Simulated Annealing Algorithm for Solving the Matching and Dispatching Problem in Dynamic Large-Scale Settings

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**Introduction**

Ridesourcing services: Scope definition

Ridesourcing services connect, match, and dispatch operating vehicles to waiting requests within a very short duration in real-time settings.

Main considerations:
- Matching & Dispatching
- Rebalancing
- Dynamic travel time estimation

The objective is to put forward a flexible method that can provide good vehicle-request matching solutions in dynamic settings. The focus is to serve as many requests as possible with a constant fleet size without largely compromising the cumulative waiting time of system users. The method is tested in a simulation framework and the results are compared to more standard nearest-vehicle matching solutions.

**Model**

The Matching and dispatching problem

Objectives:
- Maximization of the number of served requests.
- Minimization of the waiting time for all potential passengers.
- Equal distribution of workload over the different vehicles.

Constraints:
- Maximum capacity of operating vehicles C.
- Maximum allowable detour for passengers (shared trips) Ω.
- Maximum waiting time of potential passengers Δ.

Batch vs instantaneous assignment:

Accumulating requests during a given time step of the simulation time $t^\text{pm}$ may improve the assignment solution.

**Simulation Framework**

Shenzhen network [1]

Main Parameters:

<table>
<thead>
<tr>
<th>Simulation settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shenzhen CBD area (km²)</td>
</tr>
<tr>
<td>Vehicle capacity C</td>
</tr>
<tr>
<td>Allowable detour D (%)</td>
</tr>
<tr>
<td>Waiting time Δ (minutes)</td>
</tr>
<tr>
<td>Requests (thousand)</td>
</tr>
</tbody>
</table>

**Solution Approach**

Building an initial solution

The first insight into solving the assignment problem between vehicles and requests is to start by building the bipartite matching (BM) graph, and then to proceed with solving a linear assignment problem using the Hungarian algorithm. The objective is to minimize the total distance traveled while exclusively assigning each request to a single Transport network Company (TNC) vehicle for shared and unshared trips.

Cost matrix

<table>
<thead>
<tr>
<th></th>
<th>$r_1$</th>
<th>$r_2$</th>
<th>$r_3$</th>
<th>$r_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v_1$</td>
<td>2.0</td>
<td>3.0</td>
<td>0.6</td>
<td>INF</td>
</tr>
<tr>
<td>$v_2$</td>
<td>0.2</td>
<td>0.5</td>
<td>0.4</td>
<td>4.2</td>
</tr>
<tr>
<td>$v_3$</td>
<td>0.5</td>
<td>0.5</td>
<td>0.7</td>
<td>INF</td>
</tr>
<tr>
<td>$v_4$</td>
<td>0.1</td>
<td>0.4</td>
<td>0.2</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Computation of cost

- $c(v_i; r_j) =$ estimated cost of serving demand $r_j$ by vehicle $v_i$

Reoptimization

Greedy Insertion Heuristic (GIH) [2]

A long-sighted approach would require to account for future planned vehicle movements. From this point stems the need for consideration of all possible assignments and selecting the one with the lowest incurred cost. To speed up the process, it is possible to build the similarity matrix for waiting requests and then employ spectral clustering.

Local Search and Simulated Annealing (SA)

It accepts deteriorating solutions in attempt to accommodate more requests. This method compromises between available time for assignment and neighborhood exploration.

**Results**

Abandonment, Seat Occupancy Rate (SOR), and waiting time

Compared to BM and Greedy Heuristic GH (nearest-vehicle assignment), the method allows a better service and an improved utilization of available TNCs (500) at the expense of an increased waiting time. The number of iterations for convergence is relatively small.

**References**