INFORMATION DESIGN OF UNIVERSAL ADJUSTMENT PROGRAM OF PLANE CONTROL NETWORKS①

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ABSTRACT

There are many surveying adjustment programs for plane control networks. However, the data entry form is not unified and each adjustment program has to use different data manipulation methods for different networks. This paper puts forward a unified data entry method for adjustment programs. Combining surveying readings with virtual readings, the new method makes it a reality to write universal adjustment program for plane control networks. The paper also discusses relative algorithm for unified networks.
Key words: information design universal adjustment plane control networks

1 INTRODUCTION

Plane control network includes triangular, trilateral, triangular and trilateral, and other mixed networks, each one has its own adjustment program. From the user's point of view, a good program possesses universality, simplicity in both structure and data manipulation, and its conformability to surveying convention, which involves the optimal design of network information.

However, the currently used network information designs for adjustment are not very satisfactory except for triangular networks. For example, the typical information design for trilateral networks uses nodes and sides numbering and sides acumulating method. This method is very complex and quite different from that used for triangular networks. So, it is difficult to design a universal adjustment program suitable for any kind or mixed networks on the basis of this method.

2 SUFFICIENCY AND NECESSITY OF NETWORK INFORMATION

In order to design a system of universal network information, it is necessary to test its sufficient and necessary conditions. Here the network information design means the digitization of whole network elements. Sufficiency condition ensures that the digitized network has sufficient data and won't cause geometric figure-deficient problem; while necessary condition removes the repeated surplus figure-forming information.

Now let's see whether these conditions are satisfied by the currently used design patterns of network information.

The pattern for bearing adjustment of triangular networks uses the numbers of a group of sighting points, which correspond to their observed bearings as well as the initial data and observation readings, to form the digital networks. The start and end point numbering are also required when the whole sides or bearings in the network are extra observing elements. It is obvious that the design pattern satisfies the necessary condition. But it does not always meet the needs of sufficient condition. To solve this problem, it is necessary to number the nodes and their bearings in the first place, then input one by one, according to their sequence, the bearing readings and the number of sighting

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points. This design pattern coincides with the common practice in surveying and will be accepted easily by users.

The typical information design pattern for trilateral networks uses the data of nodes and sides, as well as side accumulating number, to describe the networks. Each side is described by the data of its side and nodes, which is a real number with six decimal places. The integer part refers to the number of opposite point and the first three decimal places stand for its side sequence number. The last three decimal places stand for the adjacent side number when the side turns clockwise (or counter clockwise) to form a triangle. If the side does not form a triangle with the surrounding two other sides, then the last three decimal places are all set to zero. Now let us show that the pattern satisfies neither necessary nor sufficient condition.

First, the design pattern gives neither the starting point of each side nor the side sequence relationship on each node. Second, it is required to consider the sequence of infering coordinates in numbering nodes to meet the needs of approximate coordinates. Third, it demands a complete set of data entry rules. So it does not always satisfy the sufficient condition.

Fig. 1 gives a triangle and its data of nodes and sides. Obviously, the data given in No. 1 node is sufficient to form the triangle. Therefore all other information is unneccessary and it means that the necessary condition is not satisfied.

From the above analysis, the information design pattern for triangular networks is good and the unified pattern is designed on the basis of it.

3 UNIFIED PATTERN FOR INFORMATION DESIGN

Can the information in trilateral networks be combined into the information design pattern of triangular networks? If it is possible, then how to combine them?

First let' s consider the possibility. When the added observations include all the sides in triangulation, then its actual network is equavalent to that of trilateration with partial or all bearings as added observations. So their network information can be combined under certain conditions. The remaining questions is how to combine them, in the concrete, it is how to solve the problem that there are fewer observed bearings than required ones in trilateration to form a complete digit-network. The author puts forward designing a group of virtual observed bearings to make the combination possible.

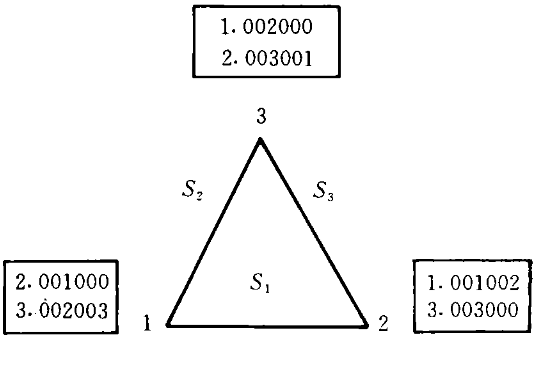

Fig. 1 Triangle and its data

Take the trilateral network shown in Fig. 2 as an example. Suppose all the sides and six bearings are actually observed. With the six observed bearings, it is clear that the inference of approximate coordinates can not be accomplished. However, if we give each unobserved bearing one virtual reading value (− 1) and suppose on each unexisted control station, there is a virtual observed zero bearing. Then we can number the observed bearings and virtual ones according to the way used in triangulation. Thus form network in trilateration is the same as that in triangulation. Obviously, the network in trilateration with added virtual bearings satisfies the sufficient condition. After the introduction of virtual bearings, it adds more input data to the original pattern, so there are some surplus data which may cause the violation of necessary condition. To avoid this situation, the following consideration should be taken: (1) Try to obtain the sides in the network by opposite observation and use single way observed sides as adjustment element; (2) Replace some of the original data by virtual data; and (3) Getting familiar with the inference principle of approximate coordinates, the user is only needed to choose necessary virtual bearings instead of all of them to warrant that each observed side has a related bearing and there is no case of geometric- deficiency. For example, the network shown in Fig. 2 only needs six virtual bearings to meet the needs of sufficient condition. In this way, the necessary condition is basically satisfied by the digital network in trilateration with added virtual bearings.

4 ALGORITHM FOR UNIFIED NETWORK INFORMATION

Now let us discuss the design of universal adjustment program for plane control networks. We will take the bearing adjustment as an example to illustrate the related algorithm in programming.

As for bearing adjustment, the inference of the approximate coordinates is of great importance. So the task is to design an algorithm on the basis of digit network with virtual data to realise the automatic inference of the approximate coordinates. The algorithm should be suitable to triangular, trilateral, mixed and other special networks.

Before the discussion of the algorithm, it is necessary to introduce the requirements of data entry:

(1) Numbering of nodes

$1 \sim P_0$ for the known nodes;

$P_0+1 \sim P_0+P_n$ for the unknown ones;

(2) Numbering of observed bearings

Numbered in sequence of the node numbers. Numbering of observed bearings begins with zero bearing to $1 \sim M$. Data entry is strictly done according to the sequence of numbering of observed bearings. Input one bearing reading together with its corresponding number of sighted point.

For unobserved bearings, input virtual bearing value (-1). For unexisted control station, input virtual zero bearing (0) and other virtual bearings (-1).

(3) Numbering of sides

$1 \sim S_0$ for the known sides;

$S_0+1 \sim S_0+S_n$ for the observing sides;

The data entry rule is that, in the sequence of numbering of sides, input a value of the side length together with its corresponding number of observed bearing.

(4) Numbering of the known azimuth angles of coordinates

$1 \sim T_0$, with each entry of a known azimuth value, input its corresponding number of observed bearing at the same time.

The author has written the universal adjustment program in True BASIC. Many applications of the program have proved its correctness and effectiveness. Due to the limitation of the paper length, here only lists the algorithem subprogram of inference of approximate coordinates.

5 SUBPROGRAM FOR ALGORITHM OF INFERENCE OF APPROXIMATE COORDINATES

100 SUB Approximate␣Coordinate␣Compute

110 Find the start and end numbers of side S1 (Pi, Pj)

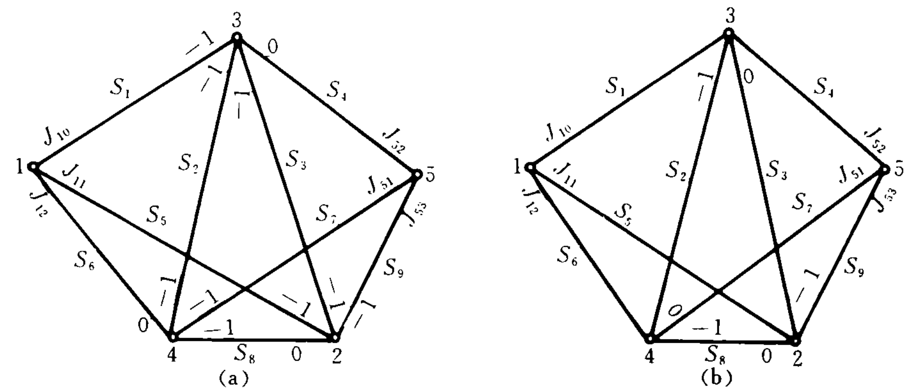

Fig. 2 Trilateral network

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smeltery. It has been shown that the technology applied in the system design are successful.

REFERENCES

1 Kaya, A *et al.* Automatica, 1983, 19(2): 111—130.

2 Wu, M *et al.* Metallurgical Industry Automation. 1992, 16(4): 23—28.

3 Bartee, T C. Data Communications, Networks, and Systems. Indianapolis: Howard W Sams & Co, Inc, 1985.

4 Shen, D Y *et al.* Metallurgical Industry Automation. 1990, 14(5): 27—31.

5 Wu, M *et al.* Journal CSIMM. 1993, 24(4): 477—482.

6 Wu, M *et al.* Automation: Theory, Technology and Applications. Changsha: CSUT Press, 1993.

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120 Let the approximate coordinates of Pi and Pj be (0, 0) and (S1, 0) respectively
130 DO ! Infer the supposed approximate coordinates of each point
140 FOR I=1 TO PP ! Loop by points(PP is the total number of points)
150 FOR J=ZR(I) TO ZR(I+1)-1 ! Loop by bearings on point I
160 IF (the supposed coordinates of point I and the supposed azimuth angle in its zero bearing are all known )
    AND (the observed value in bearing J>0)
    AND (the distance from point I to sighting point in bearing J is known)
    AND (the supposed coordinates of sighting point in bearing J is unknown) THEN
170 Infer the supposed coordinates from point I to sighting point in bearing J by traversing method
180 ELSEIF (when point I, its sighting points in bearing J and in bearing J + 1 form a triangle)
    AND (the supposed approximate coordinates of two vertexes in the triangle (say P1, P2) are known)
    AND (the other vertex P3 is unknown ) THEN
190 IF (there are two internal angles in the triangle whose absolute value>1) THEN
200 Infer the supposed coordinates of P3 by angle cotangant formula
210 ELSEIF S13 and S23 given THEN
220 Infer the supposed coordinates of P3 by side cotangent formula
230 END IF
240 END IF
250 NEXT J
260 NEXT I
270 LOOP UNTIL (the supposed coordinates of all the points in the network are known)
280 ! Find the final approximate coordinates of each point
290 IF (the number of given points are more than two) THEN
300 Calculate the rotation angle and scaling factor of coordinates from the difference between the true and supposed coordinates of points 1 & 2
310 ELSE
320 Find the start-end points of a given azimuth by it' s number of bearing
330 Calculate rotation angle of coordinates through the true and supposed azimuths of start and end points
340 Find the start-end points of a given side by its bearing number
350 Calculate the scaling factor through the true and supposed side lengths
360 END IF
370 Calculate the translation factor of coordinates through the difference between the true and supposed coordinates of point 1
380 Calculate the final approximate coordinaes of each point by rotation angle, scaling factor and translation factor of coordinates
390 END SUB
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