MANIPAL INSTITUTE OF TECHNOLOGY
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Artificial Intelligence (CSE 2225)

MINI PROJECT REPORT ON

Profit Optimization using Genetic Algorithm

SUBMITTED TO

Department of Computer Science & Engineering

by

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INTRODUCTION

1.1 Introduction

In the current economic scenario, it is crucial for businesses to adopt a strategic approach to maximize their profits in a manner that does not compromise the value of their product. Profit Optimization is the process of striking the optimal balance between the services offered by a business versus the costs associated with producing said service. Analyzing the market, production costs and demands of stakeholders will empower the business to make informed decisions and streamline their operations to stay relevant in an ever-growing competitive field. Doing so will ensure that the business stays profitable while offering effective prices in a market that is constantly evolving.

The travel and tourism industry has been identified and chosen for our area of research as there exists a complex and non-linear relationship between the tour service offered and its associated production costs. The production costs are influenced by numerous factors such as destination popularity, accommodation prices, itinerary flexibility etc. Therefore, it is imperative that the travel agency is able to model their requirements so that they can obtain the most favorable outcome, i.e a fully booked tour service that has satisfied its customers' needs.

1.2 Problem Statement

A travel agency desires to maximize their profit for a given travel group. They can do so by considering the following three factors:

1) The number of people facilitated in the tour group depends on the number of rooms available for bulk booking at hotels/lodging. If there's too few customers, the travel agency will not be able to avail group discounts on the number of rooms booked. If the size is too large, the travel agency will struggle to find a hotel that will lease out the required rooms to cater to the group.

2) The number of popular tourist destinations/spots that will be covered by the itinerary. If there's too few, the travel agency will not be able to offer a compelling experience to its customers. If they pack their itinerary with too many spots, the customers will not be able to full enjoy the places which will lead to dissatisfaction.

3) The travel agency must pick suitable restaurants for the customers to dine at in such a manner that the large group can be catered to outside of peak hours. The travel agency must also be able to avail group discounts from the restaurants to minimize costs.

1.3 ***Objective***

1) To develop an AI solution that will maximize the profits of a travel agency.

2) To model the travel agency's cost optimization requirements into a mathematical function which will be solved using the Genetic Algorithm. The AI tool will implement the following constraints:

- Variable X represents the range of the group size staying in a hotel to optimize profit while adhering to the hotel's maximum room capacity.
- Variable Y signifies the number of cities visited in a trip.
- Variable Z denotes the optimal time window for guests' arrival at a restaurant to dine, enabling the agency to gain maximum discounts from restaurants.

3) To make the AI tool user-friendly by allowing the travel agency to enter its own parameter values to check at what point will their cost to profit ratio be the best.

LITERATURE REVIEW

2.1 *Artificial Intelligence (CSE 2225) Module 3*

- The prescribed textbook (Stuart Russell and Peter Norvig – Artificial Intelligence: A Modern Approach, Pearson Education, Third Edition, 2016) was used to gather preliminary knowledge about the genetic algorithm and its working.
- Learnt relevant terminologies such as fitness function, mutation, crossover, reproduction etc to properly understand the functioning of the algorithm.
- Learnt of its application in optimization problems

```
function GENETIC-ALGORITHM(population, FITNESS-FN) returns an individual
  inputs: population, a set of individuals
          FITNESS-FN, a function that measures the fitness of an individual

  repeat
      new_population ← empty set
      for i = 1 to SIZE(population) do
          x ← RANDOM-SELECTION(population, FITNESS-FN)
          y ← RANDOM-SELECTION(population, FITNESS-FN)
          child ← REPRODUCE(x, y)
          if (small random probability) then child ← MUTATE(child)
          add child to new_population
      population ← new_population
  until some individual is fit enough, or enough time has elapsed
  return the best individual in population, according to FITNESS-FN

function REPRODUCE(x, y) returns an individual
  inputs: x, y, parent individuals

  n ← LENGTH(x); c ← random number from 1 to n
  return APPEND(SUBSTRING(x, 1, c), SUBSTRING(y, c + 1, n))
```

Fig 2.1 Genetic Algorithm pseudocode

2.2 *Efficient Economic Profit Maximization: Genetic Algorithm Based Approach*

- The above-mentioned research paper authored by Sankhadeep Chatterjee, Rhitaban Nag, Nilanjan Dey & Amira S. Ashour explains economic theory and the non-linear relation between production costs and output.
- It also explains in detail the usage of genetic algorithm procedure for profit maximization and the steps taken to generate a favourable answer.

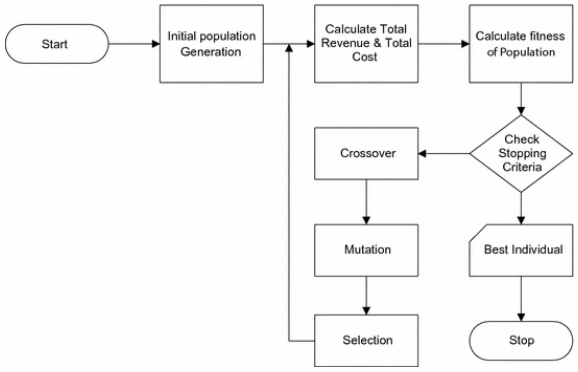

Fig 2.2 Broad application of Genetic Algorithm for profit optimization

METHODOLOGY

3.1 *Methodology*

- We opted to use a genetic algorithm to maximize this function.

```python
def fitness(x, y, z):
    return -(x**2)+(y**2) +(z**2) + 5*x + 4*y + 2*z + 10

def genPop(size):
    population = []
    for i in range(size):
        x = random.uniform(0, 5)
        y = random.uniform(0, 5)
        z = random.uniform(0, 5)
        person = (x, y, z)
        population.append(person)

    return population
```

Fig 3.1: Code Snippet for generating population.

- Here we have initialized a fitness function that needs to be maximized along with what the range of each variable is.
- The generate population function is used to generate a population for the initial run.

```python
def cross(parent1, parent2):
    crossPoint = random.uniform(0, 1)
    kid1 = (
        crossPoint * parent1[0] + (1 - crossPoint) * parent2[0],
        crossPoint * parent1[1] + (1 - crossPoint) * parent2[1],
        crossPoint * parent1[2] + (1 - crossPoint) * parent2[2]
    )

    kid2 = (
        crossPoint * parent2[0] + (1 - crossPoint) * parent1[0],
        crossPoint * parent2[1] + (1 - crossPoint) * parent1[1],
        crossPoint * parent2[2] + (1 - crossPoint) * parent1[2]
    )

    return kid1, kid2

def selection(gen, fitnessval):
    total_sum = sum(fitnessval)
    calcProbs = []
    for fit in fitnessval:
        probability = fit / total_sum
        calcProbs.append(probability)
    return random.choices(gen, calcProbs, k=2)

def mutation(chromosome, mutation_rate):
    mutatedx = max(0, min(chromosome[0] + random.gauss(0, mutation_rate), 5))
    mutatedy = max(0, min(chromosome[1] + random.gauss(0, mutation_rate), 5))
    mutatedz = max(0, min(chromosome[2] + random.gauss(0, mutation_rate), 5))
    return mutatedx, mutatedy, mutatedz
```

Fig 3.2: Code Snippet for crossover, selection, and mutation functions

- The genetic algorithm first creates a random population then loops over each generation while selecting half the population size as parents and discarding the others, now using crossover and mutation a new population is created which will become the parents for the next generation. Now this process occurs for a 1000 generations as in the code with a mutation rate of 0.1 or 10%.

```
def genetic_algorithm(size = 300,generations = 3000,mutRate = 0.05):
    population = genPop(size)
    for i in range(generations):
        fitness_values=[]
        for x,y,z in population:
            fitness_each=fitness(x, y, z)
            fitness_values.append(fitness_each)

        parents=[]
        for i in range(size // 2):
            parent=selection(population, fitness_values)
            parents.append(parent)

        newPop = []
        for parent1, parent2 in parents:
            offspring1, offspring2 = cross(parent1, parent2)
            offspring1 = mutation(offspring1, mutRate)
            offspring2 = mutation(offspring2, mutRate)
            newPop.extend([offspring1, offspring2])
        population = newPop

    peak = max(population, key=lambda x: fitness(x[0], x[1], x[2]))
    return peak
```

Fig 3.3: Code Snippet of the GA function calls

- The population after 1000 generations is sorted based on fitness function and the highest values are taken as the answer.

```
best_solution = genetic_algorithm()
print("Best solution:", best_solution)
print("Maximum value:", fitness_function(best_solution[0], best_solution[1], best_solution[2]))
```

Fig 3.4: Code Snippet for result

RESULTS

4.1 Results

```
arcot@Anirvesh_G15 MINGW64 ~/OneDrive/Desktop/MRM-TaskPhase (main)
$ C:/Users/arcot/AppData/Local/Programs/Python/Python311/python.exe c:/Users/arcot/OneDrive/Desktop/MRM-TaskPhase/genetic.py
solution: (2.5110912092211266, 5, 1.0076707665532854)
 value: 62.2498181444185

arcot@Anirvesh_G15 MINGW64 ~/OneDrive/Desktop/MRM-TaskPhase (main)
$ C:/Users/arcot/AppData/Local/Programs/Python/Python311/python.exe c:/Users/arcot/OneDrive/Desktop/MRM-TaskPhase/genetic.py
solution: (2.6152095811070115, 5, 0.9959865818794591)
 value: 62.23671064489614

arcot@Anirvesh_G15 MINGW64 ~/OneDrive/Desktop/MRM-TaskPhase (main)
$ C:/Users/arcot/AppData/Local/Programs/Python/Python311/python.exe c:/Users/arcot/OneDrive/Desktop/MRM-TaskPhase/genetic.py
solution: (2.189647554391077, 5, 0.7826755500839824)
 value: 62.10645144297326
```

Fig 4.1: Output of the algorithm after multiple runs remains consistent

4.2 Discussion

- It is observed that the optimal solution is to have a minimal offset of around 1 hour to have 2 people for the trip and visit 5 places. This is for the range of 0 -5 for people , 0-10 for place and 0-2 for time offset.
- The maximiser works well for small ranges but when the range becomes too large the random function is free to choose a wider range of numbers and hence the initialization itself is skewed.

CONCLUSION & FUTURE ENHANCEMENTS

5.1 Conclusion

In today's world competition is any field of business is a given. Businesses must be able to make profits while providing a great customer experience. Harnessing the power of artificial intelligence presents a transformative opportunity for businesses to revolutionize their operations and maximize profits. One of the ways for businesses to be viable is to make use of AI based methods to increase profits while providing utmost customer satisfaction. AI aids in quick decision making as it can scan through vast amounts of data in a short time and provide efficient solutions to the problems. This project aims to solve the very same problem. By taking multiple inputs about the planned trip, this AI model suggests the most efficient way in which a company can maximise their profits while not compromising on customer satisfaction.

5.1 Future Enhancements

As we look ahead to the future of AI models designed to maximize company profits, several exciting enhancements are poised to revolutionize the field. These advancements not only promise greater efficiency and accuracy but also aim to address key challenges and expand the capabilities of profit optimization algorithms.

1. Increase in number of Parameters: Currently the model takes only takes 3 inputs to maximize the profit, the model can be improved to take a higher number of inputs so that more parameters can be maximize hence overall cost reduces.

2. Continuous Performance Monitoring and Optimization: AI models will implement continuous performance monitoring and optimization mechanisms to track key performance indicators, identify areas for improvement, and refine profit-maximizing strategies over time. This will make sure that the model learns from every trip the travel agency organizes and works on itself so that it can provide better results to plan the upcoming trips.

REFERENCES

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- Artificial Intelligence: A Modern Approach Third Edition Stuart J. Russell and Peter Norvig ~Prescribed Textbook

- https://www.sniffie.io/pricing-vocabulary/profit-optimization/~ Economic Theory

CONTRIBUTIONS:

- *Anirvesh Arcot:* Worked on the genetic algorithm code to obtain the necessary output pertaining to the constraints.
- *Sania Serrao:* Researched the application of genetic algorithm for profit optimization and helped improve the accuracy of the output. Compiled the report.
- *Viraj Edlabadkar:* Formalized the problem statement into the ranges required for the code and helped choose the fitness function. Compiled the synopsis.

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Artificial Intelligence (CSE 2225) MINI PROJECT REPORT ON Profit Optimization using Genetic Algorithm SUBMITTED TO Department of Computer Science & Engineering by Name: Anirvesh Arcot Registration Number: 220962388 Roll No: 61 Semester: IV Name: Sania Serrao Registration Number: 220962101 Roll No: 24 Semester: IV Name: Viraj Edlabadkar Registration Number: 220962105 Roll No: 26 Semester: IV Name & Signature of Evaluator (Jan 2024 - May 2024) Table of Contents Page No Chapter 1 INTRODUCTION 1.1 Introduction 3 1.2 Problem Statement 3 1.3 Objective 4 Chapter 2 LITERATURE REVIEW 2.1 Course Content 5 2.2 Research Paper 5 Chapter 3 METHODOLOGY 3.1 Methodology 6 Chapter 4 RESULTS AND DISCUSSION 4.1 Results 8 4.2 Discussion 8 Chapter 5 CONCLUSIONS AND FUTURE ENHANCEMENTS 5.1 Conclusions 9 5.2 Future Enhancements 9 REFERENCES 10 CONTRIBUTIONS 10 INTRODUCTION 1.1 Introduction In the current economic scenario, it is crucial for businesses to adopt a strategic approach to maximize their profits in a manner that does not compromise the value of their product. Profit Optimization is the process of striking the optimal balance between the services offered by a business versus the costs associated with producing said service. Analyzing the market, production costs and demands of stakeholders will empower the business to make informed decisions and streamline their operations to stay relevant in an ever-growing competitive field. Doing so will ensure that the business stays profitable while offering effective prices in a market that is constantly evolving. The travel and tourism industry has been identified and chosen for our area of research as there exists a complex and non-linear relationship between the tour service offered and its associated production costs. The production costs are influenced by numerous factors such as destination popularity, accommodation prices, itinerary flexibility etc. Therefore, it is imperative that the travel agency is able to model their requirements so that they can obtain the most favorable outcome, i.e a fully booked tour service that has satisfied its customers' needs. 1.2 Problem Statement A travel agency desires to maximize their profit for a given travel group. They can do so by considering the following three factors: 1) The number of people facilitated in the tour group depends on the number of rooms available for bulk booking at hotels/lodging. If there's too few customers, the travel agency will not be able to avail group discounts on the number of rooms booked. If the size is too large, the travel agency will struggle to find a hotel that will lease out the required rooms to cater to the group. 2) The number of popular tourist destinations/spots that will be covered by the itinerary. If there's too few, the travel agency will not be able to offer a compelling experience to its customers. If they pack their itinerary with too many spots, the customers will not be able to full enjoy the places which will lead to dissatisfaction. 3) The travel agency must pick suitable restaurants for the customers to dine at in such a manner that the large group can be catered to outside of peak hours. The travel agency must also be able to avail group discounts from the restaurants to minimize costs. 1.3 Objective 1) To develop an AI solution that will maximize the profits of a travel agency. 2) To model the travel agency's cost optimization requirements into a mathematical function which will be solved using the Genetic Algorithm. The AI tool will implement the following constraints: ? Variable X represents the range of the group size staying in a hotel to optimize profit while adhering to the hotel's maximum room capacity. ? Variable Y signifies the number of cities visited in a trip. ? Variable Z denotes the optimal time window for guests' arrival at a restaurant to dine, enabling the agency to gain maximum discounts from restaurants. 3) To make the AI tool user-friendly by allowing the travel agency to enter its own parameter values to check at what point will their cost to profit ratio be the best. LITERATURE REVIEW 2.1 Artificial Intelligence (CSE 2225) Module 3 ? The prescribed textbook (Stuart Russell and Peter Norvig – Artificial Intelligence: A Modern Approach, Pearson Education, Third Edition, 2016) was used to gather

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Here we have initialized a fitness function that needs to be maximized along with what the range of each variable is. ? The generate population function is used to generate a population for the initial run. Fig 3.2: Code Snippet for crossover, selection, and mutation functions ? The genetic algorithm first creates a random population then loops over each generation while selecting half the population size as parents and discarding the others, now using crossover and mutation a new population is created which will become the parents for the next generation. Now this process occurs for a 1000 generations as in the code with a mutation rate of 0.1 or 10%. Fig 3.3: Code Snippet of the GA function calls ? The population after 1000 generations is sorted based on fitness function and the highest values are taken as the answer. Fig 3.4: Code Snippet for result RESULTS 4.1 Results Fig 4.1: Output of the algorithm after multiple runs remains consistent 4.2 Discussion ? 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Sania Serrao: Researched the application of genetic algorithm for profit optimization and helped improve the accuracy of the output. Compiled the report. ? Viraj Edlabadkar: Formalized the problem statement into the ranges required for the code and helped choose the fitness function. 2 3 4 5 6 7 8 9 10