Research on Matching Method Between Highway Mileage Pile Number and Geographical Coordinates

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Abstract—In 2019, the mileage of some roads across the country changed, and the highway mileage was readjusted and confirmed, resulting in that the old and new mileage could not be matched and applied. According to the Mileage stake data and geographic coordinate data collected by the multi-functional road intelligent comprehensive detection vehicle, the unknown whole kilometer stake and the corresponding geographic coordinate are obtained by applying the dynamic segmentation and linear interpolation method. The algorithm studied in this paper is verified based on ArcGIS to analyze the accuracy of the matching method. After the adjustment of road network naming and numbering, it is difficult to trace the source to adjust the historical attribute information, evaluation indicators, historical maintenance and other data, so as to provide a scientific reference basis for the study of intelligent maintenance decision-making and a query management method for road managers.

Keywords- mileage stake; geographic coordinates; dynamic segmentation; linear interpolation;

1 INTRODUCTION

In the transportation industry, the recording of road location information does not use the actual geographical coordinates but uses the road mileage stake. However, in March 2018, the Ministry of transport issued the notice on carrying out the naming and numbering adjustment of the national highway network (jglf [2018] No. 27). All provincial transportation authorities must update the relevant traffic signs adjustment, mileage stake number transmission and road network data of the highway network in strict accordance with the national deployment [1]. In Gansu Province, there are 4 adjusted mileage piles of original national roads, 7 upgraded provincial roads to national roads, and 13 recalculated and reorganized provincial road pile numbers. Due to the naming and numbering adjustment of the national highway network, the

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mileage pile after traceability adjustment cannot match the mileage pile before adjustment. Tracking the historical detection data, making comparative analysis, and establishing the pavement performance decay model has brought great obstacles [2].

The research in domestic and foreign, Kaiyu Fu and others used the dynamic segmentation of the linear reference tool provided by ArcGIS for data processing, and then calculated the pile number according to the rules of mileage pile calculation [3]. By introducing the dynamic segmentation technology, Shun Fang takes the mileage stake number as the correction reference basis for the measured M value of the route system, realizes the matching between the traffic flow of the road section and the space vector map, enables the route network in the geographic information system to establish the flow attribute, and provides a scientific reference basis for further network analysis, research, and decision-making of the road network [4]. Chao Geng and others used the dynamic segmentation technology to identify the black spot road sections of traffic accidents. Based on the division of dynamic road sections, they obtained the black spot road sections of accidents and reminded them of traffic accidents [5]. Zhepu Xu and Qun Yang dynamically segmented the asphalt pavement condition based on the kernel density estimation, analyzed the pavement damage rate, international flatness index and rutting depth by using the kernel density estimation of line elements, and obtained the continuously changing road condition map with the kernel density value as the index [6-7]. The above method can solve the problem that the vehicle can only locate the position on the road, but cannot locate the mileage stake of the road; Road detection provides more accurate location information for maintenance; The visual presentation of road diseases is well integrated into the pavement management system and provides support for maintenance decision-making. However, there are some problems such as single method and low accuracy. Based on this, this paper proposes two methods to study the matching between highway mileage pile number and geographical coordinates, and verifies and analyzes them according to the measured data.

2 MILEAGE STAKE AND GEOGRAPHICAL COORDINATES

2.1 Mileage stake number

The 'pile' within mileage pile number refers to a long strip-shaped object partially vertically buried underground, which is mostly used to identify the ground position, while the pile number is used to identify and distinguish many 'piles'. In the road location information identification, the mileage pile number is used to represent as the "K kilometers±meters". The pile number is the "ID number" of the road, and it has uniqueness. The pile number is represented by kilometer-sign and hundred-meter stake. Figure.1 shows kilometer sign. The number on the top represents the total distance from the starting point of the highway to this sign, the letters and numbers below are the name of the highway, G30 represent LianHuo expressway, and 2023 represent 2023 kilometers from the starting point of the expressway. Figuer.2 shows hundred meter stake. There will be 9 stakes between each two adjacent kilometer signs, with a distance of 100 meters. The main function is to accurately locate the exact position within 100 meters per kilometer. 2023 represent a total of 2023 kilometers from the starting point of the expressway, and 1 represent the position of 2023 kilometers plus 100 meters.

Figure 1. Kilometer card

Figure 2. 100m pile

2.2 Geographical coordinates

Geographic coordinates are spherical coordinates that express the location of ground points in latitude and longitude. In people's life, the geodetic coordinate system is mainly used for projection transformation. The commonly used coordinate systems in China are 1980 Xi'an geodetic coordinate system and 2000 national geodetic coordinate system. In practical application, according to different needs and combined with the characteristics of various coordinate systems, geographical coordinates must be transformed to facilitate utilization and auxiliary decision-making. The projection coordinate system mainly used is the 2000 national geodetic coordinate system.

2.3 Data sources

The data source is mainly from multi-functional road intelligent comprehensive detection vehicle, which is equipped with positioning system. The positioning system adopts the combined positioning mode of spatial positioning and distance positioning to realize high-precision positioning in the driving process of road detection vehicle. During the working process of the inspection vehicle, the high-precision single-point positioning (≤2.5m) is continuously obtained through the spatial positioning equipment, and the various raw data collected at the same time (road image, smoothness, rut and front image, etc.) are marked with position labels. In order to use the geographic location to evaluate the pavement performance and identify the diseases that need to be maintained, there is no need to correct the station number during the detection process, and to ensure that no matter what kind of path to reach the same point, the position will not change, so as to achieve zero-correction absolute positioning.

Through the interpretation of mileage stake number and geographical coordinates, the precise positioning is combined with the actual operation needs, the highway mileage pile and geographical coordinates are matched, and the road condition information is displayed, inquired, counted, analyzed and disposed on the map. The data collected by the multi-functional road intelligent comprehensive detection vehicle is mainly stored in the form of text, with the main attributes including pulse, pile number, geographical coordinates (x, y, z) and effectiveness. According to the collected data, the matching method between mileage stake number and geographical coordinates is studied.

3 MATCHING METHOD BETWEEN STAKE AND GEOGRAPHICAL COORDINATES

3.1 Dynamic segmentation method

Dynamic segmentation is the process of calculating the map position (shape) of events stored in the event table. Multiple groups of attributes can be associated with any part of linear elements through dynamic segmentation. According to the relative position information stored in the attribute table and the corresponding linear data, dynamic segmentation is a process of dynamically calculating the actual geographical coordinates corresponding to the relative position on the row data. Dynamic segmentation is named because it expresses different attributes without dividing the actual geographic data, but dynamically calculates the geographic location corresponding to the attribute. The following takes the Lanhai Expressway G75 in Gansu as an example to perform dynamic segmentation. Lanhai expressway is 524 km long in Gansu Province. The starting point number is K0, the starting point name is Hanjiahe, the ending point number is K524, and the ending point name is Guanzigou. It is managed and maintained by four management and maintenance units in Gansu Province. The pavement types include asphalt concrete and cement concrete. The event sorting based on the above information is shown in Table1. The above linear information is shown in Figure.3.

TABLE 1. G75 EVENT TABLE OF LANHAI EXPRESSWAY

Route name	**Start station**	**End station**	**Management and maintenance unit**	**Pavement type**	**Maintenance or not**	**Pavement evaluation grade**
Lanhai Expressway	K0	K21	Lanzhou Highway Development Center	asphalt concrete	no	excellent
Lanhai Expressway	K21	K91+943	Dingxi Highway Development Center	asphalt concrete	no	good
Lanhai Expressway	K91+943	K156+619	Dingxi Highway Development Center	asphalt concrete	yes	excellent

Lanhai Expressway	K156+619	K394+637	Gansu provincial public air travel	asphalt concrete	no	excellent
Lanhai Expressway	K394+637	K434+688	Longnan Highway Development Center	asphalt concrete	yes	excellent
Lanhai Expressway	K434+688	K440+874	Longnan Highway Development Center	asphalt concrete	no	excellent
Lanhai Expressway	K440+874	K443+95	Longnan Highway Development Center	hydraulic concrete	no	excellent
Lanhai Expressway	K443+95	K451+549	Longnan Highway Development Center	asphalt concrete	no	excellent
Lanhai Expressway	K451+549	K524	Longnan Highway Development Center	asphalt concrete	yes	excellent

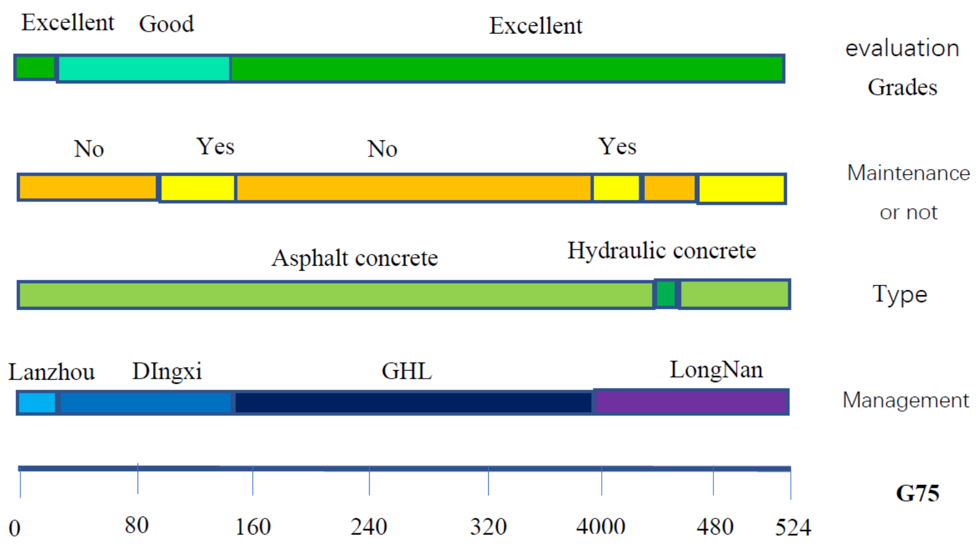

Figure 3. Event line of G75

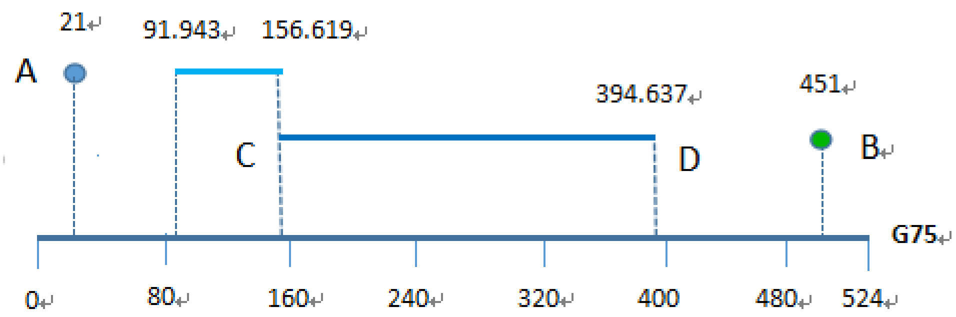

Figure 4. Dynamic segment display

TABLE 2. G75 ROUTING NODE INFORMATION

Number	X coordinate	Y coordinate	Scale value (M)
1	104.070904	34.501418	235.005
2	104.069717	34.485008	236.850
3	104.597123	33.585335	370.745
4	104.705304	33.506696	385.500
5	104.769354	33.445112	394.805
6	....	....	....

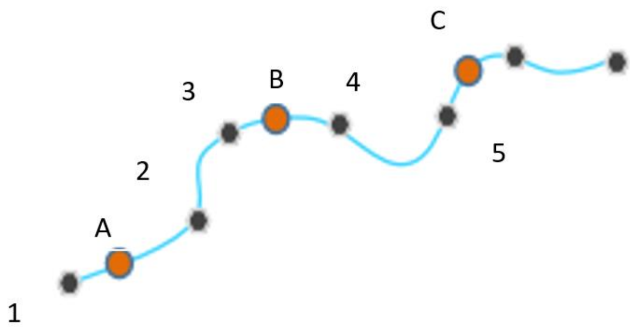

Figure 5. Dynamic segment display

Dynamic segmentation mainly involves two data structures: routing and event table. The route in dynamic segmentation is illustrated by Lanhai expressway G75, and the mileage stake in G75 is the *M* value of node data. The event table in Figure.4 shows point events and line events. *A* represents point event. The road condition evaluation index on G75 route, which is 21 km away from the starting point, is "good". Line segment CD represents line events, corresponding to G75 route. The management and maintenance unit is **Gansu provincial public aviation brigade**. Using dynamic segmentation technology, point events and line events are displayed on the map for viewing and browsing. As shown in Figure.5, in the dynamic segmentation, the local coordinates and station *M* values of nodes 1, 2, 3, 4 and 5 are known, shown in Table2. Through the dynamic segmentation technology, the geographical coordinates of point event *A*, *B* and the geographical coordinates of line event CD can be obtained for accurate positioning. The *M* value and geographic coordinates of nodes A and B can be obtained by interpolation of nodes 1, 2, 3 and 4, the *M* value and geographic coordinates of node C can be obtained by extrapolation of nodes 4 and 5.

3.2 linear interpolation

Linear interpolation is a kind of interpolation method, which generally refers to linear interpolation in mathematics. Using the proportional relationship, a set of known independent variable values and its corresponding function values are used to find an approximate calculation method for parameter of an unknown function, which is a numerical approximation algorithm. It has practical significance in the calculation of road mileage pile and geographical coordinates. In the data collected by the road comprehensive inspection vehicle, the geographical coordinates of the stations with an interval of 5 meters will be collected once. The geographical coordinates of the known stake K350+999 are (99.368740, 40.241790) and K351+004 are (99.368684, 40.241796). How to calculate the geographical coordinates of the whole mileage stake K351 with linear interpolation. The geographical coordinates of the whole chainage k351 are calculated by linear interpolation method. Linear interpolation always expresses X between 0 and 1, 0 corresponds to the minimum value of X 99.368684, 1 corresponds to the maximum value of X 99.368740, and the proportion of station k351 in the line segment is 20%, then x can be calculated according to the formula, as shown in Eq(1):

$$(x\text{-}minX)/(maxX\text{-}minX)=0.2 \quad (1)$$

Bring the minimum and maximum value into the calculation to obtain 99.368695. The corresponding solution of *y* value is same too, as shown in Eq(2):

$$0.2*(maxY\text{-}minY)+minY=0.2*(40.241796-40.241790)+40.241790=40.241791 \quad (2)$$

From the above linear internal difference, the geographical coordinates of k351 can be calculated as (99.368695, 40.241791).

4 EXPERIMENTAL SYSTEM

Through the application of dynamic segmentation and linear interpolation method, the pile number and geographic information of Lianhuo expressway G30 in Gansu Province are matched. The data collected by the multi-functional road intelligent comprehensive detection vehicle are processed and analyzed by ArcGIS, and the data of the whole pile number of Lianhuo expressway G30 is collected by using the handheld GPS with an accuracy of 2.5 m. The result is shown in Figure.6. Red represents the result of processing with linear interpolation algorithm, the specific results are as follows table.3. Green represents the result of dynamic segmentation processing, the specific results are as follows table.4. The Measured values are shown in Table 5.From Figure 6, it can be seen that the error is very small at stake A and B, the matching effect of the two methods is good, and there is a large error at point C and D. the matching effect of linear interpolation is better than the dynamic segmentation method. The main reason is that the road section is a curved road.

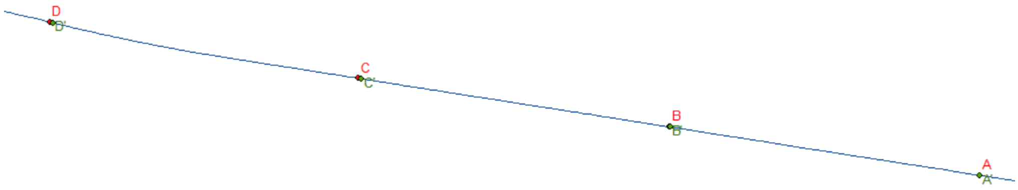

Figure 6. G30 data processing results

TABLE 3. DYNAMIC SEGMENTATION RESULT DISPLAY

Point number	**Stake number**	**Dynamic segmentation X coordinate**	**Dynamic segmentation ycoordinate**
A	2022	102.007880,	38.229037
B	2023	101.996750,	38.230794
C	2024	101.985633,	38.232552
D	2025	101.974542,	38.234585

TABLE 4. DISPLAY OF LINEAR INTERPOLATION RESULTS

Point number	**Stake number**	**Linear interpolation xcoordinate**	**linear interpolation ycoordinate**
A’	2022	102.007875	38.229038
B’	2023	101.996705	38.230801
C’	2024	101.985530	38.232568
D’	2025	101.974433	38.234610

TABLE 5. DISPLAY OF MEASURED VALUE RESULTS

Point number	**Stake number**	**Measured value xcoordinate**	**Measured value ycoordinate**
A”	2022	102.007876	38.229038
B”	2023	101.996715	38.230808
C”	2024	101.985535	38.232560
D”	2025	101.974439	38.234609

5 CONCLUSION

In order to accurately describe the basic information and dynamic information of highway, this paper uses dynamic segmentation algorithm and linear interpolation method to accurately match the pile number and geographical coordinates. On long downhill and curved highway, the dynamic segmentation matching error is relatively large, and the matching accuracy of linear interpolation method is higher than that of dynamic segmentation method. Based on the two methods, this paper establishes the matching relationship between road segment vector data, attribute data and real-time data, which effectively solves the problem of dynamic analysis based on linear features. It also lays the foundation for other spatial analysis of road network layer data based on ArcGIS, and provides technical support for a traffic map.Using the research results of this paper, a map of national and provincial trunk line maintenance in Gansu Province will be built to realize electronic maintenance management. Maintenance personnel use mobile equipment to quickly find maintenance points according to coordinates and complete the layout of mileage piles. Managers can also know the maintenance progress in real time through the electronic map.

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REFERENCES

[1] https://baijiahao.baidu.com/s?id=1598966235590062078&wfr=spider&for=pc

[2] Xu Yifei, Zhu Ming, Nie Shangsen Exploration of point positioning method in 3D scene based on BIM + GIS highway design [J] Geological hazards and environmental protection, 2021,32 (01): 91-95;

[3] Fu Kaiyu, Li Bing, Liu Yun Implementation of highway mileage pile number calculation method based on ArcGIS [J] Journal of Zhaotong University, 2019,41 (02): 98-102

[4] Fang Shun Visual analysis of road section flow based on ArcGIS dynamic segmentation technology [J] Transportation technology and economy, 2012,14 (02): 91-94 DOI:10.19348/j.cnki. issn1008-5696.2012.02.022.

[5] Geng Chao, Peng Yuhua Traffic accident black spot section identification method based on dynamic segmentation and DBSCAN algorithm [J] Journal of Chang'an University (NATURAL SCIENCE EDITION), 2018,38 (05): 131-138

[6] Xu zhe Pu, Yang Qun Dynamic segmentation method of asphalt pavement condition based on kernel density estimation [J] Journal of Chang'an University (NATURAL SCIENCE EDITION), 2020,40 (02): 10-20 DOI:10.19721/j.cnki. 1671-8879.2020.02.002.

[7] Zhang Yan Production and application of highway thematic map in highway collaborative inspection system [D] Southeast University, 2018.