1. ***Introduction***

The genetic algorithm, encompassing the concept of “survival of the fittest”, takes into account the structure and behaviour of a gene, where each gene has its own unique identity and a collection of genes with the same length resides in each chromosome. In the genetic algorithm implemented for this task, each gene represents a customer (or delivery location) which the company will deliver goods to, and each chromosome represents a unique travelling route of a fleet of vehicles dispatched by the company across each delivery location specified.

1. ***Implementation***

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| **Algorithm 1.** Genetic algorithm pseudocode. | | | | | |
| **Input:** | | | List of customers with their respective longitude, latitude, and demand,  List of vehicles with their respective capacities and costs | | |
| **Output:** | | | The best solution containing routes of each dispatched vehicle,  The cost of the best solution | | |
| 1. | Initialise population size, number of generations, tournament size, and mutation rate | | | | |
| 2. | **While** no valid solution found: | | | | |
| 3. |  | Initialise population of first generation | | | |
| 4. |  | **For** each generation: | | | |
| 5. |  |  | | **While** new population is not full: | |
| 6. |  |  | |  | Select two parent chromosomes via tournament selection from the previous generation |
| 7. |  |  | |  | Apply crossover to create two child chromosomes |
| 8. |  |  | |  | Using random probability, apply mutation to child chromosomes |
| 9. |  |  | | **End while** | |
| 10. |  |  | | Current population ← New population | |
| 11. |  | **End for** | | | |
| 12. |  | Best solution ← Chromosome with best (minimal) fitness value | | | |
| 13. |  | **If** best solution is valid: | | | |
| 14. |  |  | | **End while** | |
| 15. | Best cost ← calculate fitness value (route cost) of best solution | | | | |
| 16. | Return best solution and best cost | | | | |

The efficiency of the route in each chromosome is evaluated by their respective fitness values, which is calculated from the sum of the products of each dispatched vehicle’s route distance and the cost of the respective vehicle per kilometre (km) travelled, whereby each vehicle starts and ends their route at the same depot location. The Euclidean distance formula as shown in Equation (1) is used to calculate the distance between two locations.

(1)

A number of chromosomes reside in each population, and a new population is created in each generation for a number of generations specified, by selecting two parent chromosomes from the previous generation via tournament selection, then carrying out crossover on the parent chromosomes and mutation on the two children chromosomes created. The process of tournament selection, crossover, and mutation takes place continuously until the new population is full. Since each tournament is an independent event where the best chromosome among a randomly chosen subset of the population is selected, this ensures that the fittest chromosomes have a higher chance of being propagated to the next generation.

The algorithm will run until it reaches the specified number of generations, then checks if the final selected route is valid in terms of the constraints (each delivery location visited exactly once). If the final selected route is valid, then the loop terminates.

1. ***Results***

The following table shows multiple valid solutions generated by the algorithm in several runs:

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| Total Distance = 132.30048071569578 km  Total Cost = RM 175.26  Vehicle 1 (Type A):  Round Trip Distance: 54.082 km, Cost: RM 64.90, Demand: 24  Depot -> C5 (10.483 km) -> C1 (4.839 km) -> C2 (5.012 km) -> C3 (10.827 km) -> C7 (16.413 km) -> Depot (6.508 km)  Vehicle 2 (Type B):  Round Trip Distance: 54.995 km, Cost: RM 82.49, Demand: 27  Depot -> C9 (11.691 km) -> C10 (5.060 km) -> C6 (14.325 km) -> C4 (9.776 km) -> Depot (14.142 km)  Vehicle 3 (Type A):  Round Trip Distance: 23.224 km, Cost: RM 27.87, Demand: 6  Depot -> C8 (11.612 km) -> Depot (11.612 km) |
| Total Distance = 123.365179630506 km  Total Cost = RM 166.91  Vehicle 1 (Type A):  Round Trip Distance: 32.166 km, Cost: RM 38.60, Demand: 24  Depot -> C7 (6.508 km) -> C2 (10.746 km) -> C6 (1.834 km) -> C5 (2.594 km) -> Depot (10.483 km)  Vehicle 2 (Type B):  Round Trip Distance: 62.915 km, Cost: RM 94.37, Demand: 27  Depot -> C1 (13.152 km) -> C3 (10.620 km) -> C8 (14.290 km) -> C9 (11.358 km) -> C10 (5.060 km) -> Depot (8.436 km)  Vehicle 3 (Type A):  Round Trip Distance: 28.284 km, Cost: RM 33.94, Demand: 6  Depot -> C4 (14.142 km) -> Depot (14.142 km) |
| Total Distance = 134.5577248226585 km  Total Cost = RM 179.13  Vehicle 1 (Type A):  Round Trip Distance: 58.828 km, Cost: RM 70.59, Demand: 23  Depot -> C7 (6.508 km) -> C2 (10.746 km) -> C4 (8.006 km) -> C8 (21.955 km) -> Depot (11.612 km)  Vehicle 2 (Type B):  Round Trip Distance: 58.859 km, Cost: RM 88.29, Demand: 26  Depot -> C3 (10.347 km) -> C1 (10.620 km) -> C5 (4.839 km) -> C6 (2.594 km) -> C9 (18.768 km) -> Depot (11.691 km)  Vehicle 3 (Type A):  Round Trip Distance: 16.871 km, Cost: RM 20.25, Demand: 8  Depot -> C10 (8.436 km) -> Depot (8.436 km) |