Burning Algorithm for Route Planning of Multi-Mode Public Transport Networks

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1. Introduction

Effective public transportation is being paid more attention by transportation administration and travellers, since the increasingly terrible traffic jams in cities. Improving the efficiency of public transportation route planning is the focus of research of intelligent public transportation systems and location based services. With the wide operation of urban light railway, public transportation network changes from traditional single bus line networks into multi-mode public transport networks. Research of route planning algorithms based on multi-mode public transport networks is to address this new situation. However, this does not change the nature of the problem. That is to get the optimized route between two points. The restrictions still include number of transfers, travel time and cost factors. The difference in features of various public transportation networks must also be taken into account. Typical algorithms for route planning are improved Dijkstra algorithms and heuristic examples, such as A*. If the number of stations is large, the efficiency of Dijkstra algorithms decreases sharply. The key of heuristic algorithms is to describe and define an evaluation function and this will play an important role to obtain the final results.

There are two ways to improve the efficiency of the route planning algorithms. One is to improve these traditional algorithms. The other is to put forward new algorithms. This paper discusses the burning algorithm, which is a natural algorithm to improve the efficiency of route planning based on multi-mode public transport networks.

2. Features and modelling of multi-mode transport networks

We can summarize the features of multi-mode public transport networks as follows:

- The public transportation system includes many stations. For example, Beijing has more than four thousand different stations.
- The number of stations that have direct connections between lines is only small compared to the total number of stations. That means it is a sparse matrix.
- For the same mode of public transportation, the distances between neighbouring stations are nearly constant in the same area. Even if the distances are different in various regions, the travel time can be closer.
- Stations in different modes of public transportation have different distances between two neighbour stations.

- To reduce the cost in money and time spent on travel, the optimal route should minimize the number of transfers.
- For an individual journey, the maximum number of transfers should be less than 5.
- For route planning based on multi-mode public transport networks, the cost relies on the number of transfers and the distance.

Based on the above features, we can infer the form of a model for multi-mode public transport networks. The most important inferences are listed below:

- The distance between any two stations can be described as the number of stations between them.
- When looking for the optimal route with minimum cost, first consider the minimum number of transfers. Then minimise the number of stations passed through.
- The maximum number of transfers should be no more than 5.

3. Burning Algorithm

The Burning Algorithm is a kind of algorithm similar to point diffusion. It starts from one designated point and diffuses to adjacent connected points until it finds the other target. Originally, the burning algorithm is used in networks without weight. This allows it to be used in multi-mode public transport networks efficiently but with some lost of accuracy. However, the process is reasonable and effective in application. Since it takes human decision-making behaviour into consideration, it can provide more satisfactory service for end users. Before executing the algorithm, it needs to pre-process the data of the public transport networks. Traditionally, data of public transport networks is recorded as every route and the stations it passes. Here, we generate an adjacency table from the data. The table includes two structures. The head structure is like this

VexName	FirstArc

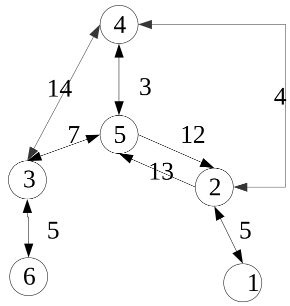
. VexName is the identifier of the station and FirstArc is the pointer that refers to table structure of the other vertex in the first arc. The other structure is a table structure such as

AdjVexID	NextArc	Weight

. AdjVexID is used to record the other vertex ID in the arc. NextArc records the pointer of next arc. Weight is instead of the impedance of the arc. Its measurement is the number of stations. For different public transport networks, the travel time between adjacent stations varies. This research uses that typical of bus lines as the standard. Those of others modes are converted to accord with it. The algorithm procedure comprises six steps, as illustrated in the following example.

4. Application example

The example demonstrates the two typical situations in multi-mode public transport networks, static and dynamic. The application example illustrates the execution steps using figures and some explanation to show how the burning algorithm can be applied to multi-mode public transport networks. The basic multi-mode public transport networks of the example are as follows.



The goal is to find the shortest route. Most arcs refer to bus lines except arc 4, which represents a subway. For the dynamic situation, real-time data would be used to give the impedance of arcs. Based on the above networks, we can compare the burning algorithm with that of Dijkstra.

5. Comparison between burning algorithm and Dijkstra

It is critical to consider the computing efficiency of burning algorithm. In this research, Dijkstra algorism is taken as a reference. The comparison is made from four aspects: applicable range, accuracy, storage complexity and algorithm complexity. For calculating an optimized route between a pair of points, the algorithm complexity of burning algorithm is only $O(n)$ and that of Dijkstra is $O(n^2)$. If it wants to get all the shortest routes between every pair of points, the algorithm complexity of burning algorithm is $O(n^2)$ and that of Dijkstra is $O(n^3)$.

6. Conclusions

The method described uses the algorithm for transportation network with weights. Through analysis of the algorithm and the examples we conclude: burning algorithm is effective and efficient for route planning based on multi-mode public transport networks.

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Biography

Dr. Jianghua Zheng graduated from Peking University. At present, he takes position as associate professor in Xinjiang University. He also does some joint researches in Peking University and Beijing Key Lab of Spatial Information Integration and Its Applications. His interests include navigation information services, emergency management and ITS.