Study on the Impact of Community Opening on the Surrounding Roads

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Abstract: With the increase of traffic demand, urban traffic problems are becoming more and more serious. Whether it is possible to ease urban traffic congestion by opening the roads of existing closed communities is a problem worth studying. In order to solve this problem, this paper establishes a network model of traffic distribution linear programming based on the shortest path, and proposes three evaluation indicators such as traffic improvement factor, road segment saturation mean value and road segment saturation standard deviation to evaluate and contrast closed community opening. The amount of traffic before and after and the degree of road occupancy reflect the specific impact of the opening of the closed community on the surrounding roads. In this paper, two different traffic networks and traffic flow data are simulated and modeled. The results show that although the road network density increases after the opening of the community, it may reduce the total traffic load, but not any community opening can alleviate urban traffic congestion. . Many factors such as the area, location, external and internal road conditions can affect the traffic status of the road network. Therefore, whether to open a closed cell requires an assessment based on the specific cell and surrounding road conditions before making a decision.

1. Introduction

With the rapid development of China's economy, the city's scale is increasing and the urban population is increasing, resulting in a sharp increase in the traffic demand of pedestrians and vehicles in the city. Although the government is meeting the growing traffic demand through new roads, interchanges, subways and other transportation facilities, Due to the limited urban space and road resources, in many cities, these infrastructures are still difficult to meet the rapidly growing traffic demand, and traffic congestion in some cities is becoming more and more prominent [1]. On February 21, 2016, the State Council issued a number of opinions on further strengthening the management of urban planning and construction.

See, in which Article 16 on the promotion of the block system, in principle, no closed residential quarters will be built, and the completed residential quarters and unit complexes should be gradually opened up, which has aroused widespread concern and discussion in the society. In addition to the security issues that may arise from open communities, the main focus of discussion is whether open communities can improve urban traffic congestion.

In the past ten years, the city government has announced that it will gradually phase out closed communities [2], and some people gradually realize that closed communities affect urban traffic [1-3], but some people disagree.

In the end, it should not be open, how to grasp the degree of openness, and some researchers have done a lot of research on such issues [4-9]. Literature [1] proposed a countermeasure to alleviate urban traffic congestion, that is, the closed community traffic is open, and it has been deeply studied by establishing a suitable impedance analysis model for the urban branch. The literature [2] believes that the community should be open. Through the investigation and analysis of the openness of the settlement, the author puts forward the viewpoint of the equilibrium of the openness of the settlement, and combines the survey data and the actual case to propose the strategy of achieving the equilibrium of the openness of the settlement. . The literature [10] uses the analytic hierarchy process to analyze the various indicators in the evaluation system, and establishes several factors that have a greater degree of influence, such as road network density, capacity, vehicle delay

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and branch utilization. The optimal road effective length optimization model, the calculation model of the delay level of the imported road vehicle and the actual capacity calculation model of the imported road are used to study and analyze the influence of the traffic opening of the community on the surrounding road traffic. Literature [11] analyzes the impact of open and closed communities on road traffic from three perspectives: the number of intersections, the traffic volume of intersections and the complexity of intranets. The simulation model is used to quantitatively study the traffic of surrounding roads before and after the opening of different types of communities. From the perspective of traffic planning, this paper analyzes and studies whether the open community road can optimize the traffic network structure, improve road traffic capacity, improve traffic conditions, and improve the effect. First, the impact of closed communities on urban traffic is theoretically explained. Then, specific evaluation indicators are proposed to quantify the impact and evaluation of the impact of surrounding road traffic before and after the opening of the community. Then, the traffic diversion model based on the shortest path is established, and the model solution and calculation results are analyzed through two sets of traffic network simulation data. Finally, the work of this paper is summarized.

2. The Impact of Closed Communities on Urban Traffic

Under the combined effect of population, vehicles and land use, a series of problems such as safety and transportation have emerged in the city. Solving urban traffic conditions is especially important for the lives of urban residents. In China, residential areas, commercial areas, hospitals, schools, etc. in cities are mostly a complete land. There is no urban public transportation road inside, which is what we call closed-type communities. We know that closed-type communities divide urban land into blocky patterns, forming a sparse and thin road network. In such a road network, traffic flow is concentrated on the main roads, and because of the Too little contact can not play the role of mutual diversion, easy to cause traffic congestion. In addition, as the main component of the city, the community is also the main source of traffic flow while taking on functions such as residence, office, medical care and education. Therefore, the size of the cell and the amount of traffic generated directly affect the surrounding traffic conditions. For example, the area of the cell or the side length is too large, so that the bypass distance is increased and the traffic volume is concentrated, thereby forming a traffic superposition. During peak hours, the flow is single, and the traffic volume of the community entrance and exit is large, which easily forms a traffic bottleneck and also increases the pressure of urban road traffic [1, 12].

As a "capillary" in the urban road network, the branch road can increase the connectivity between small and medium-sized units in the city, strengthen the connection between urban trunk roads, and form a regional micro-circulation traffic system. Therefore, the opening of community traffic can reduce the size of the community, make the connection between the roads closer, reduce the superposition of traffic, improve the shunting capacity, and thus improve traffic congestion [1,12]. Therefore, this paper will conduct quantitative research and analysis on the service capabilities of the network before and after the opening of the community, and reflect the changes in the road network's ability to undertake traffic demand through specific indicators.

3. Evaluation Indicators and Related Definitions

3.1 Related Definitions.

In order to construct a suitable evaluation index to quantify the description and evaluation of the impact of surrounding road traffic before and after the opening of the community, this paper first defines the following two concepts.

Traffic demand: The traffic flow generated by the travel demand of the road network users, that is, the traffic volume generated by the users of the road network within a certain period of time without considering the congestion of the road network.

Traffic load: refers to the traffic flow completed by the road network, that is, the traffic volume passing through the road network within a certain period of time.

3.2 Evaluation Indicators.

It can be seen from the foregoing analysis that the closure of the cell will cause the urban road network to be sparse and uneven, but the community is also a population gathering place, which will lead to an increase in the traffic load of the surrounding roads. To this end, if the cell is open, vehicles that would otherwise need to detour can travel through the cell to reach the destination in a shorter path. That is to say, under the premise of constant traffic demand, the total traffic load actually completed by the entire road network will be reduced. According to this idea, this paper proposes the ratio of the shortest distances of all the vehicles that have completed the given traffic demand before and after the opening of the community, as an indicator to evaluate the impact of the opening of the community on the slow block. The specific definition is as follows:

Traffic volume: Under the premise of not exceeding the maximum carrying capacity of each road section, complete the shortest distance of all vehicles for a given traffic demand.

Traffic improvement factor: Under the condition that the traffic demand is constant, the ratio of traffic volume completed by the front and back road networks of the open cell is denoted by r in this paper.

It can be seen from the above definition that the traffic volume reflects the actual amount of traffic that the transportation network can afford to complete these traffic demands given the demand. When the structure of the road network changes, it may cause the actual traffic volume undertaken by the traffic network to change under the same demand. The traffic improvement factor r reflects this change. If r<1, the road is explained. The condition of the net has improved, and the smaller the r, the greater the improvement. On the contrary, it indicates that the road network condition has deteriorated, that is, the road network needs to bear more traffic than the original road network structure in order to complete the same traffic demand. Of course, if r=1, it means that the new road opening has no effect on optimizing the road network. Specifically, there are no two urban road nodes, so that the shortest path between them becomes shorter because of the opening of new roads. . In summary, only when r<1, it is possible to ease the traffic pressure by opening the road in the community.

The purpose of the opening of the closed community is to alleviate the traffic congestion in the city, that is, for some sections that are too busy or even congested. It is hoped that after opening the community road, the traffic can be shunted, so that the traffic load of the congested roads is reduced. This paper uses the concept of road segment saturation to reflect the busyness of the road.

Where n is the total number of segments in the road network. It can be seen that the higher the value of, the more busy the road segment is. The smaller the distance, the more idle the road section is. At the moment, it indicates that the road section is in a state of traffic saturation. In fact, when it is closer to 1, it is already in fact that the road is more congested.

Considering that the road segment saturation of each road segment in the whole road network is different, this paper proposes the road segment saturation mean value to describe the road busyness of the entire network, which is defined as follows:

$$M = \frac{1}{\mathrm{n}} \sum_{i=1}^{n} \tau_i \tag{1}$$

The mean saturation of the link (M) reflects the average degree of traffic load on all sections of the road network. It can be seen that for a given traffic demand, the busyness of each road segment is as low as possible, that is, the smaller the M value, the better, indicating that the smoothness of the road network is better. Not only that, a good transportation network should avoid the imbalance of traffic load on each road section, that is, some sections should not be very congested, and the traffic volume of some sections is small, so this paper defines the section saturation variance ( ) to describe For the difference in traffic flow between road sections in the road network, see equation (2).

$$\delta^2 = \frac{1}{n-1}\sum_{i=1}^{n}(\tau_i - M)^2 \quad (2)$$

It can be seen from equation (2) that, given the traffic demand, the smaller the variance of the road segment saturation, the more balanced the traffic volume of each road segment is, which reflects that the road resources of the entire road network are balanced.

In summary, for the given traffic demand, the three evaluation indicators proposed in this paper can be used to measure the improvement of traffic conditions in the road network before and after the opening of the community road. Next, this paper will establish a model to illustrate how to analyze the impact of the opening of the community road on the traffic network based on these three indicators.

4. Mathematical Model

The traffic network in and around the city can be abstracted into a directed graph G(V, E), a set of points v in V, and E is a set of edges e in the figure. This article uses v to represent the intersection of roads, with e the road that can be used is shown in Fig. 1. Fig. 1(a) is a road network diagram before the opening of the cell and the surrounding road, and Fig. 1(b) is a road network diagram of the surrounding road and the surrounding road [13].

4.1 Basic Model.

Suppose there are N nodes, S edges, and any two nodes i, j have equal traffic demand. If there are multiple shortest paths between node i and node j (such as node 2 to node 6 in Figure 1), the traffic flow between the two points is shunted by the K path, and the shunt coefficient is expressed, and

$$0 \le \lambda_K(i,j) \le 1, \quad \lambda_K(i,j) = \sum_{k=1}^{K}\lambda_k(i,j)$$

If there is a unique shortest path P and the shortest path length is d(i,j), the traffic flow between nodes i, j is completed by path P. The purpose of the model establishment is to find the appropriate diversion method for the given network traffic demand, so that the total traffic volume in the whole network is the smallest. Based on this idea, this paper proposes an optimization model, see equation (3):

$$\begin{cases} \min \quad \sum_{\substack{i,j=1 \\ i\neq j}}^{N}\sum_{k=1}^{K}\lambda_k(i,j)G(i,j)d(i,j) \\ s.t \quad f_s \le b_s \quad s = 1,2,...,S \\ \quad \sum_{k=1}^{K}\lambda_k(i,j) = 1 \quad i,j = 1,2,...,N, i \neq j \\ \quad 0 \le \lambda_k(i,j) \le 1 \quad k = 2,3,...K \end{cases} \quad (3)$$

Among them, the shunt coefficient is the variable to be solved of the model, which is the superimposed flow on the sth side, which is the maximum flow allowed on the sth side, and G is the known traffic demand matrix, which is any two nodes i, j The need for transportation. The objective function of the model (5) minimizes the total amount of traffic load (denoted as F) assumed in the network (wherein, traffic load = flow × traffic demand × path length). Under this model, we need to compare the changes in the total traffic load F in the network before and after the opening of the community under the same traffic demand. If F is reduced, that is, r < 1, it means that the open cell has achieved the role of optimizing the network, and the smaller the value, the more obvious the effect of optimizing the traffic network.

After the shunt coefficient is obtained, the link saturation mean and the link saturation variance can be calculated. Specifically, for any road segment s (that is, the edge), all traffic flows through the road segment (the flow may be from the shortest of the different pairs of points) are accumulated, so that each expression can be obtained according to the expression (2). The saturation of the road segments can be calculated according to equations (1) and (2) to obtain the link saturation average and the link saturation variance of the entire network.

4.2 Model Improvement.

The model (5) expresses the basic relationship of traffic distribution in a traffic network. In practical applications, the basic model also has the following disadvantages:

(1) When there are multiple shortest paths between two endpoints, the model cannot guarantee the average shunting of multiple shortest paths;

(2) When the traffic flow to the shortest path exceeds the upper load limit, the model does not allow the flow to be shunted to the secondary short circuit, so the model will have no solution at this time.

For the first problem, new constraints need to be added to constrain the equalization of multiple path shunts. To this end, adding a free variable to constrain the shunt coefficient, so that the absolute value of the difference between the path shunt coefficients is introduced in the objective function, then the optimization model will tend to find a smaller shunt coefficient, it is not difficult to imagine, The smaller the size will be, the smaller the average shunt will be (ie, for a given (i, j), all will be as equal as possible). For the second problem, this paper corrects the model with reference to the actual situation. When the traffic load in a road section reaches its upper limit, the road section will have congestion phenomenon. At this time, other vehicles will not enter the road section, but Divide through other paths. Therefore, when generating the shuntable path, those paths whose length is less than or equal to w times the shortest path are allowed as the shuntable path (where w can be selected by the model user). Of course, under the effect of the objective function (the minimum total traffic load F of the network), when the shorter paths are not overloaded, the shunt coefficients of those longer paths are automatically set to zero. The improved model is shown in the following equation (4):

$$\begin{cases} \min \quad \sum_{\substack{i,j=1 \\ i \neq j}}^{N} \sum_{k=1}^{K} \lambda_k(i,j) G(i,j) d(i,j) + \sum_{l=1}^{L} t_l \\ s.t \quad f_s \le b_s \quad s = 1,2,\ldots,S \\ \quad -t_l \le \lambda_K(i,j) - \lambda_{K-1}(i,j) \le t_l \\ \quad\quad k = 2,3,\ldots,K, K+1, K+2\ldots \\ \quad \sum_{k=1}^{K} \lambda_k(i,j) = 1 \quad i,j = 1,2,\ldots,N, i \neq j \\ \quad 0 \le \lambda_k(i,j) \le 1 \quad k = 2,3,\ldots K \end{cases} \tag{4}$$

Where k+1, k+2, etc. refer to those sub-short paths with the shortest path w times, the superimposed traffic assumed on the s-th edge, the maximum allowable flow on the s-th edge, G is known The traffic demand matrix is the traffic demand between any two nodes i, j.

5. Model Solving and Analysis

The model given by equation (4) belongs to the linear programming problem, so this paper uses the optimization tool linprog command of MATLAB software to solve. In the calculation of the shortest path between any two points in the traffic network diagram, mature algorithms such as Floyd and Dijkstra can be used [14]. This paper uses the Dijkstra shortest path algorithm to calculate the shortest path between a given pair of points, and obtains the condition that satisfies the condition. Multiple split paths. In the simulation, this paper assumes that there is a unit of traffic demand between any given two nodes i, j, ie.

This paper first uses the road network diagram shown in Figure 1 for simulation. There are 9 nodes in the figure. Before the cell is opened, there are 11 edges, as shown in Figure 1(a). After the cell is opened, there are 12 sides, as shown in Figure 1(b). The edges in the figure are bidirectional directed edges, representing two-way roads. By solving the model of equation (4), the indicators before and after the cell is opened are shown in Table 1.

Table 1 Comparison of calculation results of simulation data

index	Before the opening of the community	After the community is opened
Traffic volume completed by the road network	152	144
Traffic improvement factor	94.74%	
Saturation mean	0.7677	0.6667
Saturation variance	0.0213	0.0115

It can be seen from the above calculation results that the e(4,5) is not able to pass before the opening of the cell, and the traffic demand between the pair (4, 5) and (4, 6) needs to be bypassed, so the road network is completed. The traffic volume is relatively large, and after the community is opened, the traffic between these pairs does not need to be bypassed. Under the premise that the traffic demand has not changed, the total load of the entire traffic network is reduced. Therefore, for a cell having the characteristics (the cell area is larger than the minimum traffic grid), the road added by the cell opening can optimize the road network. In addition, since the total load of the road is reduced, the average value of all saturations is also lower than before. The traffic load on each side is more balanced in the entire transportation network, which can be seen from the decrease of the saturation variance.

In order to more accurately reflect the reality, we extend the road map around the cell shown in Figure 1. The road network structure is shown in Figure 2 (the figure is a directed graph). The thickness of the line shows the different road segments. In this group of data simulation, although the road width and speed limit requirements have been added, only the traffic capacity on the road segment needs to be weighted here, that is, the correction in the model (6) is performed, and the simulation calculation is performed. The results are shown in Table 2.

Table 2

Index	Before the community is opened	After the community is opened
Traffic volume completed by the road network	1156	1140
Traffic improvement factor	98.62%	
Saturation mean Saturation	0.0135	0.0140
standard deviation	0.0079	0.0090

It has been assumed that there is traffic demand between any nodes. The nodes in Figure 2 are more numerous than those in Figure 1, so the total traffic demand increases, but this does not affect the trend of the indicators. It can be seen from the data in Table 3 that the traffic improvement factor is 98.62%, indicating that the total traffic load of the network is reduced, but the saturation mean and the saturation standard deviation are both increased, which indicates that the load capacity of each road segment is different. After the opening of the community, the distribution of traffic flow in the entire network is even more uneven, which will aggravate the congestion of some road sections, and some road sections are idle but cannot be diverted. In summary, the calculation result of the simulation data 2 indicates that the cell is not suitable for opening.

6. Model Application Description

This paper only gives the simulation of two basic cell structures, but because the road conditions are more complicated, the following explains how the proposed model can be applied to complex situations.

When the model proposed in this paper is applied in practice, it also needs to consider constraints such as road width, speed limit, and intersection capacity. For such cases, when the model is applied, it is only necessary to weight-correct the traffic capacity on the road segment according to the specific influencing factors. For example, suppose the maximum flow rate of the s road segment is: if the road width is half of the original due to road construction in reality, the traffic capacity of the road segment becomes half of the original, and the maximum flow rate of the road segment is set to 0.5. The model can be calculated, where 0.5 is the weighting coefficient of the reaction road condition change.

In practice, the shape and area of the cells are different, and the conditions that can be used as roads vary. Since the model proposed in this paper has abstracted the cells and roads into graphs, the change of the topology of the graphs for the complex cells is not affected by the use of the model. The model users only need to accurately evaluate the roads based on the actual situation. Capacity can be brought into the model for solving.

In this paper, when abstracting the traffic network into a graph, the directed graph is used, and the two directions between the two points correspond to the two-way line in reality. If the road segment s is a one-way street in actual application, the maximum traffic of the edge corresponding to the traffic direction is not allowed to be zero.

In the above simulation experiment, the traffic demand matrix G in the model is simplified, that is, the traffic demand between any two nodes i, j. In actual application, the actual traffic demand matrix G can be substituted into the model according to the actual situation of the road.

7. Conclusion

With the large-scale expansion of cities, the increase of urban population density and building density, urban traffic congestion has become a very prominent and urgent problem to be solved. Based on solving the problem of urban traffic congestion, this paper puts forward three evaluation indicators such as traffic improvement factor, road saturation mean and road saturation variance, and establishes a traffic optimization linear optimization network model based on shortest path selection. The simulation results show that the density of the road network is improved after the opening of the community, and the total traffic load is reduced, but this does not mean that the opening of the community will certainly alleviate the traffic congestion. The calculation results of simulation data 2 indicate that many factors such as cell area, location, external and internal road conditions may affect the traffic state of the road network. Therefore, whether the open cell can be blocked cannot be generalized, and it is necessary to use scientific methods to pre-evaluate and then decide whether to open.

The model proposed in this paper has considered many factors of actual road conditions, such as road width, road speed limit, one-way street, intersection capacity and other practical factors (these factors can be weighted by the shortest path). It can provide a quantitative scientific basis for realistic decision-making.

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