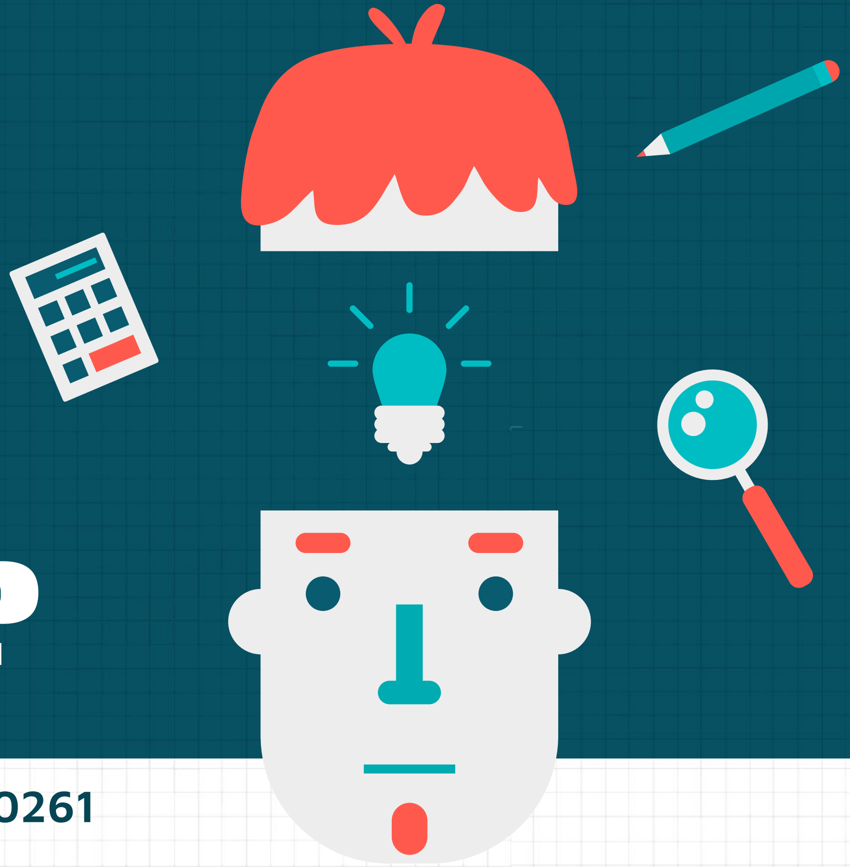
Comparing GA and Google OR To Solve VRP



LM01
Group 8

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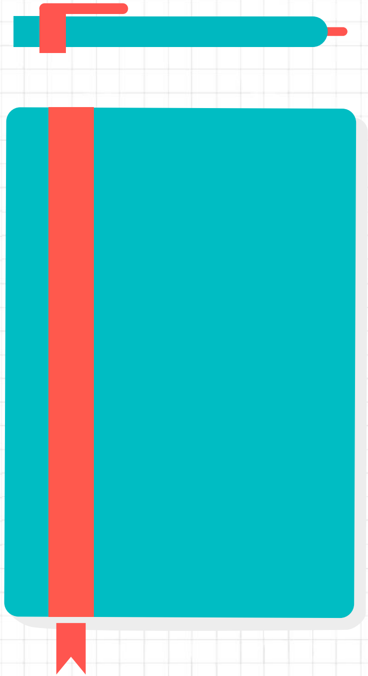
Introduction

Vehicle Routing Problem (VRP) is a Routing Problem based On the Travelling salesman Problem, with added number of vehicles. The purpose of solving VRP is to find an optimal Route for the vehicles to deliver items.

Literature Review



- VRP is explained as an operation find the minimum cost of transportation and minimum distances in distributing items from depot to some customers or store exactly one time (Martins et al., 2020)
- VRP has many variations over the years, such as Open Vehicle Routing Problem(OVRP), Vehicle Routing Problem with Simultaneous Pickup and Delivery (VRPSD), Capacitated Vehicle Routing Problem (CVRP). Among many of the variations we decided to focus on one variation of the VRP, that is CVRP
- Capacitated Vehicle Routing Problem (CVRP) is a variation of VRP that considers a vehicle's maximum capacity (Bala et al., 2018)
- Methods to solve VRP and TSP have been developed by many researchers these past years(Mat et al. , 2017) such as, Heuristics Algorithm, Ant Colony Algorithm, Genetic Algorithm, reinforcement learning
- Aside from reinforcement learning, OR-Tools has advantages compared to other algorithms as in (Wu et al., 2020), it has less computational time than RL

Problem Definition

Among many type of VRP, we choose CVRP (Capacitated Vehicle Routing Problem) as our main problem. Where every vehicle have a limited carrying capacity, the goals would be to deliver item at various locations while simultaneously picking up items at the deliver spot.

To solve this VRP we compared two famous methods that are proven to solve CVRP at optimal result. Genetic Algorithm and Google OR. Later, we compared the total distance and computational time computed by both algorithm to find the most optimal algorithm for this problem.

Methodology

Data Collection and Processing

Collecting datasets from some sources to obtain a diversity of datasets and number routes. The datasets is contain two components, first is the coordinates and second is the demand. Format of the datasets is .txt file.

Process

- Read data from .txt file
- Generate distance matrix from coordinates
- Transform data to certain format

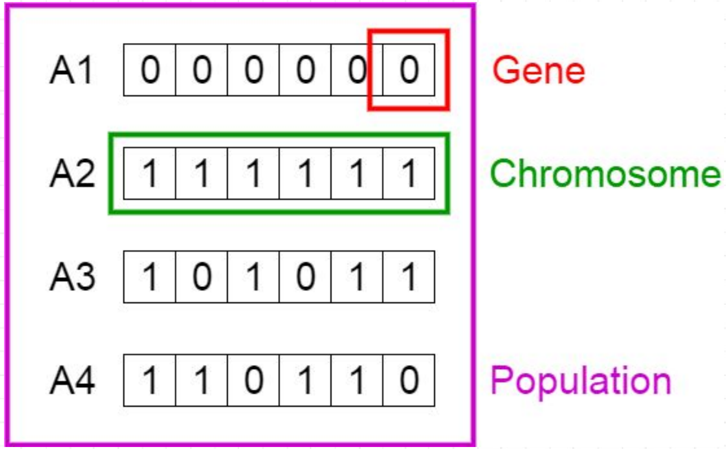
The tests are conducted on Google Colab Platform with 12.69GB of RAM and 38.72GB of disk capacity.

Methodology - Algorithm

Genetic Algorithm

- Chromosome
  Set of parameters that represent the solution of the CVRP. Each chromosome is unique and only represents one solution.

- Population
  Possible solution that contains chromosomes.



Methodology - Algorithm

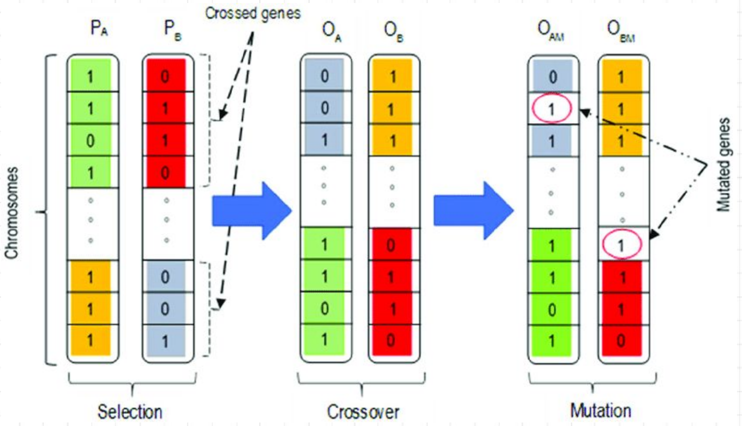
Genetic Algorithm

- Fitness Function

  Determines the fitness of a solution that consists of total distance that needed to go through each route with the sequence on the corresponding chromosome.

- Crossover Operator

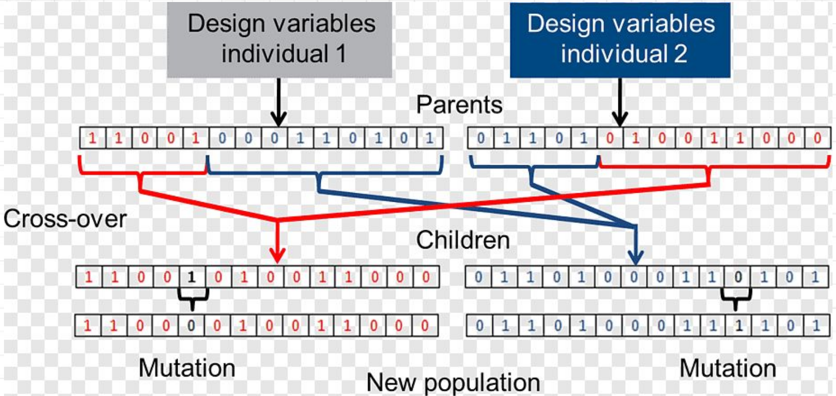
  Used to combine the genetic information of two parents to generate new offspring. It is one way to stochastically generate new solutions from an existing population in each generation.



Methodology - Algorithm

Genetic Algorithm

- Mutation
  Mutation defined as random tweak in the chromosome, to get a new solution. The objective is to maintain genetic diversity from one generation of a population of genetic algorithm chromosomes to the next. The mutation chance is 10% for every generation.



Methodology - Algorithm

Google OR

- Distance Callback
  A function that takes any pair of locations and returns the distance between them. It also sets the arc costs, which define the cost of travel, to be the distances of the arcs.
- Demand Callback and Capacity Constraints
  Returns the demand at each location, and a dimension for the capacity constraints.
- Solving the vehicle routing problems is mainly done using approximate methods (namely local search), potentially combined with exact techniques based on dynamic programming and exhaustive tree search.

Datasets (Coordinates, Demand)

5 Routes

Solomon 1987 - C208

Vehicle = 2 car x 50
Demand = 70

20 Routes

github.com/Valdecy

Vehicle = 4 car x 6000
Demand = 22.500

25 Routes

Solomon 1987 - C203

Vehicle = 5 car x 200
Demand = 460

50 Routes

Solomon 1987 - C205

Vehicle = 10 car x 90
Demand = 860

100 Routes

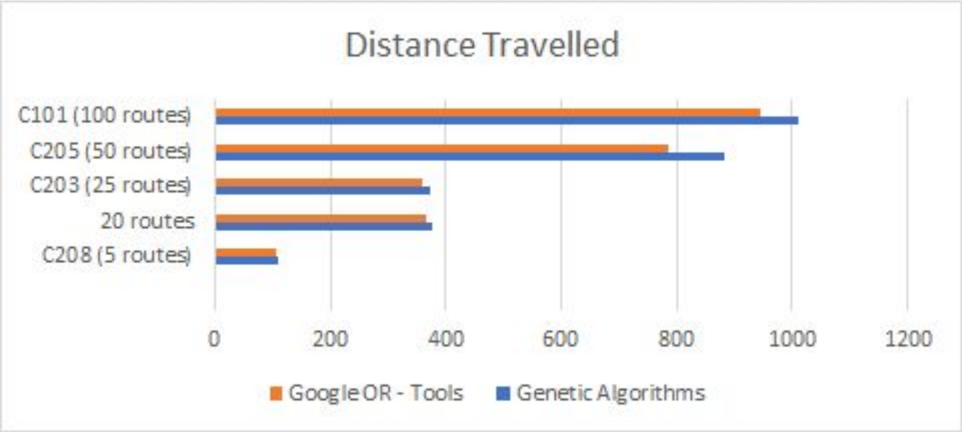
Solomon 1987 - C101

Vehicle = 25 car x 200
Demand = 1810

Results

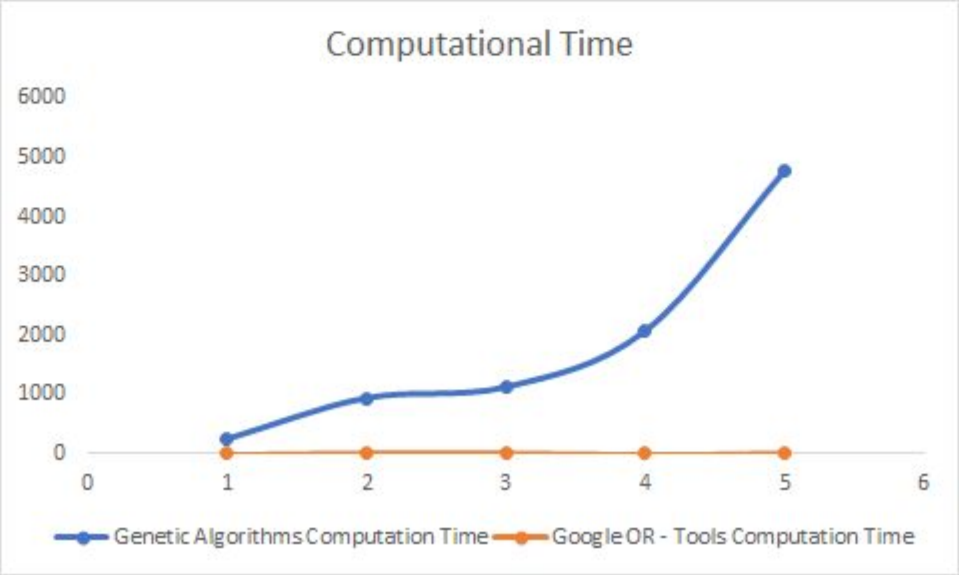
	Genetic Algorithms		Google OR - Tools	
Instances	Distance	Computation Time	Distance	Computation Time
C208 (5 routes)	110.19	228.84s	106	1.01s
20 routes	375.28	928.26s	367	1.02s
C203 (25 routes)	371.32	1113.8s	359	1.02s
C205 (50 routes)	883.9	2068.74s	785	1.01s
C101 (100 routes)	1009.47	4789.68s	946	1.02s

Results



Note: The Further the distance travelled, the less efficient the algorithm performs

Results


Computational Time
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
Genetic Algorithms Computation Time
Google OR - Tools Computation Time

Conclusions

Distance

For the first three instances, both algorithm performs almost the same. Starting from 50 coordinates, OR - Tools outperforms GA substantially

Computational Time

Google’s OR tool has substantially less computational time compared to Genetic Algorithm in all cases presented

Thank You