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Research on Low Cost Algorithm of Urban Walking Traffic Network Accessibility

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Abstract: *Walking traffic is an important part of urban traffic environment. In modern cities, a large number of community street grids have weakened connectivity and walking. This paper presents a low cost algorithm based on semantic network model. This algorithm can quickly analyze whether a decision is ideal or not by using the matrix operation corresponding to the network. Through the semantic network and its corresponding correlation matrix, it can effectively reduce the computational cost, support the early planning of urban pedestrian traffic planning, and put forward a preliminary framework for the subsequent detailed planning.*

Keywords: *Semantic Network; Walking Traffic; Accessibility; Low Cost Algorithm*

1. Introduction

In the urban traffic environment, the quality of pedestrian traffic has gradually become an important factor, the importance of urban community walking accessibility has been widely recognized in the industry.

In modern cities, a large number of community street grids have weakened connectivity and walking. The passive dependence on motor vehicle traffic not only increases the cost of ecological environment, but also increases the cost of time for residents. Without talking about the interest and intentionality of pedestrian traffic, there are many deficiencies in the actual urban construction in terms of the walking service radius of residential communities.

In China ' s latest community planning norms, there are many provisions related to pedestrian traffic accessibility, such as "residential commercial center walking radius is not greater than 500 m. District, business point radius is not greater than 300 m ", "nursery service radius should not be greater than 300 m "and so on[1].

Before urban traffic network planning, designers usually consider a large number of urban scale problems in the planning stage. If there is a low-cost algorithm combined with computer aided planning, it will greatly improve the efficiency and quality of work. In view of this, we do a low-cost algorithm research on the accessibility or convenience of community walking through the urban semantic network [2].

2. Application Algorithm

For walking accessibility, in addition to using attribute-based GIS network model to analyze [3], using urban traffic data and POI interest point data to reduce the cost of reconnaissance [4], we can also quantify by walking semantic network distance. Since the physical distance between the nodes of urban spatial semantic network is sometimes not considered, different unit values should be given according to the planning object when the semantic network is transformed into a graph.

First of all, we need to vectorize the two-dimensional semantic network of urban space. Here, we can use the semantic network multiplier method to calculate the various routes and lengths of a certain point of the block to reach another point, and also calculate the range that a certain point can reach within a certain walking distance. Then, the relationship chain eij between VI and vj is segmented, and the spatial distance is set to Dij. According to the required accuracy d (d = 10m, 50m, 100m or 300m,

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etc.), eij is divided into m-segments, and the endpoint of the segment is defined as a semantic network node, where m = INT (Dij / d). In this way, the semantic network graph can correspond to the spatial scale, and the accuracy changes with the adjustment of d.

For neighborhoods with single directionality and few reentry phenomena, we can calculate them through a directed two-dimensional spatial semantic network. For any starting point vi, the centrifugal direction is given to all the relational chains, and the contradictory points are adjusted. Then the directed semantic network is obtained, and then the adjacency matrix A is constructed. By multiplying the adjacency matrix, we can obtain the position that any starting point vi can reach within a limited range.

For complex block structures, we can use a more accurate but computationally intensive undirected two-dimensional spatial semantic network to calculate. For any two semantic network nodes vi and vj, if in the adjacency matrix An corresponding to the whole semantic network, the corresponding number k is greater than zero (k is an integer), then there are k paths with space distance n between vi and vj, and the actual two-dimensional distance is n * d. Extracting useful “paths”or “traces “from these paths is a non-repetitive path. Of course, in the process of calculating the adjacency matrix an, when n increases in turn by integers from 1, k is the shortest path from vi to vj when the matrix values corresponding to vi and vj are nonzero integer k for the first time. When the path from vi to vj has several paths in a certain range, the “path”or “trace”is the optional path between two points.

Through the above values, we can analyze and judge the control range of the starting point and the target point. For example, n * d is the allowable walking limit of a certain function, so for any originating node vi, the range of nodes less than n * d is the reachable region.

3. Computational Analysis

Firstly, we take a community fragment in a city as an example and construct a semantic network, such as Figure 1 and Table 1.

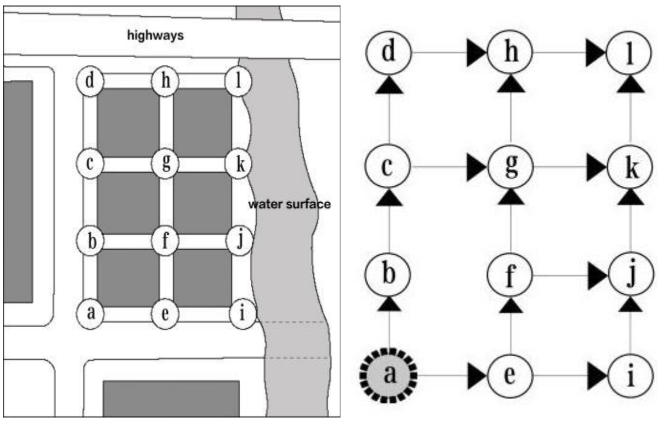

Figure 1: Community semantic network

Table 1: Figure1’s adjacency matrix

Table 1 A^1 $M_{12 \times 12}$	a	b	c	d	e	f	g	h	j	k	l
a	0	1	0	0	1	0	0	0	0	0	0
b	0	0	1	0	0	0	0	0	0	0	0
c	0	0	0	1	0	0	1	0	0	0	0
d	0	0	0	0	0	0	0	1	0	0	0
e	0	0	0	0	0	1	0	0	0	0	0
f	0	0	0	0	0	0	1	0	1	0	0
g	0	0	0	0	0	0	0	1	0	1	0
h	0	0	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	1	0	0
j	0	0	0	0	0	0	0	0	0	1	0
k	0	0	0	0	0	0	0	0	0	0	1
l	0	0	0	0	0	0	0	0	0	0	0

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In order to simplify the calculation and explain the problem, we use the block of orthogonal grid, where the actual spatial distance is 300 square blocks. For example, “ab”, “bc” and “ae” are about 250 m, or any two-point function φ (USN) is “connected”, and the horizontal distance is 250 m. The b node can be understood as the equipartition insertion point mentioned above.

We construct the semantic network of community two-dimensional space through the block structure, and make it directional by centrifugal search, so we get the corresponding A1 matrix. With A1 matrices we can get A2 and A3 matrices by matrix multiplication, as shown in Table 2.

Table 2: Adjacency matrix power

Table 2 $M_{12\times 12}$ A^2	a	b	c	d	e	f	g	h	i	j	k	l
a	0	0	1	0	0	1	0	0	0	1	0	0
b	0	0	0	1	0	0	1	0	0	0	0	0
c	0	0	0	0	0	0	0	2	0	0	1	0
d	0	0	0	0	0	0	0	0	0	0	0	1
e	0	0	0	0	0	0	1	0	1	0	0	0
f	0	0	0	0	0	0	0	1	0	0	2	0
g	0	0	0	0	0	0	0	0	0	0	1	2
h	0	0	0	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	0	0	0	0
j	0	0	0	0	0	0	0	0	0	0	1	1
k	0	0	0	0	0	0	0	0	0	0	0	1
l	0	0	0	0	0	0	0	0	0	0	0	0

Table $M_{12\times 12}$ 3 A^3	a	b	c	d	e	f	g	h	i	j	k	l
a	0	0	0	1	0	0	2	0	0	2	0	0
b	0	0	0	0	0	0	0	2	0	0	1	0
c	0	0	0	0	0	0	0	0	0	0	0	3
d	0	0	0	0	0	0	0	0	0	0	0	0
e	0	0	0	0	0	0	0	1	0	0	3	0
f	0	0	0	0	0	0	0	0	0	0	0	3
g	0	0	0	0	0	0	0	0	0	0	0	0
h	0	0	0	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	0	0	0	1
j	0	0	0	0	0	0	0	0	0	0	0	0
k	0	0	0	0	0	0	0	0	0	0	0	0
l	0	0	0	0	0	0	0	0	0	0	0	0

If we are concerned about walking up to a range of 500m or 750m, that is, 2D or 3D, then we can use A+A2and A+A2+A3 matrices and get the number of optional routes and reachable matrices. Through the sum of adjacency matrix, we can clearly see whether point a can be reached to any point within the set range, and there are several possible lines, as shown in Table 3.

Table 3: Sum of adjacency matrix power

Table 2 $M_{12\times 12}$ $A+A^2$	a	b	c	d	e	f	g	h	i	j	k	l
a	0	1	1	0	1	1	0	0	1	0	0	0
b	0	0	1	1	0	0	1	0	0	0	0	0
c	0	0	0	1	0	0	1	2	0	0	1	0
d	0	0	0	0	0	0	0	1	0	0	0	1
e	0	0	0	0	0	1	1	0	1	2	0	0
f	0	0	0	0	0	0	1	1	0	1	2	0
g	0	0	0	0	0	0	0	1	0	0	1	2
h	0	0	0	0	0	0	0	0	0	0	0	1
i	0	0	0	0	0	0	0	0	0	1	1	0
j	0	0	0	0	0	0	0	0	0	0	1	1
k	0	0	0	0	0	0	0	0	0	0	0	1
l	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 $M_{12\times 12}$ $A+A^2+A^3$	a	b	c	d	e	f	g	h	i	j	k	l
a	0	1	1	1	1	1	2	0	1	2	0	0
b	0	0	1	1	0	0	1	2	0	0	1	0
c	0	0	0	1	0	0	1	2	0	0	1	3
d	0	0	0	0	0	0	0	1	0	0	0	1
e	0	0	0	0	0	1	1	1	1	2	3	0
f	0	0	0	0	0	0	1	1	0	1	2	3
g	0	0	0	0	0	0	0	1	0	0	1	2
h	0	0	0	0	0	0	0	0	0	0	0	1
i	0	0	0	0	0	0	0	0	0	1	1	1
j	0	0	0	0	0	0	0	0	0	0	1	1
k	0	0	0	0	0	0	0	0	0	0	0	1
l	0	0	0	0	0	0	0	0	0	0	0	0

Then we extract the reference data of each part of the matrix starting from a in Table 4.

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Table 4: Matrix reference data

		a	b	c	d	e	f	g	h	i	j	k	l
2Dmatrix:	a	0	1	1	0	1	1	0	0	1	0	0	0
		a	b	c	d	e	f	g	h	i	j	k	l
3Dmatrix:	a	0	1	1	1	1	1	2	0	1	2	0	0
		a	b	c	d	e	f	g	h	i	j	k	l
4Dmatrix:	a	0	0	0	0	0	0	0	3	0	0	4	0
		a	b	c	d	e	f	g	h	i	j	k	l
5Dmatrix:	a	0	0	0	0	0	0	0	0	0	0	0	7

From the data we can draw: a point and b, c, e, f, i respectively, there is a range of 500m path. There are two paths to reach 750m between a point and g, j, respectively, but only one path to b, c, d, e, f, i. Point a and point h have three paths up to 1000m, and point k have four paths up to 1000m.

4. Planning Scheme

Through the above analysis, we can calculate the reachable range of point a within any walking range. At the same time, we can also obtain the number of optional routes through this method, and then we can calculate and count the path data of any point in the community to other points. Due to the large amount of calculation, one-to-one calculation is no longer carried out in the absence of computer assistance.

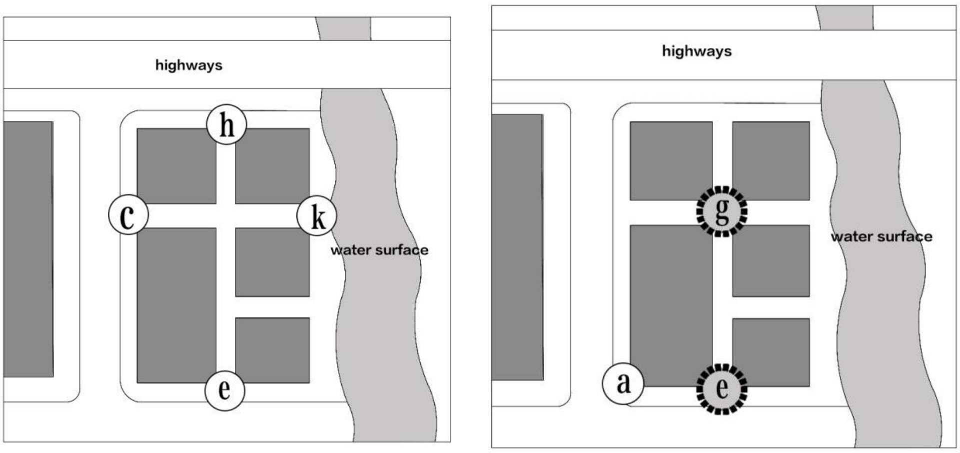

Figure 2: Programming

Through data analysis, we can arrange and plan various functions within the community through the semantic network model, providing the basis for urban design. For example, for the kindergarten's "service radius should not be greater than 300 m", through intuitive observation, we can conclude that compared with node g, point a is certainly not the best. By calculating the accessibility of each point in the community, setting childcare functions at point's c, h, e and k can be counted as one of the planning schemes. Assuming that the neighborhood scale of the community is 250 m, that is, D = 250. If the middle school with a service radius of 1000 m in the community is considered, point a and point l at the edge are only beyond the specified range, then we need to consider that the middle school needs to serve a larger residential area, and point b and point e are critical points. For other functions, such as residential commercial center, the relevant provisions require that "walking radius is not greater than 500 m", so the g point and e point can be used as planning options, such as Figure 2.

5. Conclusion

As an expanded application, this low-cost and simple analysis tool can not only quickly analyze and judge the pros and cons of the previous pedestrian traffic scheme, but also expand to the analysis of motor vehicle mobility accessibility [5] .if we combine the physical accessibility model, preference model, gravity model or multi-index analysis model to construct the semantic network accessibility model [6].

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Of course, the accuracy and detailedness of the above calculation methods are not the purpose of this paper. We should explain that the early traffic planning does not require high-cost calculation, but is the potential and role of an analysis platform in the process of urban planning and planning.

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