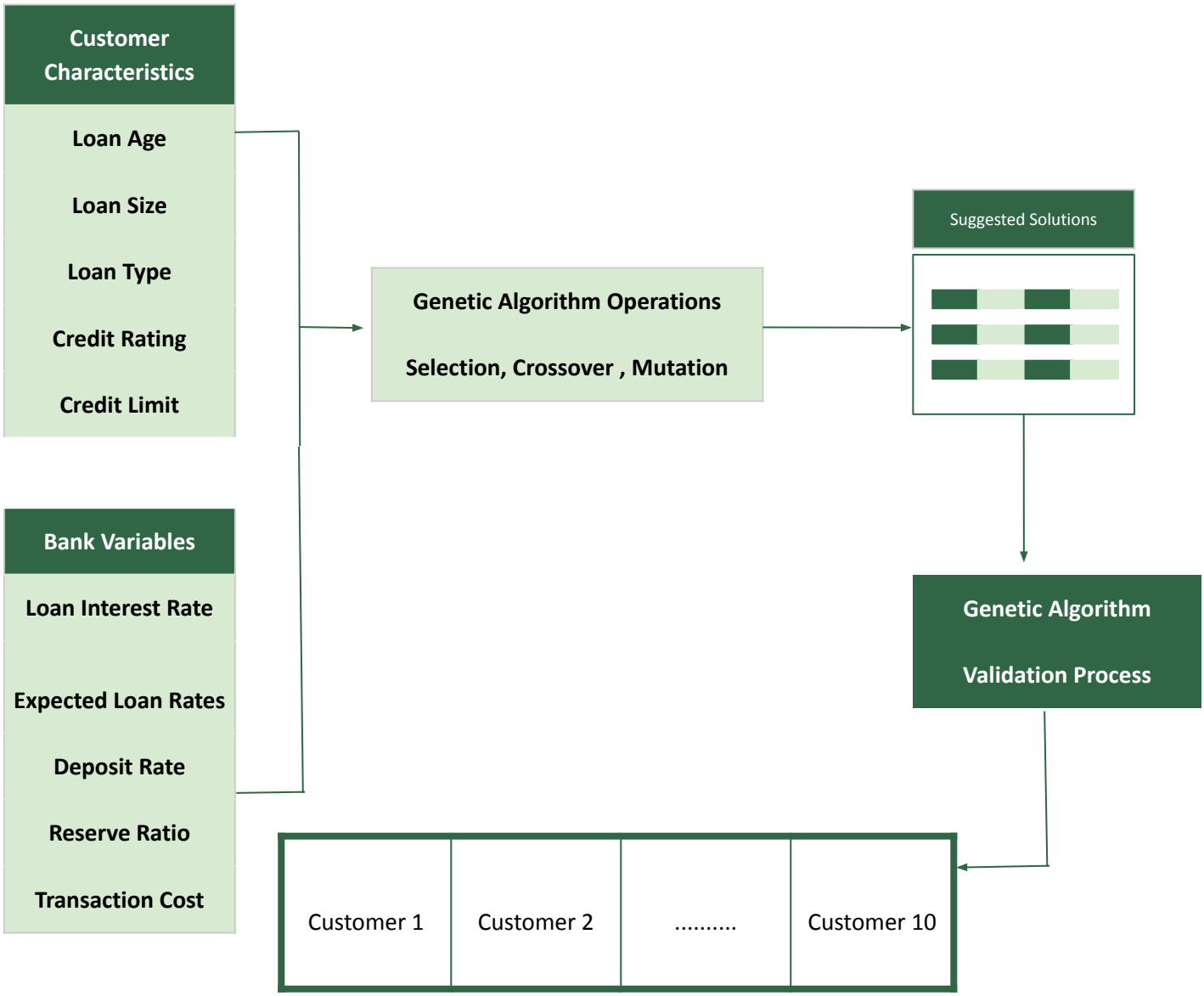
- To stabilize systemically banks while achieving maximum profit
- to establish the capital base so that banks would increase lending efficiently

PROBLEM REPRESENTATION

In our proposed method, the lending decision is dynamically decided based on customer's loan characteristics.

With the assumption that all customers are applicable to get the required loan, GA is employed to search for the most suitable customers depending on a set of factors such as

• Loan age •loan size, •loan interest rate, •loan type, and •borrower credit rating.



PROBLEM FORMULATION

Decision Variables

LOAN AGE α

Varies from 1 to 20

CREDIT LIMIT

maximum loan amount that can be given to the customer based

LOAN SIZE L

determines the amount of loan requested customer

LOAN TYPE ϕ

- Mortgage(M)
- Personal (P)
- Auto (A)

LOAN INTEREST RATE (rL)

Based on the values of ϕ and α, the loan interest rate r L is assigned

EXPECTED LOAN LOSS (λ)

used to determine the range of the expected loan loss

FITNESS FUNCTION

The GA's fitness function (F x) simply consists loan revenue (ϑ), loans cost (μ), total transaction cost (ϖ), and cost of demand deposit (β).

Components of Fitness Function

Loan Revenue (ϑ)

The value of the loan revenue is calculated using the loan interest rate (rL), loan size (L), and the expected loan loss (λ).

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

Loans Cost (μ)

The value of the loan cost is determined using the loan size (L) and the predetermined institutional cost (δ).

$$\mu = \sum_{i=0}^{n} L\delta$$

Total Transaction Cost (ϖ)

The value of the total transaction cost is determined using institute transactional cost (T) [T = (1-K)D - L] and the customer transaction rate (rT). The value of rT has been assumed to be 0.01 for the purpose of this project.

$$\varpi = \sum_{i=0}^{n} r_L T$$

Components of Fitness Function

Cost of Demand deposit (β)

The value is determined using the bank's deposit interest rate (rD) and the bank's deposit (D)

$$\beta = r_D D$$

$$F_X = \vartheta + \mu + \varpi - \beta - \sum_{i=1}^{n} \lambda$$

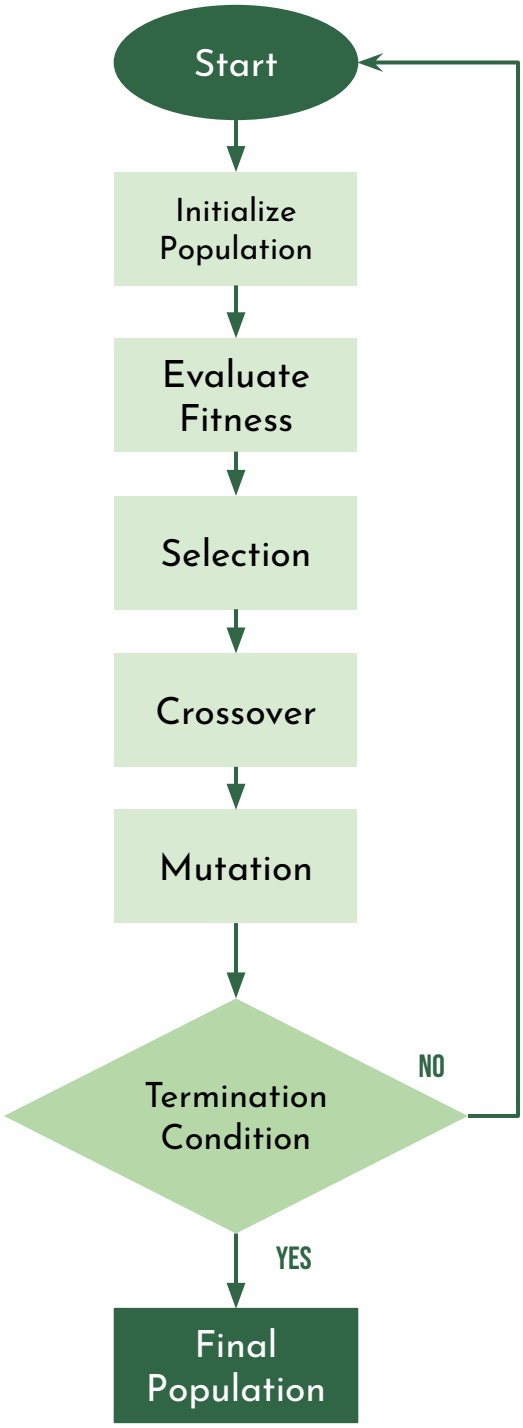
```
#Initializing parameters for Genetic ALgorithm

max_iter=50           # maximum iteration for the algo to run
n=60                  # population size
N=10                  # Number of customers
prob_cross=0.8        # probability of crossover
prob_mut=0.006        # probability of mutation

#Given predefined loan characteristics
D=60                  # Financial institutions's Deposit
K=0.15                # Reserve Ratio
delta=0.0025          # Pre-determined Institutional Cost
rT=0.01               # Customer Transaction Rate
rD=0.009              # Deposit Rate
```

GENETIC ALGORITHM & PARAMETERS

Parameters	
Population size (n)	60
GA Generation(max_iter)	60
Crossover Ratio	0.8
Mutation ratio	0.006
Selection	Roulette Wheel Selection
Crossover	Single Point Crossover
Mutation	Flipping bits
Stopping Criteria	Until max_iter



Steps Involved in Genetic Algorithm

1) Chromosome Encoding

The genes in the chromosome have binary encoding (and therefore have values 0 or 1). The length of the chromosome is equal to the number of eligible borrowers. Each borrower is therefore represented by a gene in the chromosome. A 0 in the gene means that the loan was not provided to the borrower. Similarly, a 1 in the gene means that the loan was provided to the borrower. Each customer is identified by their index number in the chromosome. Therefore, each chromosome with combinations of 0s and 1s represent a loan allocation solution.

	Loan_Size	Interest	Rating	Loss	Loan_Type(phi)
0	10	0.021	AAA	0.0002	M
1	25	0.022	BB	0.0058	M
2	4	0.021	A	0.0001	M
3	11	0.027	AA	0.0003	M
4	18	0.025	BBB	0.0024	M
5	3	0.026	AAA	0.0002	M
6	17	0.023	BB	0.0058	M
7	15	0.021	AAA	0.0002	M
8	9	0.028	A	0.0010	M
9	10	0.022	A	0.0010	M

Dataset of 10 Customers

2) Initializing population

Randomly generate an initial population of chromosomes and validate each randomly generated chromosome (rgc) for feasibility to create a population of feasible solutions.

3) Calculating Fitness Value

Evaluate the fitness of each chromosome in the population and add it to the fitness. Fitness values affect the probability of selection of a chromosome for reproduction meaning that chromosomes which have higher fitness values are more likely to be selected in future generations

4) Selection (Roulette Wheel Selection)

Select mating pool from the original population on the basis of fitness values.The probability of selection of each chromosome is proportional to its corresponding fitness value.Create a mating pool of the same size as the original population consisting of chromosomes selected with the previously described probabilities.

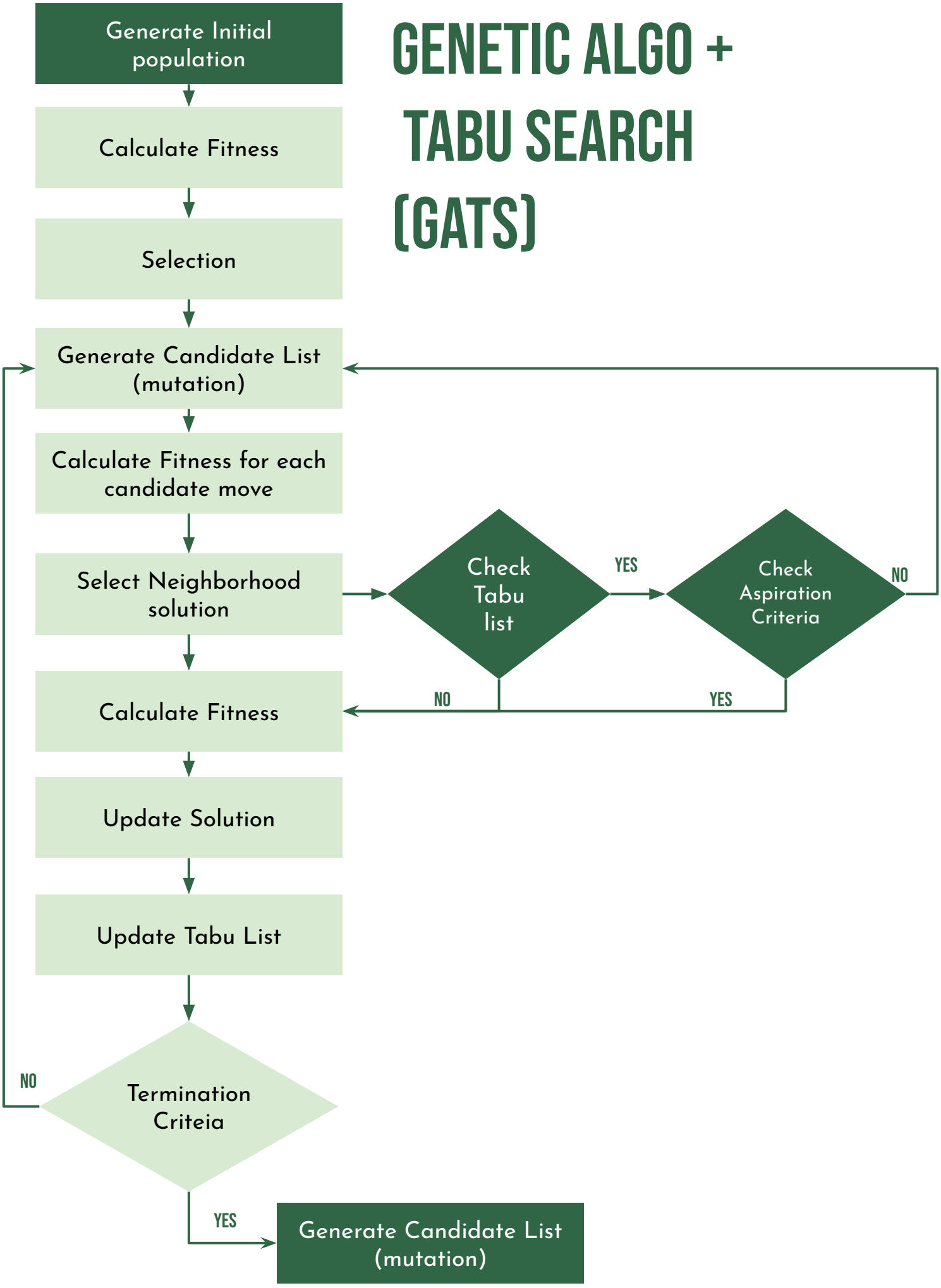
5) Crossover (Single Point Crossover)

In the crossover function pairs of chromosomes are created, then on the basis of the probability of a crossover occurring called the crossover ratio, randomly determine which pairs will undergo crossover. For the pairs which undergo crossover, determine the position of crossover. Choice of crossover - Single point Crossover

6)Mutation (Bit-Inversion)

Mutation is the process of randomly inverting the values of genes in the chromosome to create variety in the solutions. Randomly determine the chromosomes to carry out the mutation on, with the probability equal to the mutation ratio. 1's are changed to 0's and 0's to 1's.

GENETIC ALGO + TABU SEARCH (GATS)



Steps Involved in Genetic Algorithm+Tabu Search

Parameters	
Population size (n)	60
(max_iter)	60
Mutation ratio	0.5
Selection	Roulette Wheel Selection
Aspiration Criteria	If it leads to better fitness value
Mutation	Flipping bits
Stopping Criteria	Until max_iter

1) Chromosome Encoding

Randomly generate an initial population of chromosomes which are feasible Solutions

2) Generate Initial Population

Each borrower is therefore represented by a gene in the chromosome. A 0 in the gene means that the loan was not provided to the borrower. 1 in the gene means that the loan was provided to the borrower.

3) Calculate Fitness of Initial Population

Calculate Fitness of the initial Population which is then used for selection of population by Roulette wheel selection

4) Selection using Roulette Wheel Selection

Using the method of Roulette Wheel Selection , Select mating pool from the original population on the basis of fitness values.

5) Select Initial Chromosome from Selected Population

Randomly select one chromosome from the population . the chosen chromosome is the initial chromosome

6) Generate Candidate List - Mutation(chromosome)

Generate List of 5 neighborhood solution which is called candidate list , by performing mutation operation with probability of mutation=0.5

7) Selection of Neighborhood Solution

Choose a neighborhood solution (chromosome) from the candidate list such that the chromosome has the maximum fitness value from the list

•If the chosen chromosome is not already present in the Tabu list , this chromosome gets updates as the neighborhood solution

•If it is present in the Tabu list , Aspiration Criteria is checked and if the chromosome in Tabu list leads to better solution , it gets updated as neighborhood solution.

8) Calculate Fitness Value of the neighborhood solution

Fitness value of the neighborhood solution is calculated and if the fitness of neighborhood solution is better , the current chromosome is updated and equals to neighbood solution

9) Update Tabu List

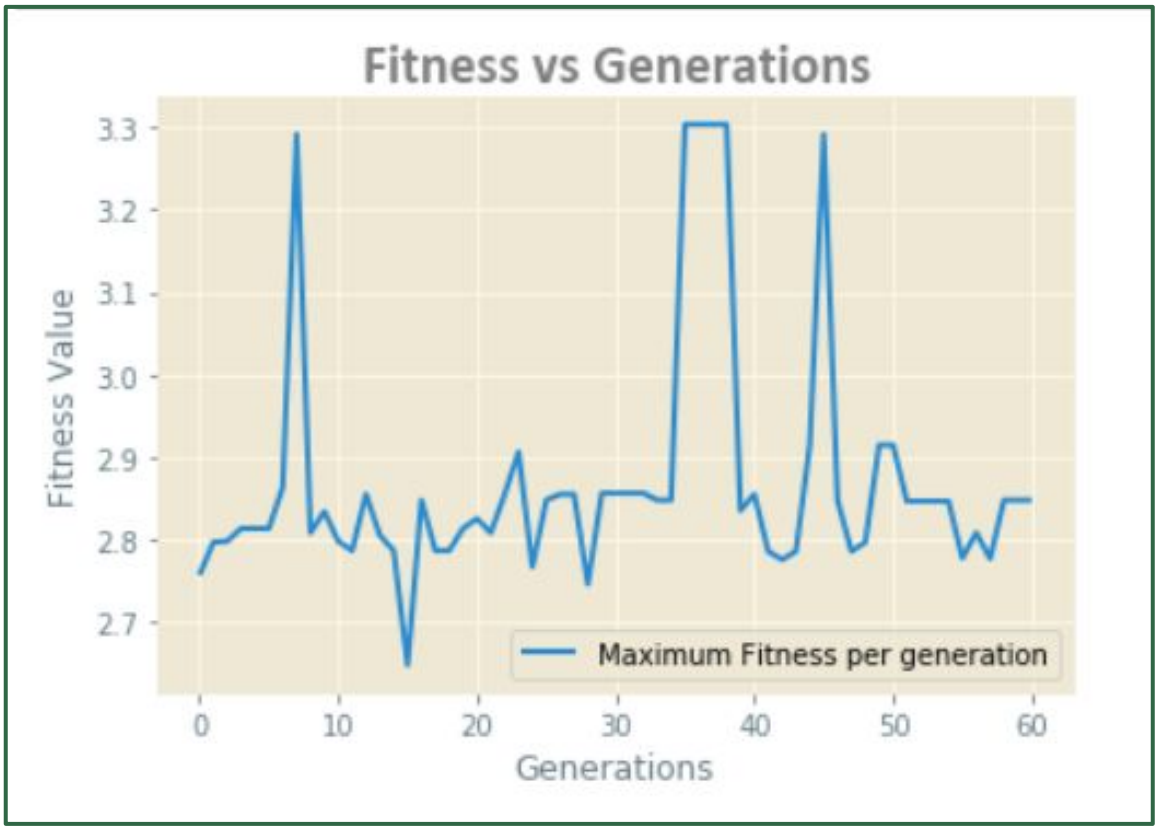
Add the chromosome to Tabu list and update the Tabu counter List

10)Termination Criteria

Repeat the above Until termination criteria reached

RESULTS AND INFERENCE

Genetic Algorithm



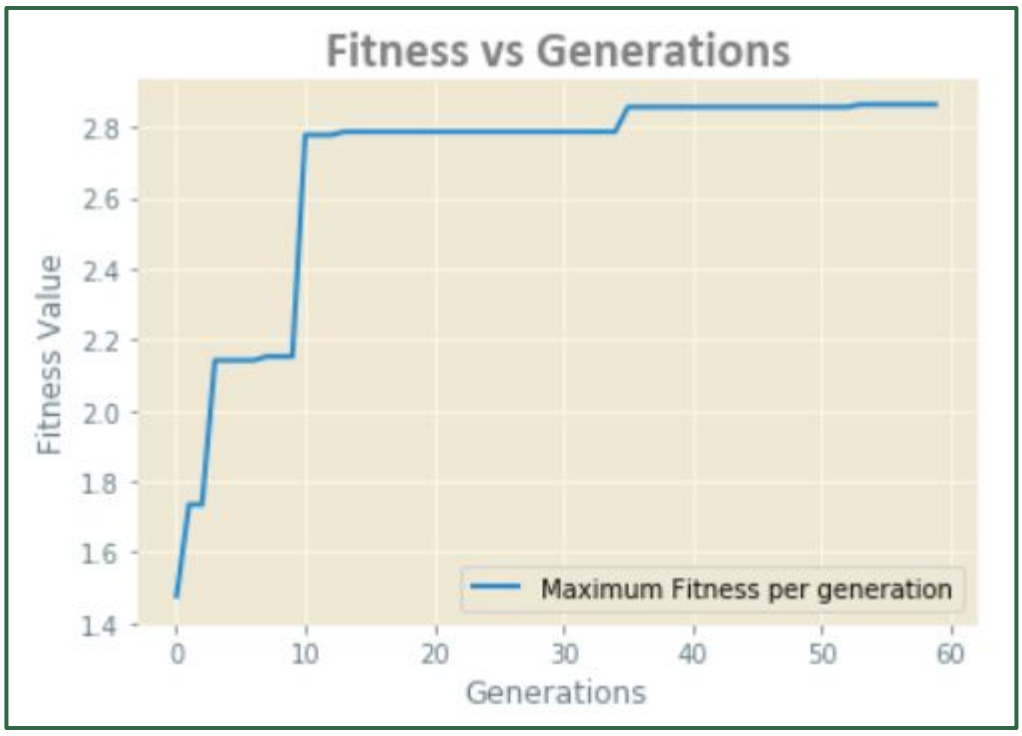
Best Solution Obtained from GA:

1	0	1	1	0	1	0	0	1	1

Best Solution's Fitness Value = 3.3029

Customers 1,3,4,6,9,10 will have their loan sanctioned

GATS (Genetic Algorithm + Tabu Search)



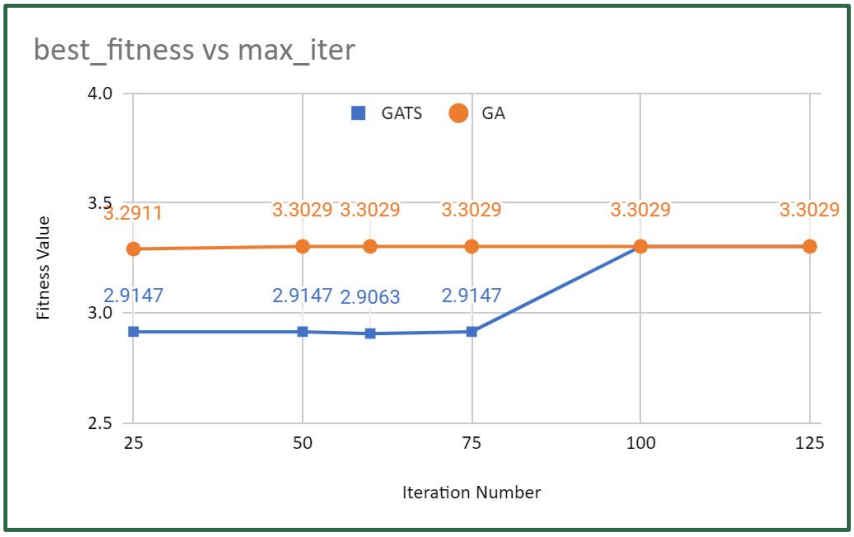
Best Solution Obtained:

0	0	1	0	1	1	1	0	1	0

Best Solution's Fitness Value = 2.86345

Customers 3,5,6,7,9 will have their loan sanctioned

	best_fitness	
Iteration Number	GATS	GA
25	2.9147	3.2911
50	2.9147	3.3029
60	2.9063	3.3029
75	2.9147	3.3029
100	3.3029	3.3029
125	3.3029	3.3029



Inference

- Convergence rate of GA is better than GATS.

  Reason for Convergence of GATS is lesser than GA is that maintaining Tabu list reduces exploration.

- At max iterations = 60 GA achieved optimal solution , fitness value = 3.3029 , where as GATS solution has fitness value of 2.86345

  Thus, performance of GA is better than GATS

Performance of GATS could be improved by, having a •better aspiration criteria , •better method for choosing neighborhood solution , •changing probability of mutation