Multi Modal Route Planning

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Introduction

For a traveler it is often reliable to use different modes of transport for a travel whenever it is available. But there are very few efficient systems to find such a travel plan, there are systems that aid traveler to choose different modes of transport, such as Google Transit.

Multimodal Route Planning(MRP) is a system that provides the traveler with optimal, feasible and personalized route plan between a given source and destination in Bangalore city. The system is designed to provide combinations of various public travel approaches like bus and metro.

Related Work

- Multi-Modal Route Planning [1] by Thomas Pajor performs multimodal route planning on a large scale networks involving roads, railways and flights. He combined the different realistic models for road, railway and flight networks into multi-modal graphs. He used dijkstras algorithms with labelled constraints.
- *In another paper Multi-Modal Journey Planning in the Presence of Uncertainty by* Adi Botea et la (2013) [2] solves the multimodal planning problem by introducing a heuristic search planner, based on Weighted AO* (WAO*).

Proposed Solution

- Dataset used

Bus Network:

BMTC Bus network data in csv format.

Files:

- Routes.csv: Description of all bus routes in Bangalore city.
- UniqueBusStops.csv: List of unique bus stops along with Longitude and Latitude information

Metro Network:

- Data scraped from BMRC web page.(manually)

Proposed Solution (cont...)

- Modeling The Network

- **Road Network:**
  Nodes: Bus stops.
  Edge between two bus stations is inserted if there exists a route between them.
  Edge weight: Haversine Distance.
  Total Bus stops: 5338

- **Metro Network:**
  Nodes: Metro station.
  Edge between two metro stations is inserted if there exists a route.
  Edge weight: Haversine Distance.
  Total Metro stations: 42

Proposed Solution (cont...)

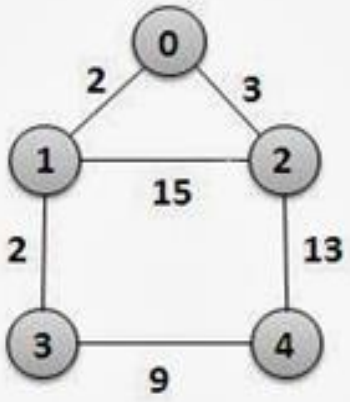
- Combining The Unimodal Networks

Both unimodal networks were combined to the nearest node (<1km distance) which gives the multimodal network.

Proposed Solution (cont...)

Data Structures Used

A. Graph



	0	1	2	3	4
0	0	2	3	0	0
1	2	0	15	2	0
2	3	15	0	0	13
3	0	2	0	0	9
4	0	0	13	9	0

Adjacency Matrix Representation of Weighted Graph

Proposed Solution (cont...)

Data Structures Used (cont..)

B. Priority Queue

It is implemented as a binary heap which supports following operations:

- FindMin in Θ(1)
- DeleteMin in Θ(log n)
- Insert Θ(log n)
- Update Key Θ(log n)

Proposed Solution (cont...)

- **Our Graph Node**

Each node of graph stores following information required for further processing:

- Bus Stop/ Metro Stop Names
- Longitude and Latitude Information
- List of routes passing through the given nodes

Proposed Solution (cont...)

- **Our Transit Algorithms:**

We used following two approaches for finding shortest path:

- A* algorithm with haversine heuristics
- Using simple Dijkstra's Algorithm

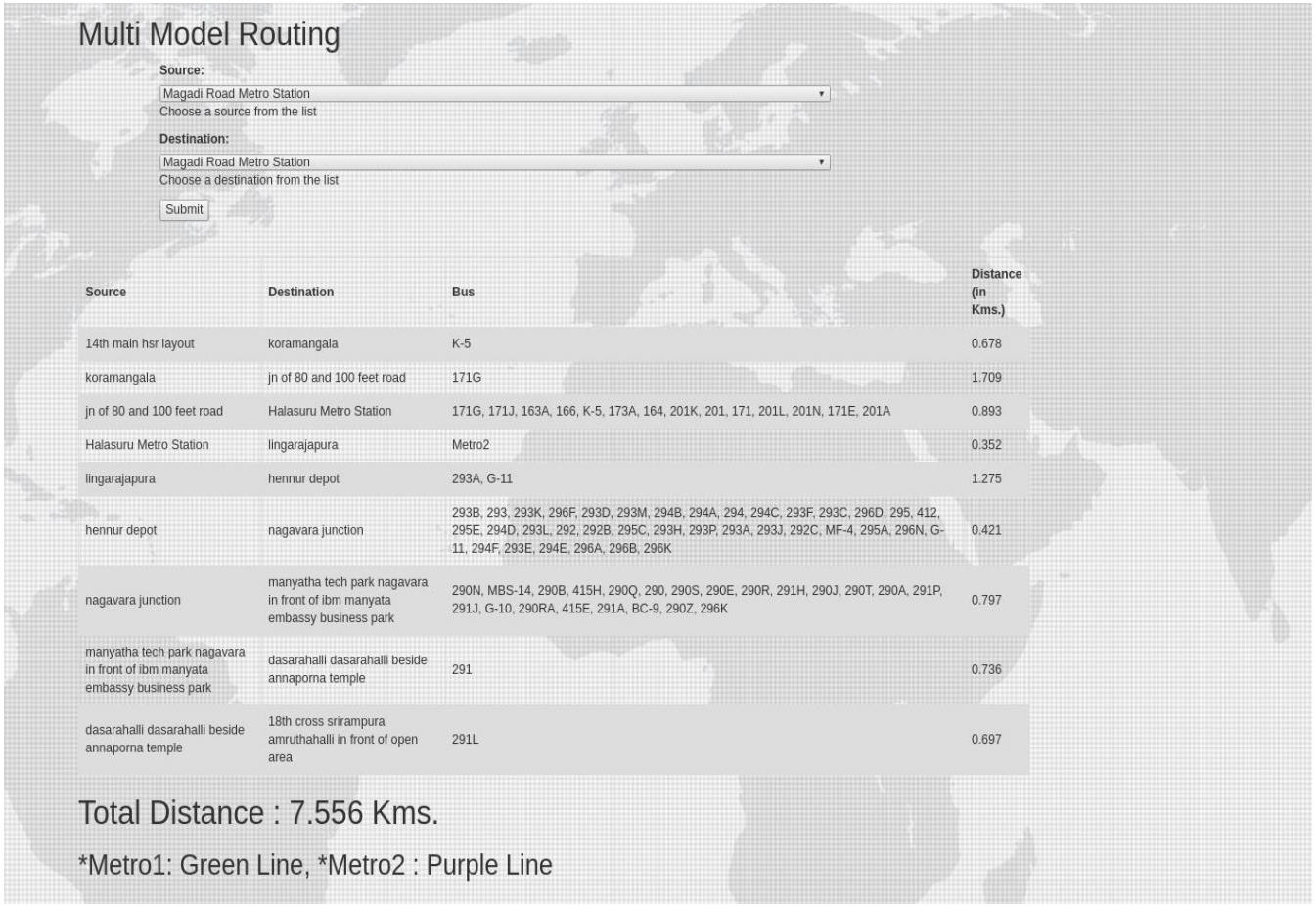
Dijkstra Algorithm (Pseudo Code)

```
dist[s] ←o                          (distance to source vertex is zero)
for all v ∈ V-{s}
     do dist[v] ←∞                  (set all other distances to infinity)
S←∅                                 (S, the set of visited vertices is initially empty)
Q←V                                 (Q, the queue initially contains all vertices)
while Q ≠∅                          (while the queue is not empty)
do  u ← mindistance(Q,dist)         (select the element of Q with the min. distance)
    S←S∪{u}                         (add u to list of visited vertices)
    for all v ∈ neighbors[u]
        do if  dist[v] > dist[u] + w(u, v)      (if new shortest path found)
              then    d[v] ←d[u] + w(u, v)      (set new value of shortest path)

                                    (if desired, add traceback code)

return dist
```

Complexity Analysis

- Time complexity of algorithm = O(ELogV)
- Total number of nodes = 5380
- Time taken for result = 5380 * 5380 tp <= 2 sec (Approx)

Demo



App in Motion

Technologies Used

- **Back-End**
  - Python Programming Language
  - Django Web Development Framework
  - Django Rest API
- Front-End
  - Django Web Development Framework
  - Bootstrap Framework

Key Challenges

- A* algorithm with haversine distance as heuristics criteria didn't work well since the heuristic criteria is not found admissible. The algorithm takes exponential time in unbound space, $O(b^d)$ and depends on the heuristics.
- Combining unimodal networks road and metro was challenging.

Future Work

- Incorporating Pedestrians
- Duration Constraint
- Caching Repetitive queries
- User location detection
- Expanding model to other cities

References

1. *Adi Botea IBM Research, Evdokia Nikolova Dept. of Computer Science and Engineering Texas A&M University, Michele Berlingerio IBM Research - "Multi-Modal Journey Planning in the Presence of Uncertainty"* 2013 . https://www.aaai.org/ocs/index.php/ICAPS/ICAPS13/paper/view/6023
2. Thomas Pajor, Universität Karlsruhe (TH), Germany *"Multi-Modal Route Planning" 2009* http://i11www.iti.uni-karlsruhe.de/extra/publications/p-mmrp-09.pdf

Questions ?

Thank You!