The problem of position determination of signal transmitting device in 3D road

Chengdong Le,Liangchen Xu,Shiqing He

Department of Mathematics, Langfang Jiaotong University, Hebei, China

Abstract: With the development of social economy, the current urban traffic problem is more prominent. In order to solve this problem very well, the idea of establishing intelligent traffic management came into being. The establishment of intelligent traffic management, cannot do without the signal launch and reception. Therefore, how to set up some wireless signal transmitting device in time to travel on the road motor vehicles to send traffic information and how to achieve full coverage of the signal and signal stability is our article to discuss the issue. For the first question, we must separate the motorway and non-motorway from all roads. Motorway lanes are usually straight and long. While the bends are usually just sidewalks or bike lanes (non-motorized lanes). So the 121 road can be clustered analysis, clustering of the two indicators for each road length (the distance between the adjacent points) and the collection point of density (by drawing, you can observe the more curved the denser the road collection point, so the road curvature into the collection point of the intensity), the result of clustering can get 48 motor lanes. And then through regress function regression and data fitting to achieve an approximate description of each type of motor vehicle description model, so that each road in a given latitude (latitude) coordinates to determine the latitude (longitude) coordinates and the corresponding altitude. For the problem of two, according to the meaning of the road to know the signal strength is only related to the distance between the sampling point and the launch device, so you can 'the motor vehicle between the signal reception is relatively close to' this indicator into ' The average of the distance between all the sampling points and the transmitting device is close to '. By reading the data will be latitude and longitude conversion distance length, so that the maximum value as small as possible. The position of the launcher can be obtained by programming by MATLAB. When considering the altitude, only the position of the transmitting device can be changed. (9.7824,56.7720), and the position coordinates when considering the altitude are D (9.7459, 56.7586, 73.5645), and the position coordinate of the signal device is B (9.7824, 56.7720). For question three, note the effect of the original signal device A on the result. We still use the average of the distance between all the sampling points of the road and the launcher to characterize the stability of the signal reception. The average distance of all non-motorized trains to the original signal device A is first determined, and then the average distance of all non-motorized lanes from the new signal device B is set, and the signal acceptance strength of the non-motorized lane can be used to characterize. And then use the same method in question two to determine the location of the new signal transmitter. Finally, the coordinates of the position of the new signal device are E (9.7459,56.7586,73.5645).

Key words:data processing; cluster analysis; regress linear regression; average distance; optimal position

1.Problem restatement

In order to facilitate urban traffic management, it is necessary to set up some wireless signal transmitting devices to send traffic information to motor vehicles traveling on the road in time. The data in the annex is the road data of a particular area. Each row of data corresponds to the location information of a sampling point on a road. The first indicator is the road index number where the sampling point is located, and the second and third indicators are the corresponding longitude (longitude) and latitude (latitude). The fourth indicator is the altitude (in meters). Motorway lanes are usually straight and long. While the bends are usually just sidewalks or bike lanes (non-motorized lanes). The original signal launcher is located in the center of this area (9.75,56.75) at an altitude of 200 meters. It is assumed that the signal strength received by the road is only related to the distance between the sampling point and the transmitting device. Consider the following questions:

1.1. All roads are classified first except for motorway lanes. An approximate description model is created for each of the other types of roads so that the latitude (longitude) coordinates and the corresponding altitude can be determined for each path at a given longitude (latitude) coordinate.

1.2. Do not consider altitude factors. How to adjust the location of the launch device, making the motor vehicle lane between the signal reception is relatively close Do you need to adjust the position and height of the launcher if you consider the altitude factor

1.3. The addition of a signal launcher for non-motorized lanes makes the signal reception on all non-motorized lanes relatively stable. How should I determine its location

Note: If a road on the sampling point less than or equal to 3 can delete this road.

2. Problem analysis

2.1 Analysis of the problem

In question one, we have to solve two problems separately.

The first question, the most critical question is how to classify motorway and non-motorway lanes. Since the information provided by the topic is - the motorway is usually straight and long, and too often curved is usually a sidewalk or bike lane non-motorized lane), so we will use the road length and road bending degree of the two influencing factors on the road cluster analysis. For the first influencing factor - the length of the road, we add the distance from the adjacent collection points on the road as the first indicator; for the second influencing factor - the degree of road bending, we use the degree of collection points on the road as the second indicator. Then, use these two indicators for cluster analysis, separation of motor vehicles and non-motor vehicle lanes. After the classification of the motorway.

The second question is how to classify the motorway and establish a corresponding model so that the latitude (longitude) coordinates and the corresponding altitude can be determined for each path under given longitude (latitude) coordinates. The specific approach is to classify the first question of the 48 motor lanes, respectively, the longitude and latitude, longitude and altitude of regress regression analysis and data fitting analysis, obtained the relationship between longitude and dimension and the relationship between longitude and altitude The

2.2 Analysis of the problem of two

Because the subject requirements are made between the motor vehicle lane signal reception is relatively close, that is, the motor vehicle to receive the signal strength to compare. And the signal strength is only related to the distance between the sampling point and the transmitting device, so it is only necessary to compare the average distance between the motor vehicle and the transmitting device. By reading the data will be latitude and longitude conversion distance length, so that the maximum value as small as possible. The position of the launcher can be obtained by programming by MATLAB. When considering the altitude, only the position of the transmitting device can be changed.

2.3 Analysis of the problem three

Since the original signal device A has an influence on the non-motor vehicle road, we first obtain the average distance from all the non-motorized lanes to the original signal device A and then set the average distance of all non-motorized lanes from the new signal device C, the signal acceptance strength of the non-motorized lane at this time can be used to characterize. And then use the same method in question two to determine the location of the new signal transmitter.

3.Model assumptions

3.1, The distance between adjacent collection points on each road is approximately as a straight line.

3.2, Assuming that the distance between the latitude and longitude line is a straight line, that is, regardless of the earth's curvature.

3.3, Assuming that the information given by the title is not wrong.

3.4, Assuming that the signal is spread in the form of spherical waves, the signal strength and the distance inversely proportional to the square

4. Model of the establishment and solution

4.1 Data preprocessing

4.1.1 Draw the two-dimensional traffic road map of the area based on the data in the annex

According to the title of the annex to the attachment of a region of the road data information, with MATLAB programming to draw the region road map. MATLAB program code see Annex 1, the results are as follows:

Figure 1: Traffic in the area

4.1.2 Conversion of latitude and longitude into length units

By reviewing the literature, we learned that the conversion formula is as follows:

Latitude 1 degree = about 111 km

A longitude unit = (length of a latitude unit) * (cosine of the region latitude)

So if you consider the true distance between the two points of the 3D road, such as with, for the longitude, for the latitude, for the altitude (unit: m), then the actual distance between:

4.1.3 The relationship between the signal strength received by the road and the distance from the sampling point to the transmitting device

By consulting the literature, we know that the relationship with:

In order to simplify the calculation, we make (this simplifies the calculation, but does not affect the results)

4.2 The establishment and solution of the first questioning model

4.2.1 Cluster analysis based on the length of each road path and the intensity of each road collection point. (In the first question, when calculating the length of the road temporarily do not consider the altitude, because this has little effect on the results)

Indicator 1: We assume that the connection between adjacent collection points on the road is a straight line, then the length of each road is the sum of the lengths between all adjacent collection points on each road. There are:

(The number of points on the road)

Indicator 2: It can be seen from Figure 1, the greater the degree of bending on the road where the collection point of the greater degree of intensity, the degree of bending is relatively small road collection points are sparser. Thus, we define a new density function to represent the degree of bending of the road. The expression is:

From the above two indicators to all the road clustering analysis, we obtained the number of motor vehicle morals 48, the specific results are as follows:

Table 1:48 Motorway number

The two-dimensional diagram of the 48 roads is as follows:

Figure 2: Schematic diagram of all motor vehicles

4.2.2 Classification of motor vehicles

Classification method one: north and south, east and west direction

Classification Method 2: the degree of road ups and downs (altitude)

Classification method three: main road, branch

4.2.3 Approximate description model for each motorway

For some road longitude (latitude) and latitude (longitude), if the linear relationship between the elevation, then use regress linear regression to obtain the equation expression; if not a linear relationship, more complex, consider the use of MATLAB data fitting toolbox Perform data fitting.

As the road is more, here only select a road to calculate the demo, the other way the same way.

For example, for the number 34327588 motorway:

The first is the relationship between longitude and latitude:

Figure 3: Fitting for motorway lanes numbered 34327588

Again the relationship between longitude and altitude:

The fitting effect is good, and the relationship between the longitude, the latitude and the elevation is obtained as follows:

The approximate description of the model for all motor vehicles is as follows:

Table 2: Approximate description of all motorways

No. Road number, and relationship

1 34327588

2 39966948

3 45368693

4 74029516 x and y fit the effect is not good; x, z fitting effect is not good

5 74029559

6 74033306

7 76726823

8 78401675

9 87574512

10 93140093 x and y fit effect is not good; x, z fitting effect is not good

11 93140099

12 93140104

13 93140110 x and y fit the effect is not good; x, z fitting effect is not good

14 4339204 x and y fit the effect is not good; x, z fitting effect is not good

15 94408417

16 94408425 x and y fit the effect is not good; x, z fitting effect is not good

17 94414166 x and y fit the effect is not good; x, z fitting effect is not good

18 94414170 x and y fit the effect is not good; x, z fitting effect is not good

19 94414171

20 94785458

21 94785459

22 94787285

23 94793569

24 94793570

25 94793571

26 94802268 x and y fit the effect is not good; x, z fitting effect is not good

27 94807552

28 94807570 x and y fit the effect is not good; x, z fitting effect is not good

29 94807578 x and y fit the effect is not good; x, z fitting effect is not good

30 98240457 x and y fit the effect is not good; x, z fitting effect is not good

31 99529608

32 99529660

33 99529669 x and y fit the effect is not good; x, z fitting effect is not good

34 99539346 x and y fit the effect is not good; x, z fitting effect is not good

35 112293206 x and y fit the effect is not good; x, z fitting effect is not good

36 126452721 x and y fit the effect is not good; x, z fitting effect is not good

37 126452910

38 126452913 x and y fit the effect is not good; x, z fitting effect is not good

39 127009808 x and y fit the effect is not good; x, z fitting effect is not good

40 127009816 x and y fit the effect is not good; x, z fitting effect is not good

41 127009826

42 127010722 x and y fit the effect is not good; x, z fitting effect is not good

43 127010724 x and y fit the effect is not good; x, z fitting effect is not good

44 127010832 x and y fit the effect is not good; x, z fitting effect is not good

45 127347067 x and y fit the effect is not good; x, z fitting effect is not good

46 127347077 x and y fit the effect is not good; x, z fitting effect is not good

47 127347084

48 142397801 x and y fit the effect is not good; x, z fitting effect is not good

4.2.4 Analysis

Through the establishment of mathematical models, using MATLAB programming to calculate the number of motorized lanes available for the 48, but the mathematical model is not 100% consistent, so you can combine the actual situation and Figure 1 to manually remove some roads The

The establishment and solution of the second question model

4.3.1 The altitude factor is not taken into account

Set the coordinates of the adjusted launcher

(1) First calculate the average distance of the motorway distance from the signal transmitting device

Since the altitude is not taken into account, the length can be calculated directly by latitude and longitude. Set the average distance of the motorway distance signal transmitter to ()

As the number of collection points on the motorway

The longitude of the first collection point on the motorway

As the latitude of the first collection point on the motorway

(2) To establish the objective function and algorithm implementation

make,

(*)

When the value is the smallest, the coordinates of the corresponding (x, y) are the coordinates of the adjusted transmitting device (x, y)

The formula (*) can be expressed in the form of a 48 * 47 matrix, as follows:

Programming with MATLAB, the program code sees Annex 3, obtained after the adjustment of the signal device position coordinates (9.7824,56.7720)

The specific location as shown in Figure B point (the green line for all motor vehicles)

Figure 4: Point B position diagram

4.3.2 Consider the altitude factor

(X, y, z) is the position coordinate of the signal transmitting device after adjustment,

(1) The distance between the adjusted launcher to each lane is recorded as (where)

It is possible to obtain the distance from the i-th collection point of the j-th non-motorized vehicle to the launcher

It is possible to obtain an average distance =, that is, the distance from each motor vehicle to the original launcher

(2) To find the signal strength of each motor vehicle lane

According to the data preprocessing, we know that the acceptance signal of the non-motor vehicle road is j

(3) To establish the objective function

make,

(**)

When the value is the smallest, the coordinates of the corresponding (x, y, z) are the position coordinates of the new transmitting device

The formula (**) can be expressed in the form of a matrix of 48 * 47, as follows

Programming with MATLAB, the program code sees Annex 4, obtained after the adjustment of the signal device position coordinates (9.7459,56.7586,73.5645)

The specific location shown in Figure D point (green line for all motor vehicles)

Figure 5: Point D position diagram

4.3.3 Analysis

First, do not consider the altitude, the location of the point B is about the center of the northeast direction; consider the impact of altitude, the location of the point D obtained at the center of the northwest direction, but distance from the center point A closer. In addition, from these two small questions can be seen that the elevation and the location of the signal device to determine a great impact.

The establishment and solution of the third questioning model

By the result of the first question, there are 73 roads on 121 roads that are non-motorized. Set to non-motor vehicle lane signal transmission device for the original launch device

4.4.1 Find the distance from the non-motor vehicle to the original launcher and the new launcher

There is a collection point on the non-motorized road, first find the distance from all the collection points on each road to the launch device, and then calculate the distance as the distance from the non-motor vehicle to the launcher.

(1) Find the distance from the original launcher to each non-motorized carriage,

We can get the distance from the first collection point to the device A

It is possible to obtain an average distance =, that is, the distance from each non-motorized lane to the original launcher

(2) Find the distance from the new launcher to each non-motorized carriage,

Similarly, the distance from the i-th collection point to the device C of the j-th non-motorized roadway is given as follows:

It is possible to obtain an average distance =, that is, the distance from each non-motorized lane to the original launcher

4.4.2 Signal strength of each non-motorized lane

According to the data preprocessing, we know that the acceptance signal of the non-motor vehicle road is j

4.4.3 Establish the objective function and algorithm implementation

make,

(***)

When the value is the smallest, the coordinates of the corresponding (x, y, z) are the position coordinates of the new transmitting device.

The formula (*) can be expressed in the form of a matrix of 73 * 72, as follows

Programming with MATLAB, the program code sees Annex 5, obtained the location of the new signal device coordinates E (9.7543,56.7463,24.3376)

The specific location shown in the blue dot below (red circle set in the figure for non-motorized lane)

Figure 6: Point E position diagram

4.4.4 Analysis: from the calculation results can be seen, the new signal device point E in the original center point A southeast direction, and relatively close from the A. In addition to considering the new device, but also consider the original signal device on the 73 non-motor vehicle road.

5.Evaluation and promotion of the model

For the first question, the advantage of this model lies in the creative establishment of two indicators to distinguish between motor vehicles and non-motor vehicle lanes, thus making the classification of the road more accurate, by observation, comparison, calculation can roughly calculate the results of this model and the actual of the degree of fit can reach more than 85%. Theoretically, this model can also be optimized to establish a more accurate index model, making the degree of coincidence. In addition, in the first question, when calculating the length of the road, the altitude is not taken into account in order to simplify the calculation (this has little effect on the result). If the time is relatively abundant, the influence of altitude can be considered.

For the second question, this paper is taken to calculate the distance between all the sampling points on the motor vehicle and the distance of the transmitting device. This signal is used to characterize the signal reception between the motor vehicles. As a result of calculation, it can be seen that the position of the obtained signal device is basically satisfactory.

For the third question, first find the average distance of all non-motorized lanes to the original signal device A, and then set the average distance of all non-motorized lanes from the new signal device C, where the signal acceptance strength of the non-motorized lane can be used to characterize. Use this model to get a more optimized result. For this model of characterization, we can think about using a more optimized model to characterize the stability of signal reception.

REFERENCES

[1] DF. Zhao. Mathematical model and calculation [M], Science Press, 2006.

[2] QY. Jiang, JX. Xie, J. Ye. Mathematical model (fourth edition) [M], higher education press, 2011.

[3] ZG. Han. Mathematical modeling method and its application [M], Higher Education Press, 2005.

[4] ZW. Wang. Mathematical Experiment and Mathematical Modeling Case [M], Higher Education Press, 2012.