URBAN TRAFFIC STATUS ANALYSIS AND PLANNING EVALUATION BASED ON MOBILE BIG DATA: A CASE STUDY OF JINGHONG CITY (1098)

Gangyu Hu[1], Jianing Shi[1], Jianzhong Huang[1*], Jingxin Wang[1]

[1] Tongji University College of Architecture and Urban Planning, Shanghai, China; [*]huang03213@tongji.edu.cn

Abstract. Taking the central urban area of Jinghong city in Yunnan Province of China as an example, this paper mainly introduces the methods of traffic status analysis and evaluation of traffic planning scheme based on mobile big data. In the section of traffic status analysis, we analyse the OD features, job-housing spatial structure and the traffic performance of the city based on big data and Visum traffic current model. In the planning evaluation part, based on the traffic current situation, we use the method of scenario simulation to evaluate traffic planning scheme. Through traffic flow and saturation calculation in the Visum traffic planning model, we can see the traffic performance of different scenarios to advise the project team on future transportation development strategies.

Keywords: Mobile big data, Traffic status analysis, Planning evaluation, Scenario simulation, Jinghong.

1. Introduction

The application of mobile big data provides new ideas and perspectives for urban traffic planning. Traffic system analysis under the condition of big data does not simply apply or transplant big data technology to the traffic field, but integrates big data technology into the analysis system of traffic system. It is an information processing process in which we organise data into information, extract features from information, find patterns from feature changes and track and evaluate countermeasures (Yang and Duan, 2015). Under the guidance of this principle, we empirically analyse urban traffic status based on one kind of mobile big data—signaling data and then conduct scenario simulation evaluation on the planning scheme. We hope to provide reference and technical support for the evaluation of urban traffic operation, the division of transportation modes, the formulation of transportation channel strategy, the determination of urban spatial structure, etc.

2. Review of Relevant Research

Related traffic big data include taxi GPS, bus IC card, vehicle license plate recognition, mobile big data, etc. And more and more research based on mobile big data has been conducted in recent years. Yang and Duan (2015) summarised the analysis techniques and latest research results from information collection and quality control, traffic system status feature extraction, traffic demand and behavior feature extraction, correlation analysis and model building, information fusion, etc. Their research mainly focused on the overall and macro-level analysis of traffic system. Some scholars also study the application of big data in traffic analysis from other perspectives, such as individual or vehicle travel (Yang, 2007), analysis and prediction of activity characteristics and patterns (Song et al, 2010; Liu et al, 2013), urban spatial distribution of commuter travel which affects urban space a lot (Yang et al, 2016; Sun et al, 2013), traffic scenario simulation evaluation based on the current situation (Huang et al, 2014), etc. Based on existing research, an important feature of mobile big data which is different from traditional data is that the behavior patterns of large-scale individuals can be obtained through long-term observation, based on which individual behavior modeling and prediction can be made (D'Alconzo et al, 2019).

Some scholars have compared traditional methods with big data research methods (Lv et al, 2014; Nagy and Simon, 2018). Based on relevant research, the differences between the two methods have been shown in Table 1.

Table 1. Comparison of traditional research methods and big data research methods

Research methods	Main data	Research subjects	Advantages	Disadvantages
Traditional Methods	Traffic survey data, etc.	Small sample data based on sampling	1.Survey depth is large and comprehensive. 2. The social and economic attributes of the respondents are clear.	1. Data quality depends on the cooperation of respondents and their understanding of the survey questions. 2. The sample size is small and the real-time performance is poor. 3. The data are hard to support elaborate analysis. 4. Weak analysis of the spatial structure and insufficient analysis of the relationship between traffic and space.
Big Data	Signalin	Large	1. High spatial	1. The data structure is limited

Methods	g data, Mobile internet Location Based Service (LBS) data, etc.	sample data based on acquisition methods	accuracy, able to refine to each traffic cell. 2. Large sample size, long time, comprehensive spatial coverage and dynamic continuity. 3. Commuting OD can reflect the spatial structure of the city to a certain extent. 4. It can obtain raw data, which can be used for various analyses.	by the data collection method. For example, some children and elderly people do not use smartphones so their information cannot be collected. There is structural bias in the sample. 2. It is difficult to see the economic and social attributes and travel mode of the collected people. 3. The accuracy of data collection is not uniform and the quality of data is uneven, which need to be screened and calibrated. 4. The data volume is large and difficult to process.

Source: Drown by authors

Under current conditions, it is difficult to obtain all kinds of basic data. Although different cities and regions have diversified data sources, the data resources available for actual research and project implementation are very limited, which brings great obstacles to the research work. Therefore, it is also worth paying attention to how to analyse and use possible data to support various research directions of traffic planning. The application of mobile big data provides broader basic data sources, newer research ideas and perspectives for the study of urban traffic system, the coupling relationship between urban spatial structure and traffic mode, etc.

3. Research Data Introduction

At present, in China, commonly used mobile big data include signaling data and mobile internet Location Based Service (LBS) data. In this study, signaling data have been used.

Signaling data is originally the control signal needed to ensure normal communication in mobile communication networks. Signaling data is recorded for events such as power on, power off, calls, text messages, location updates and base station switching. Since mobile devices are usually carried around, signaling data is equivalent to recording the spatio-temporal activity trajectory data of a ‘person’.

One record of signaling data represents a point on the spatio-temporal activity trajectory of a user and combining multiple records can synthesise a more complete spatio-temporal trajectory within a time period. The study usually identifies the characteristic points within the spatio-temporal trajectory according to the general spatio-temporal pattern of human behavior. For example, we determine a point as the user's place of work by judging the cumulative maximum dwell time position between 9 a.m. and 4 p.m. of each working day within one month. Meanwhile, the dwell time needs to exceed two hours. We determine a point as the user's place of residence by judging the cumulative maximum dwell time position between 8 p.m. and 6 a.m. of each day to the next day and the dwell time needs to exceed two hours. The rest can be done in the same manner. We can find other spatio-temporal characteristic locations such as recreation areas. Through the determination of feature points, the OD feature table of the samples can be obtained and used for the subsequent diverse analysis of traffic.

As Jinghong is a famous tourism city, the OD data we obtained include tourism OD of tourists, commuting OD of local residents on working day and total OD of all purposes. The OD data is raster data and the size of the raster is 250 metres *250 metres. The data table mainly includes: time period (24 hours), grid ID at original point, grid ID at destination point and number of people (the captured sample). The fragment of OD data table has been shown in Table 2. In order to facilitate subsequent analysis, we divided the whole Jinghong central urban area into 85 traffic zones and collected the raster data by the traffic zones to obtain OD connection data between traffic zones for subsequent calculation.

Table 2. The fragment of OD data table (example)

Hour(0-23h)	O_ Grid ID	D_ Grid ID	Count
0	100630021540040	100615021525040	1
0	100650021480040	100630021540040	1
0	100665021725040	100665021725040	1
0	100675021580040	100665021560040	1
0	100675021580040	100675021580040	2
0	100675021580040	100705021610040	2

Source: Cut from the whole signaling data OD table

4. Introduction of the Case Area

Jinghong City is located in Xishuangbanna Dai Autonomous Prefecture in the southern part of Yunnan Province of China. It is the core tourism city of Xishuangbanna Prefecture. The scope of this research is the central urban area of Jinghong City (Figure 1). The central urban area of Jinghong City includes three large spatial clusters, which are Main city, Mengyang sub-city and Olive Ba sub-city. It also includes several core tourist attractions such as Laiyang River-Citong Old Cottage Reserve, Sanda Mountain, Nanlian Mountain Country Park, Lunan Mountain Nature Reserve, Farm District, Naban River Reserve, etc. The travel in the central urban area of Jinghong shows obvious dual characteristics of commuting travel and tourism travel.

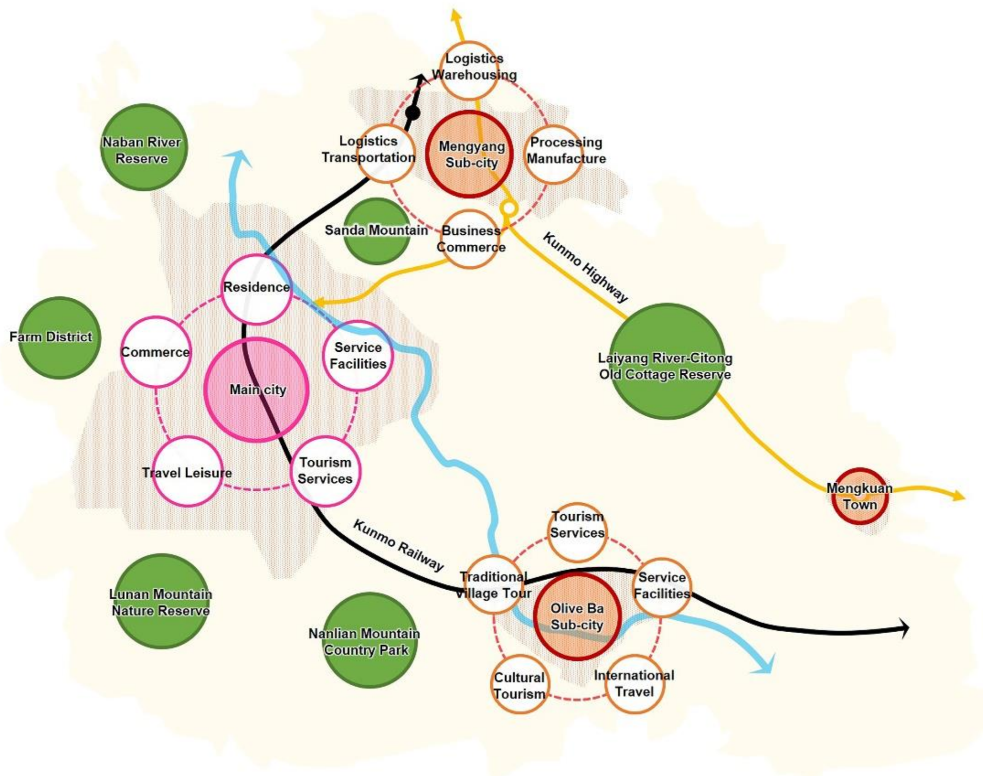

Figure 1. The spatial structure schematic diagram of the central urban area of Jinghong City

Source: Drown by authors

5. Urban Traffic Status Analysis

5.1 Analysis of OD Features

Based on commuting OD, tourism OD and total OD obtained from signaling data, we can analyse different kinds of relationships among Main city, Mengyang sub-city, Olive Ba sub-city and some other important tourist attractions. We can see that the main external connections of Main City are the tourism connections and the commuting connections are much fewer. Among the outlying tourist attractions, Laiyang River-Citong Old Cottage Reserve is the most popular one. And then come the Lunan

Mountain Nature Reserve, Sanda Mountain and Nanlian Mountain Country Park (Figure 2).

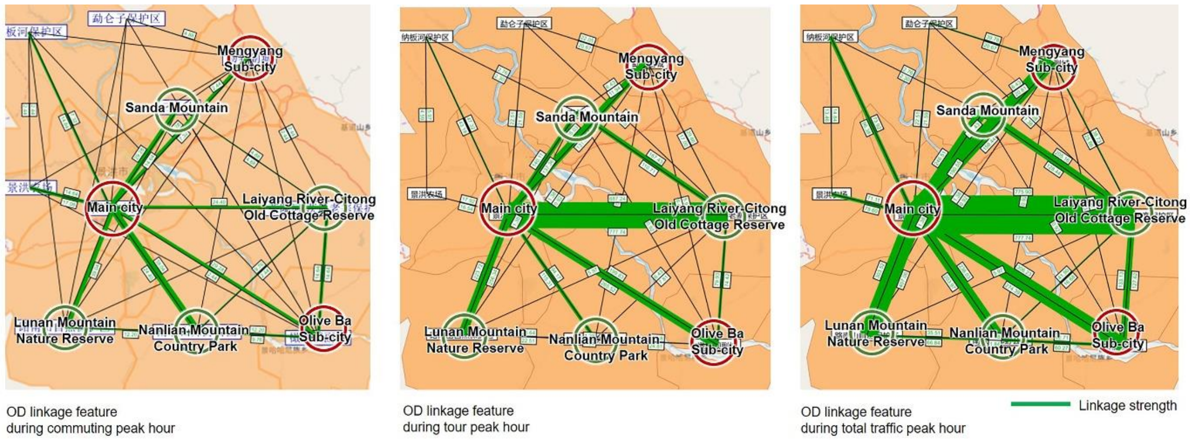

Figure 2. OD linkage features during peak hour

Source: Drawn by authors from signaling data

When we focus on the interconnectedness between the three major urban areas, we can get the table blow (Table 3).

Table 3. Linkage strength of three major urban areas

Commuting linkage strength				Tourism linkage strength				Total linkage strength			
Unit:%	Main city	Meng-yang	Oliver Ba	Unit:%	Main city	Meng-yang	Oliver Ba	Unit:%	Main city	Meng-yang	Oliver Ba
Main city	97.1	<1	<1	Main city	94.9	<1	<1	Main city	96.7	<1	<1
Meng-yang	16.7	79.1	<1	Meng-yang	48.7	42.6	<1	Meng-yang	32.5	57.1	<1
Oliver Ba	7.4	<1	85.8	Oliver Ba	18.3	<1	72.4	Oliver Ba	12.1	<1	80

Source: Drawn by authors from signaling data

In terms of commuting, the vast majority of travel is done within Main city and the two sub-cities themselves. In terms of tourism, Mengyang sub-city and Main city have a relatively strong connection. Generally speaking, the three areas are relatively independent and the connection between Mengyang and Main city is stronger than that between Olive Ba and Main city.

5.2 Analysis of Job-housing Spatial Structure

Considering that commuting travels are mainly completed within Main city and sub-cities themselves and the commuting volume in Main city is the largest, we further pay attention to the interior of Main city and analyse the job-housing spatial structure characteristics through the calculation of job-housing balance degree.

In previous research, the relationship between jobs and housing in cities is often expressed by static occupation-residence ratio. Static occupation-residence ratio is only a theoretical value due to the fact that the proportion of nearby employment cannot be directly determined. It is necessary to accurately measure the real employment equilibrium degree by further analysing the dynamic correlation between the commuting destination and residential place. Here, we put forward the concept of dynamic job-housing ratio, namely ‘job-housing balance degree’. The job-housing balance degree is the percentage of commuting trips within an urban area in the total commuting trips (Huang et al, 2017).

We have analysed the commuting OD feature and calculated the job-housing balance degree of each area in Main city. The result showed that commuting travel occurs mainly in the northern part of Main city. And the job-housing balance degree is mostly concentrated between 50 percent to 60 percent, which means the cross-district commuting is relatively common (Figure 3).

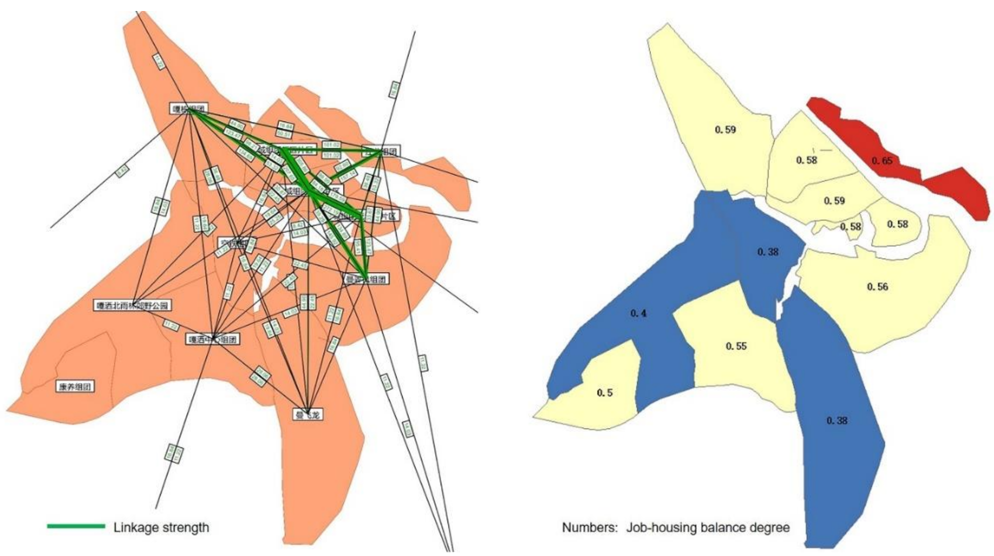

Figure 3. Commuting OD feature and job-housing balance degree of Main city
Source: Drawn by authors from signaling data

5.3 Establish Urban Traffic Status Model

The current traffic network of Jinghong central urban area includes four levels: Highway, trunk road, secondary trunk road and branch road, as shown in Figure 4. In addition, it is necessary to manually identify the number of lanes on each road based on field research and satellite image. The number of lanes on each road should be added to the attribute field. The road network will be input into the Visum model. In Visum, the speed attribute is attached to the road according to the road level and the one-way capacity of the road is calculated according to the single-lane capacity and the number of lanes. The speed and capacity of each lane of different levels of road have been shown in Table 4. In this way, the current road network model is basically established.

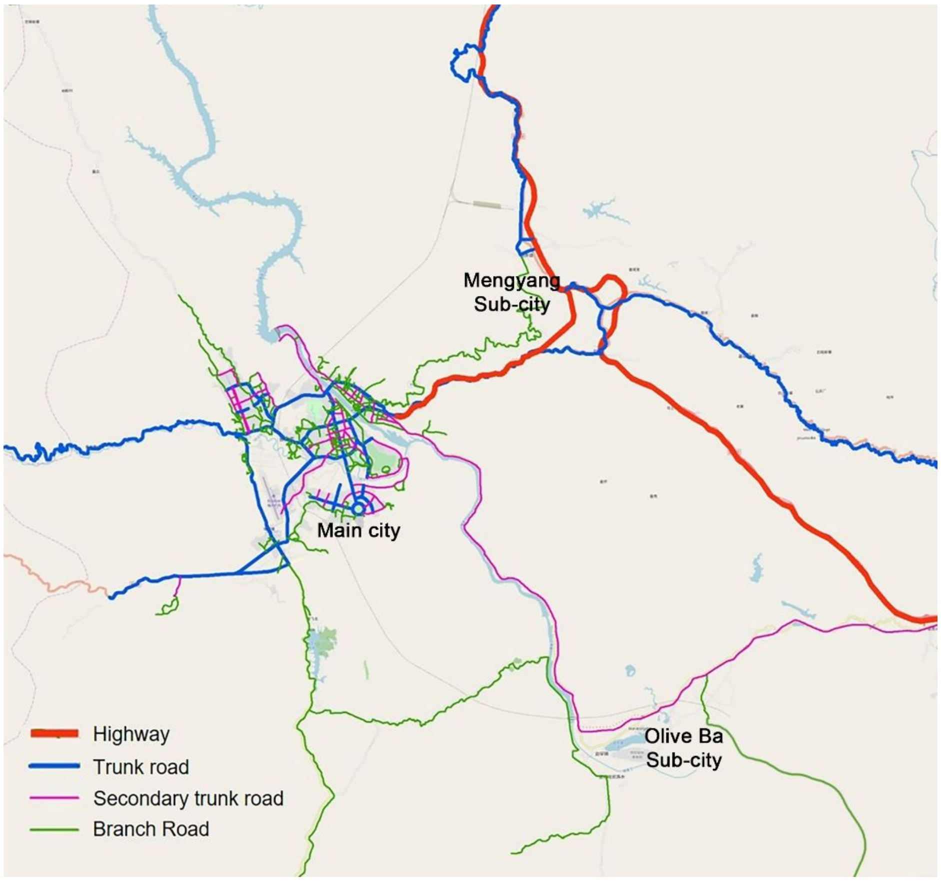

Figure 4. Current traffic network of Jinghong central urban area
Source: Drawn by authors

Table 4. Speed and capacity of different levels of roads

Road level	**Speed (km/h)**	**Single-lane capacity (pcu/h/lane)**

Highway	100	1600
trunk road	60	1000
secondary trunk road	40	800
branch road	30	500

Source: Drawn by authors

5.4 Analysis of Traffic Performance

After constructing the traffic status model by Visum software, with entering OD data into Visum, we calculate the traffic flow and saturation of Jinghong central urban area, so as to analyse the traffic performance of the city. Take the Main city as example, the traffic flow and saturation of the roads in Main city are shown in Figure 5.

As can be seen from the flow and saturation analysis results of the model, the Main city mainly has a large flow on external traffic roads, which are easy to be saturated in peak period. Some roads have a small flow. However, due to the poor road capacity, congestion is also obvious in peak period. Traffic flow and saturation analysis can clearly visualise road performance and help planners determine where road infrastructure needs to be enhanced or how travel patterns need to be adjusted to change congestion.

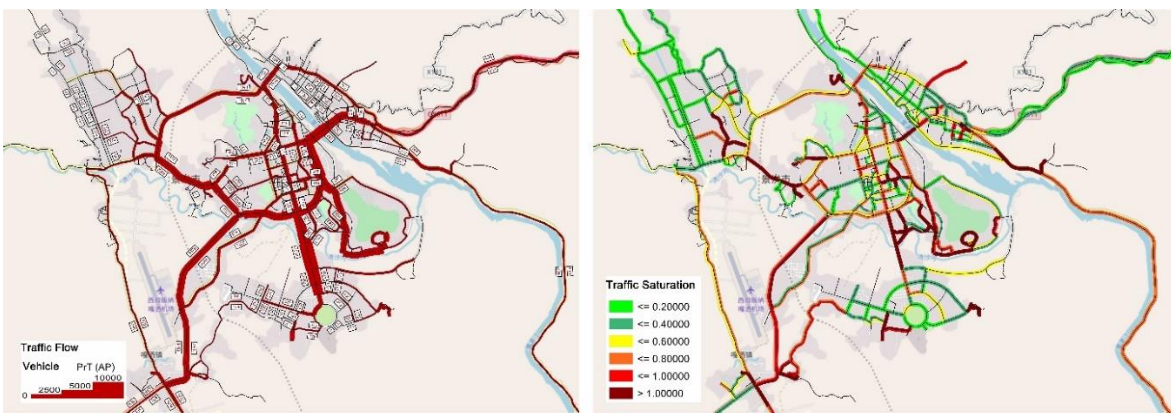

Figure 5. Urban current traffic flow and saturation in morning peak hour in Main city

Source: Drawn by authors by Visum

6. Planning Scheme Evaluation

In the section of planning evaluation, based on the analysis of the traffic current situation, we use the method of scenario simulation to evaluate the planning scheme of year 2030. First, we also need to build Visum traffic model with the planning traffic scheme. Second, we calculate the total number of trips in Jinghong in 2030 according to the projected population and give different traffic modes for different trip purposes. After the two steps, we give two different scenarios of bus travel in the future. One is that all bus travel is on the road, mainly in the form of normal buses, shuttle buses and tourist buses. The other is that the trams replace part of the road buses, especially between the tourist attractions. Through the analysis of the traffic flow and saturation calculation in the model, we can see the traffic performance of different scenarios.

6.1 Establish Urban Traffic Planning Model

Same as section 5.3, we build a planning traffic model. It can be seen from the planned road network that the planning scheme has greatly supplemented and improved the current road network (Figure 6). Whether such a road network structure can support the development of urban land use and population in the planning year needs to be evaluated.

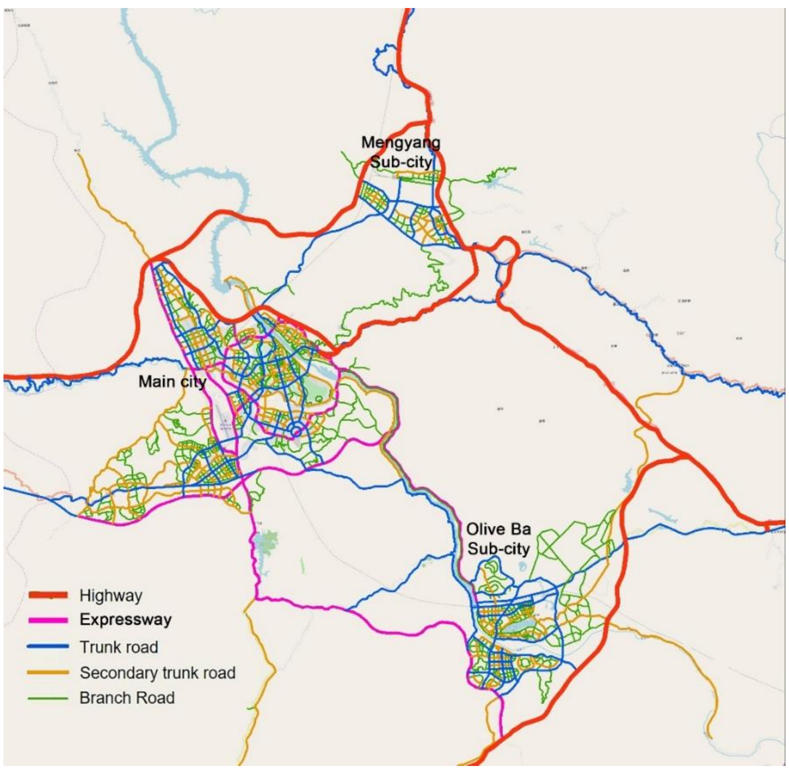

Figure 6. Urban planning traffic network of Jinghong central urban area
Source: Drawn by authors

6.2 Calculate Traffic Production and Attraction and OD Distribution in 2030

Due to the particularity of Jinghong as a tourism city, in the process of predicting the traffic production and attraction volume and generating OD in 2030, we divide the prediction into two parts: all-purpose travel of local residents and tourism travel.

In the all-purpose travel prediction of local residents, we first allocate the planned population to each traffic zone according to the overall planned population and the residential land area of each zone (Tab.5). Then, according to the 'Comprehensive Transportation System Planning of Jinghong', the travel rate of the central urban area in 2030 is 2.7 person-times per day. The population of each zone is multiplied by the travel rate to obtain the traffic production of each zone. Then, according to the land use plan in 2030, the area of different types of land in each traffic zone is calculated. The attraction amount of each zone is calculated according to the land area of each type and the attraction rate of this type of land.

Table 5. The area of each land type and planned population in each traffic zone (example)

Traffic zone number	Residential land (hectare)	Public service land (hectare)	Commercial land (hectare)	Industrial land (hectare)	Logistics land (hectare)	Road facilities land (hectare)	People (pers-on)
1	30.9	20.1	9.8	0.0	0.0	3.1	9872
2	43.2	6.8	61.0	0.0	0.0	1.0	13814
3	26.9	0.0	5.1	0.0	0.0	0.0	8605
4	23.1	13.5	5.5	0.0	0.0	0.0	7380
5	27.6	0.0	11.0	0.0	0.0	0.9	8818

Source: Cut from the whole land and population statistical table

For tourism travel, we first get the forecast tourism population of Jinghong in 2030 from the project team and then make it divided by the current tourism volume to obtain a sample expansion coefficient. Then we expand the current tourism OD based on the sample expansion coefficient to get the distribution of tourism OD in the future year. The total OD is obtained by adding the all-purpose OD and tourism OD to meet the needs of subsequent operation.

6.3 Travel Mode Division and Scenario Simulation

Based on the characteristics of the current situation, according to the law of urban transport development and the policy guidance for the future modes of transport, such as slow travel first, public transport first, etc., we predict the proportion of transportation modes in the future, mainly about bus and car proportion based on the Visum model need. Considering the particularity of Jinghong as a tourism city and the different characteristics of residents' all-purpose travel and tourism travel, we give the proportion separately. The travel proportion adopted in this forecast has been shown in Table 6.

Table 6. Travel mode division

	Bus + shuttle + tour bus	Car + taxi
All-purpose travel	35%	20%
Tourism travel	50%	15%

Source: Drawn by authors

According to the requirements of the general project team, we give two different scenarios of bus travel in the future (Figure 7). The purpose is to get traffic performance of different scenarios to advise the project team on future transport development strategies.

Figure 7. Two different scenarios of bus travel in the future
Source: Drawn by authors

6.4 Comparison of Traffic Performance of Two Scenarios

We put the above prepared data into the Visum model to do the simulation to get the traffic operation performance results of different scenarios of Jinghong central urban area in traffic peak hour (Figure 8).

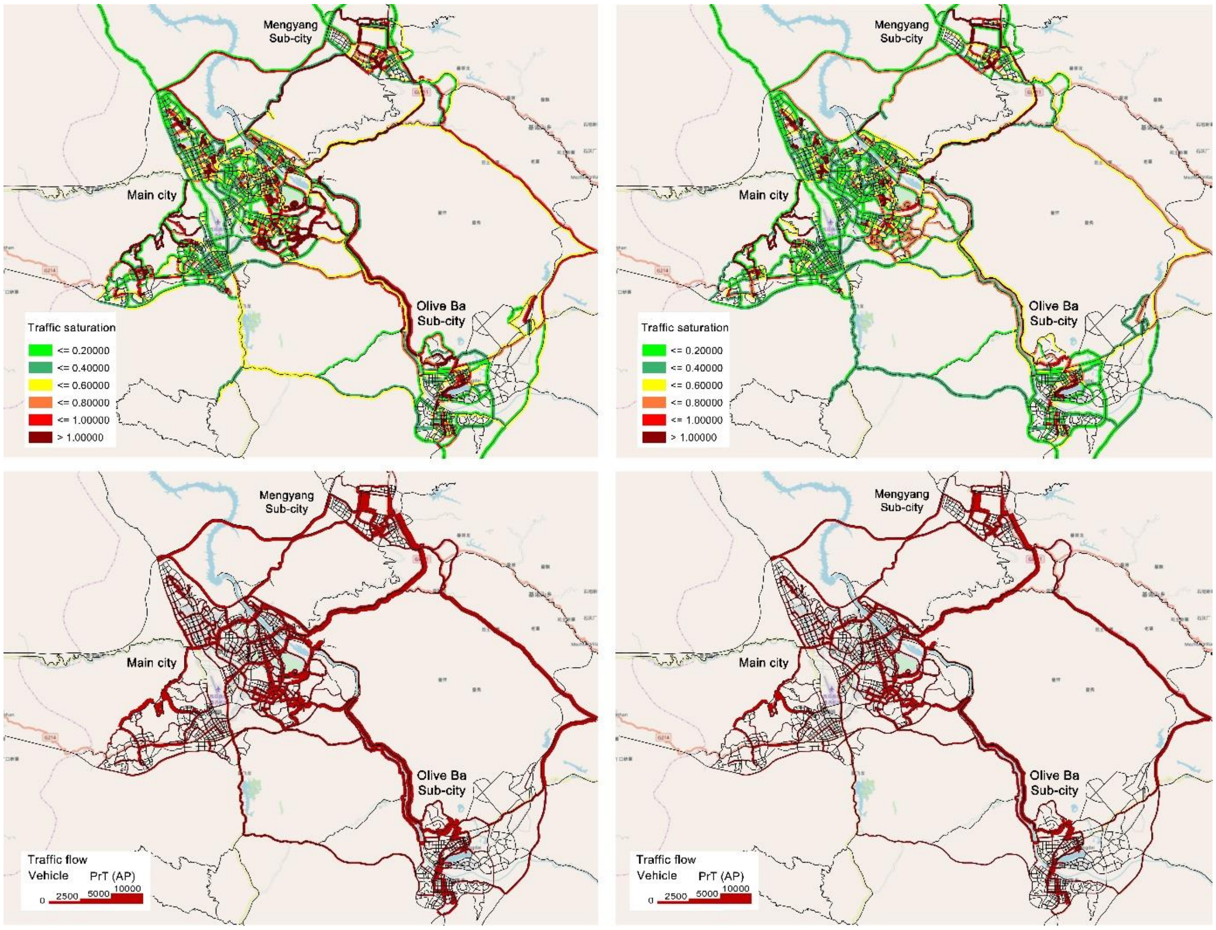

Figure 8. Traffic performance in peak hour of two scenarios (above: saturation; below: flow)

Source: Drawn by authors by Visum

By comparing the traffic flow of the two scenarios, it can be seen that the road traffic flow of scenario 2 is obviously lower than that of scenario 1. In terms of road saturation, in scenario 1, the link between Main city and the two sub-cities still shows obvious congestion in peak hour. The congestion in the southeast part of Main city is also obvious. In scenario 2, under the condition with the tram, the traffic pressure of the contact channels between Main city and the two sub-cities is significantly reduced. The road congestion is effectively improved, especially in the southeast part of Main city. It can be seen that the opening of trams between tourist attractions in scenario 2 is of great help to the good operation of urban traffic.

The results of the traffic performance will help the project team choose the scenario they need and the corresponding traffic planning scheme. Of course, scenarios can be changed according to planning requirements and the model will help the project team test different scenarios continuously.

7. Conclusion and Discussion

The research believes that the mobile big data can be used to analyse urban traffic. Based on the analysis of big data and combined with the method of scenario simulation, it is effective to evaluate the planning scheme through Visum traffic model. However, in this process, we need to pay more attention to the actual situation of different cities. For example, Jinghong as a tourism city, the capacity of tourist attractions has been further measured and included in the overall analysis of the city, so as to make the analysis results more accurate.

This paper explores the technical methods of urban traffic analysis and evaluation based on mobile big data in the context of urban planning practice, with a view to providing reference for the preparation of urban macro-level planning. At present, the above research is still in the exploration stage and some preliminary conclusions may still be open to debate. In the future, detailed research on the calibration of mobile big data is still needed and the application of mobile big data in the preparation of different levels and types of planning should be more in line with the planning needs. More practice is needed from theoretical construction to project application.

Big data does not directly lead to objectivity and science. Policy makers and the public are looking at the world through the eyes of data analysts (Yang and Duan, 2015). It is the responsibility of data analysts to obtain credible data in the wide ocean of big data. The advantage of big data lies in the more comprehensive observation of the research object and the disadvantage of big data lies in the lack of rigorous cause-and-effect modeling ability. Therefore, the comprehensive analysis of multiple data such as mobile big data, traditional traffic surveys, population data and economic census data is the development trend in the future. The rational use of big data by planners is an important foundation for big data to serve urban planning effectively.

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