OHM TERM PROJECT

Optimising Bank Lending Decisions

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PROBLEM STATEMENT

Finding Optimal Lending Decision by Banks to distribute their limited credit available to maximise their profits in times of crisis like credit crunch.

Objective:

- To stabilise the banks systematically while achieving maximum profit.
- Establish the capital base so that banks can increase lending efficiently.

Two techniques are used : Genetic Algorithm and Simulated Annealing to find the optimal solution to the problem.

INTRODUCTION

- In any financial crisis the main problem for the banking sector is to distribute the limited credit available in a way that maximises their profits in the time of crisis.
- This problem of bank lending decisions 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 metaheuristic algorithms such as evolutionary algorithms.
- GAMCC provides a framework to optimize bank objectives when constructing the loan portfolio, by maximizing the bank profit and minimizing the probability of bank default in a search for a dynamic lending decision.
- The main focus of the GA model is two-fold: to stabilise banks systemically while achieving maximum profit, and to establish the capital base so that banks would increase lending efficiently.

- Multiple factors including loan characteristics, creditor ratings and expected loan loss are integrated to GA chromosomes and validation is performed to ensure the optimal decision.

METHODOLOGY

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.

- **Loan size (L)**: The loan size determines the amount of loan requested by a specific customer. This amount is considered an effective variable in lending decisions due to its effect on the total allowable loan amount of the bank which is determined by a required reserve deposit ratio called (rD).

- **Loan interest rate (rL)**: The loan interest rate rL is assigned using interest rates data from world banks.

- **Expected loan loss (λ) and borrow credit rating**: Borrow Credit Rating is used to measure the range of the expected loan loss (λ).

- **Chromosome Encoding:** In GA, a chromosome is a set of parameters or factors that determines a proposed solution to the intended problem. In this model, each gene in the chromosome indicates a candidate customer. The value of a gene can be either 1 or 0, where 1 indicates that the corresponding customer is elected to get the loan and 0 indicates a non-selected customer.

Genetic Algorithm Fitness Function

The reference research paper given laid out formulae to calculate the fitness function Fx.

Fx = Loan Revenue + Transaction Cost – Cost of Demand Deposit – Loan Cost

Loan Revenue = $\sum rLL - \lambda$
Loan Cost = $\sum L\delta$
Transaction Cost = $\sum rTT$
Cost of Demand Deposit = rDD

$T = (1 - K)D - L$
Where, rL = Rate of interest, L = Loan size, λ = Loan loss, δ = Institutional Cost, rR = Transaction Ratio, rD =
deposit ratio, D = Total Deposit,

As given in the paper,
δ = 0.025, rT = 0.01, rD = 0.009,K = 0.15,D = 60
L and rL are unique for every customer

RESULTS

Genetic Algorithm

Initialised Population as 50
Generations: 60

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Generation: 0 SOLUTION [0, 0, 1, 1, 0, 0, 1, 0, 1, 1] FITNESS 2.6083000000000003
Generation: 1 SOLUTION [0, 0, 1, 1, 0, 0, 1, 0, 1, 1] FITNESS 2.6083000000000003
Generation: 2 SOLUTION [0, 0, 0, 1, 0, 1, 1, 0, 1, 1] FITNESS 2.6147
Generation: 3 SOLUTION [0, 0, 0, 1, 0, 1, 1, 0, 1, 1] FITNESS 2.6147
Generation: 4 SOLUTION [0, 0, 0, 1, 0, 1, 1, 0, 1, 1] FITNESS 2.6147
Generation: 5 SOLUTION [0, 0, 0, 1, 0, 1, 1, 0, 1, 1] FITNESS 2.6147
Generation: 6 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
Generation: 7 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
Generation: 8 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
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Generation: 60 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
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Global Best Solution : [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] 3.0707000000000004

SIMULATED ANNEALING

T0 => Initialised from average of 10 random inputs
Cooling Factor (k) => T’ = T – k
Number of Iterations => 100
Stopping Criteria => T_0 = Tf (final temp)

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TEMPERATURE 1.58833 SOLUTION [0, 0, 0, 1, 1, 1, 0, 0, 1, 1] FITNESS 2.6646
TEMPERATURE 1.5089135 SOLUTION [1, 0, 0, 1, 1, 1, 0, 0, 1, 0] FITNESS 2.6554
TEMPERATURE 1.429497 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 1.3500805 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 1.270664 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
TEMPERATURE 1.1912475 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 1.111831 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 1.0324145 SOLUTION [0, 0, 0, 1, 1, 1, 0, 0, 1, 1] FITNESS 2.6646
TEMPERATURE 0.952998 SOLUTION [0, 0, 0, 1, 1, 1, 0, 0, 1, 1] FITNESS 2.6646
TEMPERATURE 0.8735815 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 0.794165 SOLUTION [0, 0, 1, 0, 1, 1, 0, 1, 1, 0] FITNESS 2.5726000000000004
TEMPERATURE 0.7147485 SOLUTION [0, 0, 0, 1, 1, 1, 0, 0, 1, 1] FITNESS 2.6646
TEMPERATURE 0.635332 SOLUTION [0, 0, 1, 1, 0, 0, 1, 0, 1, 1] FITNESS 2.6083000000000003
TEMPERATURE 0.5559155 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
TEMPERATURE 0.476499 SOLUTION [1, 0, 1, 1, 0, 1, 0, 0, 1, 1] FITNESS 3.0707000000000004
TEMPERATURE 0.3970825 SOLUTION [1, 0, 0, 1, 0, 1, 1, 0, 0, 1] FITNESS 2.561
TEMPERATURE 0.317666 SOLUTION [1, 0, 0, 1, 1, 1, 0, 0, 1, 0] FITNESS 2.6554
TEMPERATURE 0.2382495 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
TEMPERATURE 0.158833 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
TEMPERATURE 0.0794165 SOLUTION [1, 0, 1, 0, 0, 1, 0, 1, 1, 1] FITNESS 3.0388
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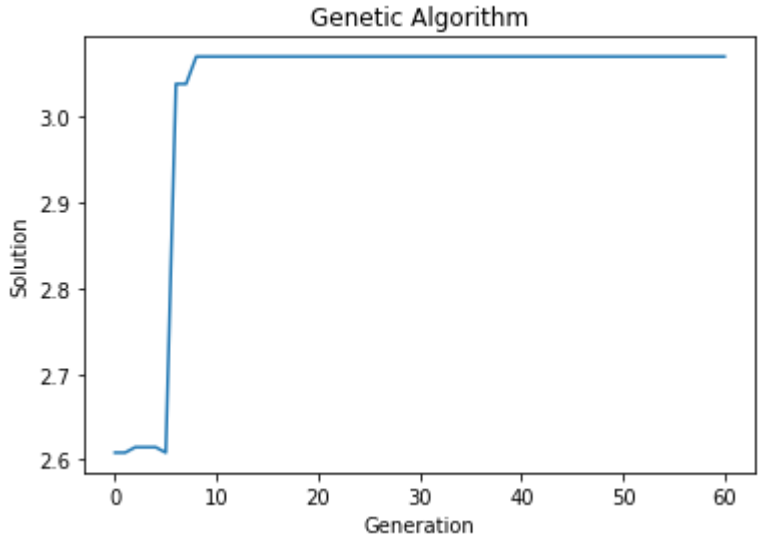
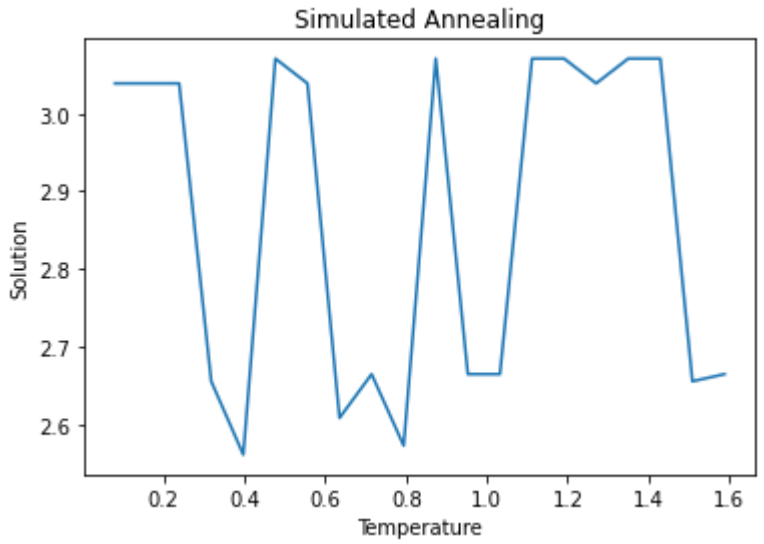
Global Best Solution [1, 0, 1, 1, 0, 1, 0, 0, 1, 1], Fitness 3.0707000000000004

DISCUSSION





Both the genetic algorithm and simulated annealing gave the same best result but in simulated annealing, sometimes at lower temperature results that were obtained are near to the optimal solution but the genetic algorithm is giving optimal solution consistently.

The best solution we have obtained is: [1, 0, 1, 1, 0, 1, 0, 0, 1, 1]

Customers who got 1 are approved for the loan while those who got 0 are disapproved.

Customer	Size	Interest	Rating	Loss	
1	10	0.021	AAA	0.0002	1
2	25	0.022	BB	0.0058	0
3	4	0.021	A	0.0001	1
4	11	0.027	AA	0.0003	1
5	18	0.025	BBB	0.0024	0
6	3	0.026	AAA	0.0002	1
7	17	0.023	BB	0.0058	0
8	15	0.021	AAA	0.0002	0
9	9	0.028	A	0.001	1
10	10	0.022	A	0.001	1