Medicines Distribution Management

PARTICLE SWARM OPTIMIZATION ALGORITHM FOR MEDICINES DISTRIBUTION WITH SIMULTANEOUS PICKUP AND DELIVERY

Problem Statement

- The distribution of medicines from pharmaceutical company to medical stores involves delivery of new medicines along with collection of expired medicines from the stores.
- The company have limited number of vehicles for delivery and pickup, the challenge involved in this distribution system is to minimize the total travel distance of the route and thus reduce the fuel cost.
- Each vehicle will be delivering new medicines and will be collecting expired medicines on the same vehicle and has a limited capacity, thus challenge is to maximize the profits on each route.

Capacitated Vehicle Routing Problem with Simultaneous Pickup & Drop

- Medicine Distribution Problem with simultaneously pick up and drop off can be categorized as CVRP-SPD *
- The target is to identify a single route between S stores from 1 depot so that K vehicles with L capacity can be utilized to maximize the profits and reduce transportation costs under given constraints
- Constraints
  - Depot - Location
  - Store – Demand, Recyclables, Location
  - Vehicle – Capacity, Return to Depot
  - Route – Distance between two Locations
  - Minimize – Transportation Distance & Vehicle Trips
  - Maximize – Profits by Reduced Fuel Consumption

Why PSO ?

- Since this is a NP-Hard Problem, it is difficult to find a best solution in a required time. We need an optimization algorithm that can identify a optimal solution in a acceptable time frame.
- PSO is based on population-based swarm optimization which is an iterative algorithm that engages a number of simple entities—particles—iteratively over the search space of objective functions.
- The particles evaluate their fitness values, with respect to the search function, at their current locations. Subsequently, each particle determines its movement through the search space by combining information about its current fitness, its best fitness from previous locations (individual perspective) and best fitness locations with regards to one or more members of the swarm (social perspective), with some random perturbations.
- The next iteration starts after the positions of all particles have been updated.

Objective Function of PSO

- Each store is served exactly once by exactly one vehicle,
- Each vehicle starts and ends its route at the depot,
- The total demand of any route must not exceed the capacity of the vehicle
- The total demands and recyclables must be less than the vehicle capacity
- Minimized the total distance travelled by each vehicle of a capacity to visit all the stores
- Fitness Function : $$\sum_{k=1}^{K} \sum_{i=0}^{N} \sum_{j=0}^{N} C_{ij} X_{ij}$$
  - N represents the number of stores,
  - K is the number of vehicles

PSO Implementation

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Initialize the Parameters

S= No of stores; Q= Capacity of each vehicle; K= No of vehicles; MSD= Max Store Demand; MSR= Max Store Recyclables; N= No of particles in swarm; T= Iteration Count

2

Design Distribution Model

Randomly generate distance matrix which shows distance between 1 Depot and S Stores

Initialize S Stores with D demands and R recyclables within MSD and MSR

Initialize K Vehicles with Q capacity

3

Build Swarm Model

Initialize N particles with an initial solution and pBest

Update gBest for 0^{th} iteration

4

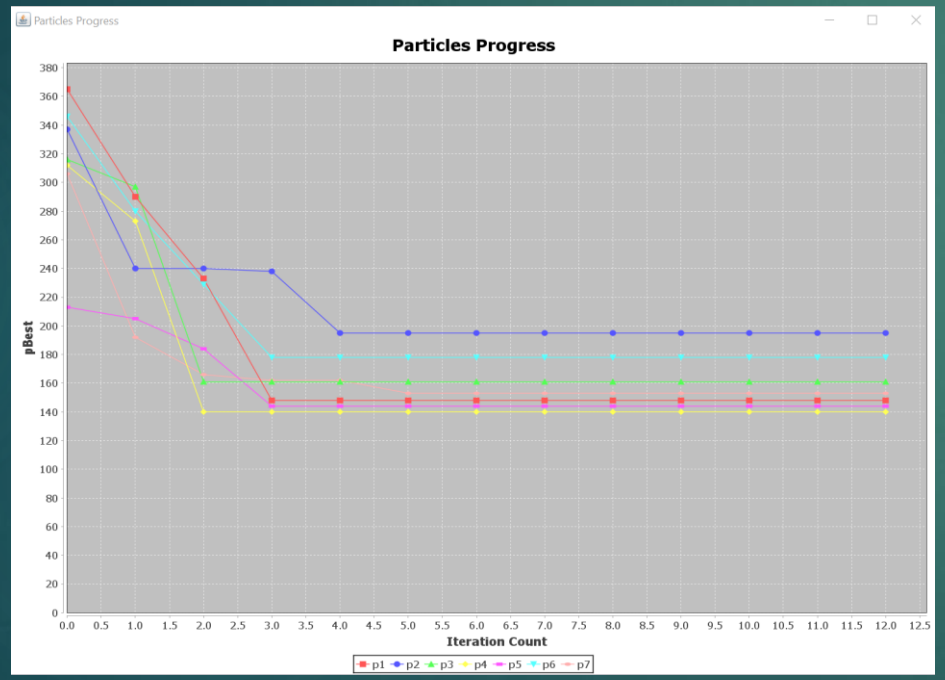
Iterate T times to find the optimal best solution – gBest with smallest fitness value

Decode gBest to identify the route

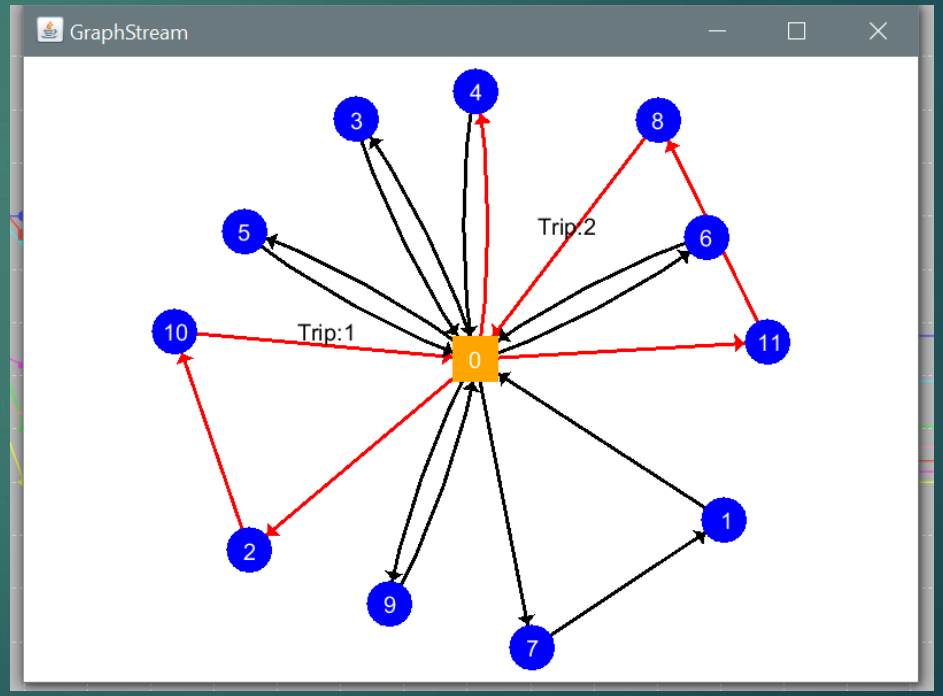
Analyze the optimal route to identify No of trips and Total Distance Travelled by K vehicles with Q capacity

Visual Simulations

Particle Progress



Vehicle Route



Analysis between Drop Only & Simultaneous Pick Up and Drop

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- Analysis of Optimal Route for dropOff Only:
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- VehicleCap:20,Trips:5,TotalDistance:333 -> [0, 2, 11, 0, 1, 3, 0, 4, 5, 6, 7, 0, 8, 9, 0, 10, 0]
- VehicleCap:12,Trips:8,TotalDistance:436 -> [0, 2, 0, 11, 0, 1, 0, 3, 4, 0, 5, 6, 7, 0, 8, 0, 9, 0, 10, 0]
- VehicleCap:15,Trips:6,TotalDistance:377 -> [0, 2, 11, 0, 1, 3, 0, 4, 5, 6, 0, 7, 8, 0, 9, 0, 10, 0]
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- Analysis of Optimal Route for simultaneously pickup and dropOff:
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- VehicleCap:15,Trips:7,TotalDistance:456 -> [0, 2, 0, 11, 0, 1, 0, 3, 4, 5, 0, 6, 7, 8, 0, 9, 0, 10, 0]
- VehicleCap:20,Trips:5,TotalDistance:333 -> [0, 2, 11, 0, 1, 3, 0, 4, 5, 6, 7, 0, 8, 9, 0, 10, 0]
- VehicleCap:12,Trips:8,TotalDistance:436 -> [0, 2, 0, 11, 0, 1, 0, 3, 4, 0, 5, 6, 7, 0, 8, 0, 9, 0, 10, 0]
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Application Demo