Comprehensive Performance Analysis and Comparison of Vehicles Routing Algorithms in Smart Cities

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Project Title: TRAFFIC: Smart Routing and Data Management Systems

Motivation

- Texas Transportation Institute estimates that in the United States in the year of 2011:
  - the economic loss due to traffic congestion in terms of extra travel delay and fuel consumption is $121 billion
  - Every significant trip has been re-planned around 2 times to avoid crashes
- The traffic accident report released by the U.S. Federal Highway Administration indicates that the urban traffic accidents lead to about 50%-60% of overall congestion delays.
- Currently, there is no routing part for any widely-used centralized Intelligent Transportation Systems (ITS) yet.

Research Plan

- Evaluate the common vehicle routing algorithms in real urban transportation scenario to find out their advantages and limitations under different scalabilities (traffic loads and trip length).
- Propose a new individual routing / re-routing vehicle algorithm and a novel mechanism to balance the global urban traffic flow by using centralized ITS.

Evaluation Framework

- Simulator: Sumo 0.17.1 Dataset: TAPASCologne 0.17.0
  - Algorithms’ Implementation (Dynamic A* Dynamic Dijkstra’s Algorithm, Static A*, Static Dijkstra’s Algorithm): Python 2.7
- We extract three scenarios (sub-maps) from the full-size map of Cologne for performance test: city centre, suburban and remote area.
  - Inspired from 3-tier architecture of SCATS.
  - They have the same shape and area (50km²).
  - They have various traffic flow and topology (number of junctions and road segments).
- For each scenario, we choose 4 OD pairs for each trip length scale (2km, 4km, 6km, 8km and 10km).
- Evaluation Metrics (the number of selected nodes, computation time, travel time, travel distance, travel time reliability, memory requirement and implementation cost)

Evaluation Results

- The computation time (in accord with the evaluation results of the number of selected nodes):
- Travel time & distance:
- Travel time reliability:
- Dynamic A* needs 55.56 times more storage space than Static A* in city center scenario, even in remote area, it still needs 31.47 times more space that its static counterpart.

Conclusions

- The conclusions can be draw with the consideration of the aforementioned evaluation results as well as the implementation cost for the four algorithms:
  - Dynamic A* > Dynamic DA > Static A* > Static DA
- The following table show the final conclusions:

<table>
<thead>
<tr>
<th>Trip length</th>
<th>10km</th>
<th>8km</th>
<th>6km</th>
<th>4km</th>
<th>2km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center area</td>
<td>Dynamic A*</td>
<td>Dynamic A*</td>
<td>Static A*</td>
<td>Static A*</td>
<td>Static A*</td>
</tr>
<tr>
<td>Suburban area</td>
<td>Dynamic A*</td>
<td>Dynamic A*</td>
<td>Static A*</td>
<td>Static A*</td>
<td>Static DA</td>
</tr>
<tr>
<td>Remote area</td>
<td>Dynamic A/ Static DA</td>
<td>Dynamic A/ Static DA</td>
<td>Static A/ Static DA</td>
<td>Static A/ Static DA</td>
<td>Static A/ Static DA</td>
</tr>
</tbody>
</table>

- In centralised ITS, the server that in charge of a specific area (centre, suburban and remote) can switch the optimal routing algorithm according to different routing request (fastest/shortest, trip length) sent from driver.

Future Works

- Introduce more algorithms to compare and change the departure time.
- Propose a new algorithm to overcome the limitations for the four evaluated algorithms especially in re-routing scenario.
- Propose a novel strategy to mitigate the urban traffic congestion from global point of view.