A study of Guangzhou road network and public transport based on betweenness evaluation

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Abstract—This paper introduces the intermediate concept in the topology structure, analyzes the road network in Guangzhou, and proves that the intermediate index of the road section has a positive relationship with the number of bus lines. By comparing the situation under different search distances, it is found that the fit advantage increases rapidly with the increase of search distance in the stage of search distance, which reflects that the intermediate index of the segment needs to show advantage in a certain scale range to make sense. When the search distance reaches more than 5km, the growth trend of fit excellence slows down and reaches a maximum in the 8km to 12km range, before starting to fall back. This reflects the fact that for conventional public transport, it is not necessary for the road section to show an intermediate advantage on too large a scale.

1. INTRODUCTION

As a basic public service which is affected by road construction conditions, sensitive to traffic flow and serves the largest public group of citizens, the layout of its lines is difficult to be unaffected by the centrality of the road. As shown in Figure 1, the number of bus lines in Guangzhou is not homogeneity on the road network, with dozens of bus lines concentrated on some roads and only a few or no lines on others. As can be seen from the diagram, some of the road sections without lines are trunk roads and secondary trunk roads, which indicates that outside the road level, the topological characteristics of the road network may also be an important factor affecting the choice of bus lines.

Ye Pengyao(2012) has set up a number of sample areas in the outer ring of Pudong New Area in Shanghai, and made a regression analysis between the centrality of the road network and the density of the bus network, and pointed out the linear positive correlation between the two. This study makes a new study on the relationship between the centrality of road network and the density of bus network, and the method and conclusion have high value and significance, but there are still some limitations. First of all, the study artificially divides several areas of urban areas, the process of district planning is artificially uncertain, and the urban areas are difficult to represent the whole city. Secondly, the study analyzes the interior of each region individually, separates the organic connection between regions, and thirdly, the data processing platform (Analysis Strokes) used in this method only stores the properties of node length, topological proximity, etc., and can not store other types of properties, so it is difficult to study them in more depth. Therefore, this study attempts to improve the method on the basis of the existing exploration, so that it can be applied to the whole city, not affected by artificial zone, can be included in the non-topological attribute data for further study.
2. RESEARCH FRAMEWORK
In the application of spatial topology, it is often necessary to identify the interior space of a building, square, neighborhood, or even the center of a city. Regardless of whether the node is expressed as a convex space or a field-of-view axis, nodes throughout the data system are connected by topological relationships. Therefore, spatial synths take node as the focus point, evaluate the index, and identify the center of the region through the evaluation results of the node index. Indicators such as connectivity, depth, and integration can be used to evaluate the importance of nodes and identify the center of space. Thus, the above importance can be called centrality. In traffic research, these concepts of spatial synth can also be applied, and the central area is generally the area with better traffic accessibility.

The platform for this study selects ArcGIS Desktop 10 and uses Spatial Design Network Analytics (sDNA) as a computing tool (Chiaradia, 2015) sDNA to analyze central indicators such as connectivity, proximity, and intermediateity, where the intermediate (betweenness) indicator is the core indicator.[2] Most of the remaining indicators are process indicators in the calculation of intermediate indicators. The principle of intermediate indicator of sDNA is based on the definition of freeman(1977) indicator, but further expand and optimize according to the research needs of geospatial, transportation network and so on. [3]

The size of the search Radius Ry value has a significant effect on the calculation of the intermediate(Bt)value. [4]

In absolute terms, as the radius increases, the number of searchable nodes (i.e., segment link) increases, and the number of paths increases, so does the number of potential passes by the shortest path. Therefore, in general, the absolute value of intermediate Bt increases with the radius.

From the relative relationship of the whole road network, the search radius is different, and the relative relationship of the intermediate values of each road segment(link) changes.

Taking the homogeneity road network as an example, the overall scale of the road network is 5×5km, 500m search radius is much smaller than the overall scale. Therefore, in addition to the low value of the edge area of the road network, the intermediate values of the segments in the non-marginal area are consistent. When the search radius is 4000 meters, because the search radius is close to the overall scale of the road network, the numerical advantage of the most central area of the road network relative to the middle ring layer and the outer ring layer is obvious, and the trend of the value decreasing with the outer circle layer is also obvious.

3. APPLICATION AND ANALYSIS
The distance measurement method of this study selects Eustitus distance and angle distance respectively for analysis, and searches for continuous space within the distance. The search distance is set to 500m, and the interval between 1000m and 15000m intervals is 1000m/time, before a global-scope search is performed. The analysis parameter does not set any weight properties for the time being.

![Figure 1. The intermediate (angle distance, global search) of the inner section of the Guangzhou Expressway around the city.](image-url)
The distribution of the intermediate TPBt value and the number of bus lines in Guangzhou and the linear regression equation. In general, the city's road section intermediate value and the number of road section bus lines show a positive relationship, that is, the higher the road segment intermediate value, the more bus lines. From Fit Excellence. The values show that the linear fit effect in Guangzhou is very good.

**Table 1. The intermediate indicators of Guangzhou road sections under different search radius and the regression analysis of the number of bus lines.**

| Intermediate indicators | TPBt. (EU distance) | TPBt. (Angle distance) |
|-------------------------|---------------------|------------------------|
| Search for distance     | Linear.             | Second-order polynyrtics. | Linear.         | Second-order polynyrtics. |
| 500m.                   | 0.0000              | 0.0024                 | 0.0006          | 0.0048                   |
| 1000m.                  | 0.0199              | 0.0341                 | 0.0348          | 0.0548                   |
| 2000m.                  | 0.1186              | 0.1542                 | 0.1859          | 0.2268                   |
| 3000m.                  | 0.1990              | 0.2419                 | 0.3120          | 0.3476                   |
| 4000m.                  | 0.2485              | 0.2887                 | 0.4015          | 0.4217                   |
| 5000m.                  | 0.3028              | 0.3366                 | 0.4547          | 0.4646                   |
| 6000m.                  | 0.3452              | 0.3727                 | 0.4880          | 0.4927                   |
| 7000m.                  | 0.3749              | 0.3972                 | 0.5127          | 0.5142                   |
| 8000m.                  | 0.3961              | 0.4130                 | 0.5321          | 0.5323                   |
| 9000m.                  | 0.4117              | 0.4244                 | 0.5492          | 0.5493                   |
| 10000m.                 | 0.4265              | 0.4363                 | 0.5635          | 0.5647                   |
| 11000m.                 | 0.4393              | 0.4472                 | 0.5733          | 0.5765                   |
| 12000m.                 | 0.4493              | 0.4560                 | 0.5747          | 0.5798                   |
| 13000m.                 | 0.4552              | 0.4609                 | 0.5722          | 0.5787                   |
| 14000m.                 | 0.4576              | 0.4627                 | 0.5680          | 0.5756                   |
| 15000m.                 | 0.4566              | 0.4614                 | 0.5629          | 0.5710                   |
| Global.                 | 0.4176              | 0.4217                 | 0.5121          | 0.5238                   |

**Figure 2. The TPBt value of the Guangzhou section (angle distance, search distance 8000 meters) and the number of bus lines are linearly regressed.**

The characteristics of the effect of search distance on fit excellence have important enlightenment for this study. It reflects the important influence of the calculation scale on the intermediatecity of the road...
section, and the intermediateness of the road section at different scales has different sensitivity to the setting of bus lines.

When the calculated search scale is small (1000 m and below), even if the middle of the road segment is high, it does not indicate that the section is suitable for the placement of bus routes. The scale of about 1000 meters roughly corresponds to the scale of the residential area, at which it is of little significance to calculate the intermediate index only for the internal roads of the residential area if the influence of the surrounding road network is not taken into account.

When the search distance reached 2000 meters, this calculation scale has broken through the general residential area scale, at this scale calculated road segment intermediate indicators have begun to have significance for bus route layout. And as the search distance grows to 5000 meters, the "meaning" increases significantly. The calculation scale of about 5000 meters is equivalent to that of a large urban area, which indicates that the intermediateness of the road section is obvious for bus lines within the scale of the area.

The "marginal effect" of the "meaningful" growth in the middle of the calculated segment decreases as the search distance exceeds 5000 meters and continues to grow. When the search distance increases to more than 10000 meters, or even to the global search, the increase in the middle of the road segment may have a counterproductive effect on the suitability of the bus line.

According to the principle of intermediate index, in a certain search distance, whether it is eucalyse distance measurement or angle distance measurement, usually the middle indicator high road section is in the calculation scale "through" better road. At a certain scale, "throughability" good road section has the following characteristics: 1, the road section in the search distance of the scale can be through the area, rather than easy to be limited by the end point or T-word intersection of the road section; 2, according to the above analysis, the appropriate length of "throughability" has a reasonable range, can not be too low, there is no need to be too long.

4. CONCLUSION
The above study abstracts the road segment pass capacity into parameters and introduces it into the calculation method of intermediate indicators. The results show that the intermediate index of the road section calculated under this method has the ability to explain the suitability of the layout of the bus route.

It should be noted that, if the data conditions support, to obtain the specific number of lanes in each section of the road, speed limit and other indicators can calculate more accurate road traffic capacity. If more complex, road capacity can also take into account the impact of intersection conditions, traffic control, frequent congestion in actual operation and other factors. However, whether the calculation method of the pass capacity of the road section is simple or complex, it can be abstracted into a parameter and introduced into the calculation of intermediate indicators.

The above analysis of the introduction of road grade factors is based on the assumption that each section of the road can play the corresponding number of lanes under the capacity of the road. However, in the actual operation, whether each section of the road can give full play to its capacity, but also affected by a variety of factors, these factors are not discussed.

REFERENCES
[1] Y. Peng, X. Chen, C. Xu (2004) Impact on Density of Public Transportation Network by Urban Road Network Layout, Journal of Tongji University (Natural Science), Vol.40 No.1: 51-56.
[2] L. Zhang, A. Chiaradia, Y. Zhuang (2015) A Configurational Accessibility Study of Road and Metro Network in Shanghai, China, Recent Developments in Chinese Urban Planning: 219-245
[3] L. Freeman (1977) A Set of Measures of Centrality Based on Betweenness, Sociometry, 40(1):35-41
[4] A. Chiaradia, C. Cooper, C. Webster (2015) sDNA a software for spatial design network analysis. Cardiff University. http://www.cardiff.ac.uk/sdna/