Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(12):642-647

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Multi-path transportation assignment model in urban transportation based on real road-network survey

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ABSTRACT

In real road-network people's travel path is different to those models such as Moore Model, Label Model, and Dijkstra etc. This paper gains the rules of people travel path choosing behavior through special survey. Using these rules can simulate the behavior of individual choosing the travel route accurately. This paper attempts using these rules on multi-path assignment model in urban transportation, and introduces control parameter of effective path which can control the assignment result's precision degree. The model based on real road-network is linearity correlation with the degree of road network, and can reduce the calculate cost and complexity compared with former travel route choosing model.

Key words: real road-network, multi-path assignment, urban transportation, simulation

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INTRODUCTION

Now travel path choice model at transportation assignment stage in traffic and transportation planning field includes Moore Model, Label Model, and Dijkstra etc[1, 2]. All of these models choose travel paths through check every road of all networks according to their own rules. With the scale-up of road network size, the calculation's cost in time and space are rising with geometric series using these models, and computer must be used to solve.

But we find there is a very big difference between these model and individual actual travel path choice behavior, through observing the individual travel path choosing mechanism in long term. With familiar road network or not, people can straight find out the shortest or shorter travel path[3, 4].

Although the shortest path factor and stochastic factor are the same in model or in practice, there are other questions can't be solved such as shorter path question, stochastic strength, and etc. For example, multi-path assignment model embodies the relation between travel behavior and road resources, and its theory is easy to understand, and this model's usage is simple, so these models have a broad application fields. But we find this model may arouse the danger of travel intension accretion when the road network is very complex through a mass of transportation planning practice, and there is no effective controls parameter to decrease the danger to reasonable degree[5, 6].

In this paper we carried a special survey for people's travel path choosing behavior based on real road-network firstly, and then attempts to establish a new multi-path transportation assignment model based on real road-network. At last we bring an example to explain solving process and improvement effect.

SPECIAL SURVEY FOR PEOPLE'S TRVAEL PATH CHOOSING BEHAVIOR BASED ON REAL ROAD-NETWORK

For get travelers on route choice behavior characteristics, we conducted a special investigation by the respondents to answer questions according to their experiences. As the relevant literature on the traveler route choice factors study more, here we list the distribution characteristics of survey results, which can basically reflect the real road-network routing features.

The survey is conducted in November 2010, a total of 325 survey forms were returned, and 314 survey forms is valid, and the effective rate was 96.62%.

The questionnaire uses chengdu road-network conditions, which includes path selection distribution from point A (JiaoDa Road) to point B (JiTou town) and from point A to point C (Tower Hill). Figure 1 is the basic road-network. Figure 2 and Figure 3 respectively, points A to point B, points A to point C of the path to the distribution.

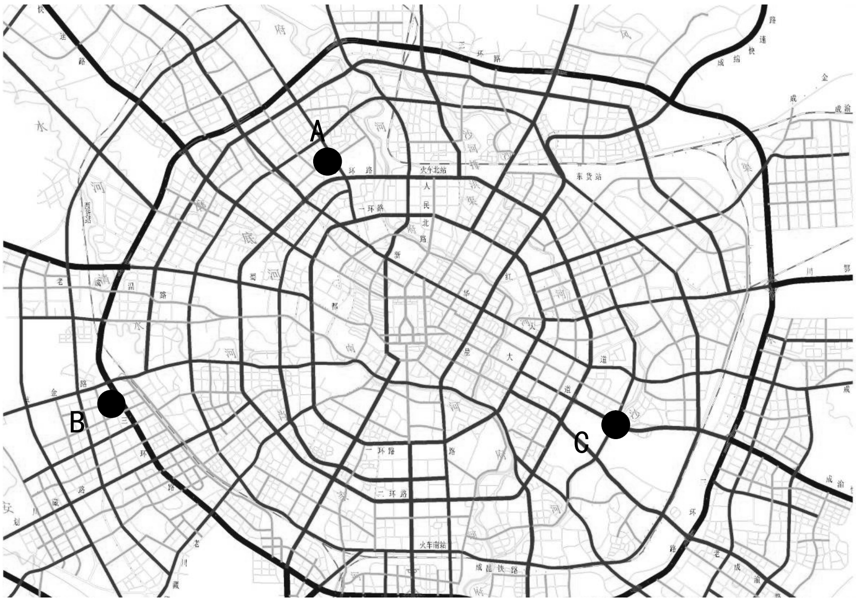
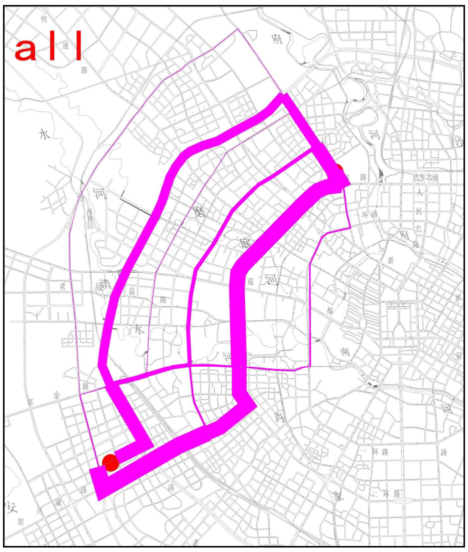


Fig.1: Chengdu Road-network



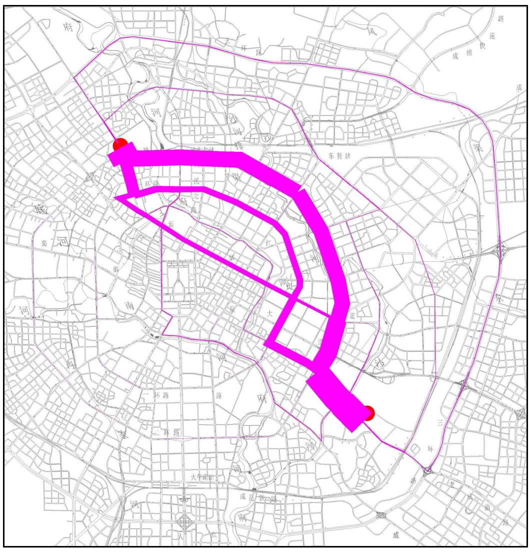


Fig.2: Path Distribution(from A to B) **Fig.3: Path Distribution(from A to C)**

Table 1: Probability of Selecting of the Chosen Paths

	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6	Path 7	Other path
A to B	42.05%	28.98%	8.16%	6.53%	4.90%	4.08%	2.04%	3.26%
A to C	52.25%	19.04%	9.32%	5.67%	2.43%	1.62%	1.62%	8.05%
average	47.15%	24.01%	8.74%	6.10%	3.67%	2.85%	1.83%	5.66%

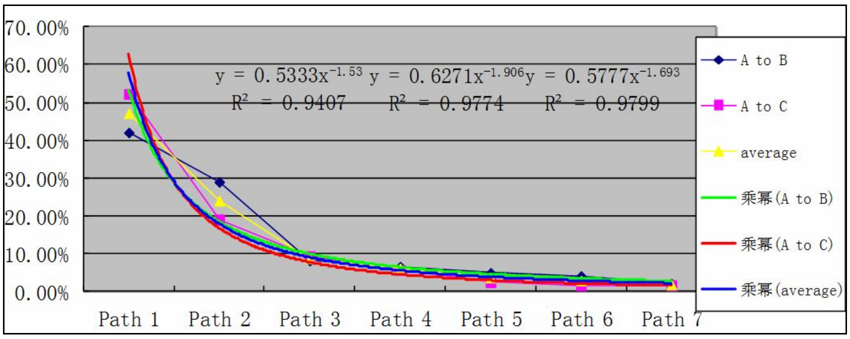


Fig.4: The Chosen Path Probability Function

Here are survey characters of travel path choosing behavior.

1) For individuals, the subjective identifiable paths' maximum value is 6-7, and in the macro path road network these 6-7 selected paths' probability is over 90%.
2) There have similar function form between each group path.
3) After standardization, the longest travel path is 50% beyond the shortest path.
4) For the two endpoints from the same travel path, the path cost difference can be identified generally at about 10%.

MULTI-PATH ASSIGNMENT MODEL BASED ON REAL ROAD-NETWORK SURVEY

Traditional transportation assignment model takes a section of road as basic analysis unit, but multi-path transportation assignment model based on real road-network take path (a series of road section from origin to destination) as basic analysis unit. This guarantees travel path is controllable, and it chooses effective nodes and effective sections using real road-network, uses controls parameter of effective path (α, effective paths are common not exceeding the shortest path 50%) to removing obvious incorrect path. Then we need use survey parameter (here we name them as parameter a and b) to gain the chosen probabilities of every path. In the end we can gain transportation volume of every road section.

Real road-network's nodes and sections are fixed, such as geography map. Here we call them as ***Fixed Graphics***. In the fixed graphics the nodes' relative position and the sections' shape are fixed. It can be defined in mathematics language as follows: define V is the not empty aggregate which has n nodes, $V=\{v_1,v_2,\cdots,v_n\}$, E is the aggregate which has m sections, $E=\{e_1,e_2,\cdots,e_m\}$, e_i which belongs to E is the relation a pair of $[u,v]$ (here $u \neq v, u,v \in V$), here name $\overline{V}$ is the not empty aggregate which has n fixed nodes, $\overline{E}$ is the not empty aggregate which has m fixed sections, and we name the fixed graphics as $\overline{G}=(\overline{V},\overline{E})$.

Effective paths: they are made up of effective nodes and they have direction. In effective path the next node are nearer than former node to the destination.

For a fixed graphics $\overline{G}=(\overline{V},\overline{E})$, the nodes have a fixed coordinate, namely $v_i=(x_i,y_i)$, there are a travel T_{st} which from s to t.

The calculating or simulating process is following:

Step 1, sets up beeline L_{st} which relates the starting position s to end position t;

Step 2, constructs the effective nodes aggregation A_{st}. The effective nodes include all the nodes of ways which beeline L_{st} pass through. Especially, if the L_{st} pass through a node, adjacent nodes which related it also are effective nodes;

Step 3, checks and finds out the connected paths from node s to node t. If is, the effective nodes aggregation and the sections among them constructs a DT, go to step 5; otherwise go to step 4;

Step 4, adds not effective node(s) to effective nodes aggregation. The choice criterion is that the distance is the shortest between the choose node (not effective node) and L_{st}, then go to step 3;

Step 5, if there is a connected path, it will be the chosen travel path; otherwise we should use the effective paths judgment criterion (controls parameter α) to choose when there are exceeding several connected paths. The effective paths are that following node is nearer destination than front node in the connected paths.

Step 6, assignment T_{st} to effective paths. We can use the following formula:

The probability of each path is chosen may use the following formula.

$$P(s,t,k) = a \times k^{-b} \tag{1}$$

$$\sum_{i=1}^{n} P(s,t,k_i) = 1 \tag{2}$$

Here, $P(s,t,k)$ is the effective path k's assignment probability about travel T_{st}, n is the amount of effective paths, a and b are the parameters obtained according to the survey. Generally, $a \in (0.5, 0.6)$ and $b \in (1.5, 2.0)$.

Step 7, check the error ε between assignment result and investigating date. If it is satisfied we will end calculate, otherwise go to step 5, adjust parameter α.

EXAMPLE

For a standard pane road network which has 16 nodes (Figure 5), each section's length is 1 unit. Now there is a travel T_{st} which starts node s to node t (here consider that example needs have universal significance, travel starts in section, not node or crossing). T_{st} is 1000 puc/d. Here we don't adjust parameter or verify result.

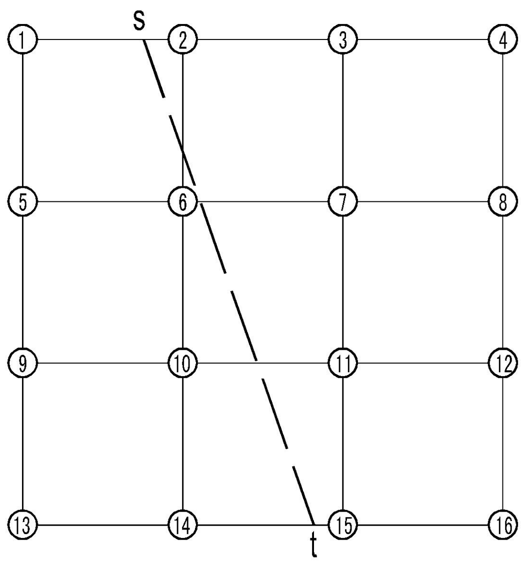


Fig. 5: Basic Road-network

Step 1, set up beeline L_{st} in fixed map figure 5;

Step 2, choose effective nodes to form aggregation

$$A = \{v_1, v_2, v_6, v_7, v_{10}, v_{11}, b_{14}, v_{15}\}$$

Step 3, check and find out the connected path(s) from node s to node t. There are many paths in this example.

Here we don't list them.

Step 4, here we needn't add not effective node(s) to effective nodes aggregation.

Step5, applying effective route judging rule, we can find out the following three effective routes:
Path 1: $s - v_2 - v_6 - v_{10} - v_{14} - t$
Path 2: $s - v_2 - v_6 - v_7 - v_{11} - v_{15} - t$
Path 3: $s - v_2 - v_6 - v_{10} - v_{11} - v_{15} - t$

Step 6, calculate the probability of each path. Assumed a is 0.58 and b is 1.70. Because this example's paths is shorter than normal case, here we raises the ratio according calculating. Then we can gain the ratio of every path.
Path 1: 0.76 Path 2: 0.12 Path 3: 0.12

Step 7, following we can calculate assignment result such as fig.6.

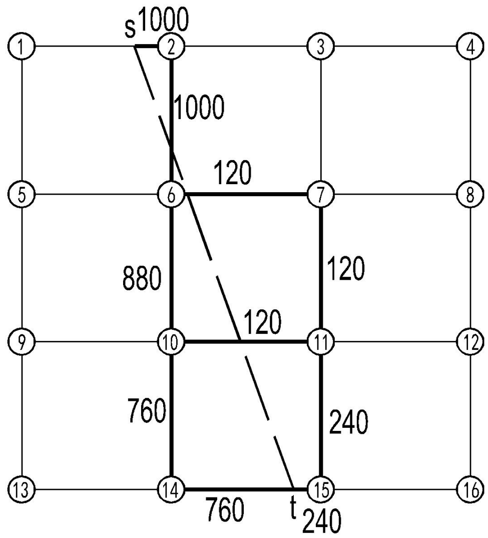


Fig. 6 Assignment Result

CONCLUSION

Multi-path transportation assignment model based on real road-network survey (MPTAM-RRNS) belongs to static simulation model. It doesn't check every section of road-network, so it maybe can't find out the shortest travel route. But it matches the people's travel habit and psychology, can simulate travel path choice behavior more factually. Using MPTAM-RRNS to transportation planning, can gain more objective and actual analysis result.

MPTAM-RRNS is linearity correlation with the degree of road network's size and complexity. Compare with common travel route choice model, such as Moore Model, Label Model, and Dijkstra etc, MPTAM-RRNS has the lowest computing complexity degree O(n), where n is the road network's size or node number, and other's have the computing complexity degree O(n^2).

MPTAM-RRNS is an application attempts of psychology and behavior in transportation planning field. However there are still enormous works to solve the factual problem, such as following:

(1) Consider the road and transportation's actual condition, including road and transportation's characteristic, vehicles or other travel individual moving rules (bidirectional moving, single-line moving, and turning management measure etc.).
(2) Consider the influence of road capacity.
(3) Consider the influence of real-time information.

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