Least-Square Collocation and Its Application in GPS Elevation Fitting

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Abstract: Measurement technology is constantly applied in industrial field, and GPS technology has made great contribution to the efficiency and accuracy of measurement. GPS elevation fitting is researched on the basis of geodetic height elevation and normal height elevation. There are some abnormalities and errors between the two elevations, so elevation fitting is adopted to eliminate the abnormalities and errors. The work mainly discussed the application of least-square collocation in GPS elevation fitting, and then explored its future development in this field. In a word, the application of elevation fitting based on the optimization of least-square collocation can effectively solve elevation abnormalities and errors.

1 INTRODUCTION

GPS technology is widely used in measurement field in which measurement accuracy is highly required. Therefore, it is very necessary to adopt GPS technology to achieve high efficient and accurate measuring results. GPS technology is not only applied in measurement field but also widely used in navigation. However, GPS technology has a very high standard on its accuracy in measurement field and navigation field. The basic principle of GPS is making use of positioning satellites to conduct precision measurement for earth forms (Du Hongfei, Xie Shaofeng, Sun Changyu, 2013). Thus, certain elevation abnormalities or errors happen in the application process due to the influence from geodetic height elevation and normal height elevation. Therefore, GPS elevation fitting is adopted to conduct corresponding error analysis and abnormality treatment. Meanwhile, least-square collocation is adopted to perform corresponding mathematical optimization and find out the best processing function, thus achieving the application of least-square collocation in GPS elevation fitting.

2 GPS TECHNOLOGY AND ITS APPLICATION FIELDS

GPS is an abbreviation of Global Positioning System. Positioning system is built on the basis of fixed-point satellites in the outer space of earth. Thus, positioning satellites actually contribute to global positioning system. Based on such core technology and technical means, GPS is mainly applied in navigation positioning and measurement fields (Li Chengren, Yue Dongjie, Ding Xu, Yuan Bao, 2013).

2.1 Positioning Navigation of GPS

Usually, at least 3 satellites are needed to realize global coverage and establish global positioning system. Thus, navigation becomes the main application field in the actual application of GPS. The main function of GPS is to collect information on earth, and then satellites can receive information through feedback method. Following that, satellites transfer the information to control center on earth through digitization and imagination treatment. Then, it represents the information in audio or image ways to help people for positioning and navigation. At present, vehicle navigation is the key field of GPS application (Liu Hao, 2013). Thus, GPS

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positioning navigation is most widely used in vehicle navigation.

2.2 Application of GPS Technology in Measurement Field

Based on the positioning technology and calculation methods, GPS also has achieved wide application in measurement field when combined with advanced measuring technologies. In engineering measurement field, some measuring errors always happen in the process of wide-area construction due to the differences between actual data and theoretical data. For example, when conducting distance measurement for some regions of complex geography, induction method is usually adopted for measuring and corresponding data calculation, ensuring very detailed technical methods in measuring. However, it still cannot achieve precision in a true sense. Therefore, it is essential to use global positioning system to achieve high efficient and accurate region measurement and data calculation. GPS makes use of the advantage of collection information on earth to realize accurate distance measurement, thus ensuring the achievement of a high-precision measurement method in measurement field. In short, according to the core technology of GPS, its main application fields are positioning navigation and precise measurement.

3 RESEARCH OF GPS ELEVATION FITTING

This work focused on the analysis of the application of least-square collocation in GPS elevation fitting. Therefore, it is very important to firstly understand what GPS elevation fitting is and why elevation-fitting operation is essential. Those questions need to be analyzed from several aspects. More specifically, GPS elevation fitting should be analyzed from its technology and practical design.

3.1 Reasons of GPS Elevation Fitting

In fact, the technology advantages of GPS are very vital for corresponding measurement in both positioning navigation and precise measurement. The measurement of GPS for geography should be conducted based on reference points. Generally, GPS measurement standards are based on the geodetic height of WGS-84 ellipsoid. Therefore, those data are obtained on the basis of theoretical standard. However, in actual engineering application, the horizontal surface of earth is usually considered as the measurement standards. Thus, this causes the discrepancies of those elevation data to a certain extent. So, it is necessary to fit those two elevation data in practical engineering construction, thus ensuring a better data use in actual GPS application. GPS elevation fitting is just one of the most common methods in elevation transformation modes. However, GPS elevation fitting can realize an accurate treatment of elevation discrepancies, thus matching the elevation data in practical application.

3.2 Principles of GPS Elevation Measurement

Before analyzing the principles of GPS elevation fitting, the work firstly explored the principles of GPS elevation measurement. Following that, some basic concepts of GPS elevation-fitting process was further studied to fundamentally interpret the practical process of GPS elevation fitting and its application principles.

3.2.1 GPS Elevation Measurement

GPS elevation measurement is to measure the coordinates on the ground and obtain geodetic-height data based on its positioning principles. Thus, geodetic coordinates play a very important role in the measuring process. Besides, systematic measuring technologies are required to carry out corresponding fixed-point measurement for geodetic-height data, thus guaranteeing accurate data in the application process.

3.2.2 System of Elevation Fitting

GPS elevation fitting system is a generalized and relative concept, and the measurement of different coordinates will generate different elevation systems. Elevation system is highly related to elevation, thus resulting in different elevation system. At present, elevation systems mostly used include geodetic height system, orthometric system and normal height system. These systems are named based on their corresponding treatment according to different elevation.

First of all, geodetic height system actually conducts measurement based on WGS-84 standard. This system uses theoretical ellipsoid as its measuring standard, so the data obtained from calculation belongs to theoretical data. Thus, certain

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discrepancies happen in practical engineering application, leading to the necessity of elevation fitting.

Secondly, orthometric system is one of the most precise measurement systems that uses practical horizontal surface as the reference for measurement. Although this system adopts practical measurement standard, there are still some difficulties in the application process. In fact, GPS elevation fitting is to fit the data gained from orthometric system and geodetic height system, thus obtaining the most accurate elevation data.

Finally, normal height system is actually a compromised system out of geodetic height system and orthometric system. As discussed above, geodetic height system gets some theoretical elevation data, so those data shows a low application value to some extent. Meanwhile, orthometric system adopts gravity measuring method, which causes some difficulty in practical operation. Besides, orthometric system results in too much work of measurement. Therefore, normal height system adopts a compromised method based on the problems of the other two systems. Normal height system makes use of average value for measurement, thus ensuring the reliability of data and largely reducing some complex and redundant measuring steps in actual measurement. In conclusion, normal height system is most commonly used in elevation measurement.

3.3 Research of GPS Elevation Fitting

Above analysis shows that GPS elevation fitting has obvious advantages including high efficiency and precision. Besides, GPS elevation fitting can achieve no cumulative errors of elevation measurement. Thus, GPS elevation fitting has a very important significance in practical application. In the following, the work discussed how GPS elevation fitting works out in practical application and how GPS elevation fitting technology is achieved.

First of all, isoline map is used in GPS elevation fitting. Isoline is a very common method for measuring and fitting. In fact, isoline is a method to obtain average value. So, the measurement data from GPS can be used to figure out several contour lines of some normal heights, and then complete the drawing of all contour lines based on the calculation. Here, the concept of contour line is consistent with the concept of isoline.

Secondly, curve fitting method is also used in GPS fitting. In fact, curve fitting method is the most mainstream calculation method out of all mathematical methods for GPS elevation fitting. This method carries out corresponding data calculation through one curve, thus geting relative average value. Curve fitting is a relatively commonly used GPS elevation fitting method. Generally, accurate method is needed in curve fitting to ensure the accuracy after the fitting.

Thirdly, multiplication curve fitting is another method applied in GPS fitting. Based on the extension way and advantages of curve fitting, GPS fitting makes use of multiplication curve fitting to maximumly reduce fitting errors. In fact, any kind of calculation contains the risks of errors, and the differentials of the errors to some extent determine the accuracy of the measurement. Multiplication curve fitting method mainly focuses on making use of the advantages of curve fitting. Individual curve fitting still causes some errors, so multiplication curve fitting method is applied to minimize errors. Therefore, multiplication curve fitting method becomes the most commonly used method in GPS elevation fitting.

4 LEAST SQUARE ALGORITHM AND LEAST-SQUARE COLLOCATION

Least square algorithm is acutally the most commonly used data fitting method in data optimization. Its main role is to reduce calculation errors and problems happened in data calculation process. In practical application, least square algorithm usually appears in the form of least-square collocation, because it is widely used in practical application especially in high-precision data calculation. Error is inevitable in many calculations. Using least square algorithm to avoid errors is actually to figure out the most suitable ratio function based on the square or differential of errors and then conduct corresponding data calculation. In addition, least square algorithm can be easily figured out for unknown data calculation, greatly minimize errors in application. This is why least square algorithm is so commonly used and why least-square collocation method achieves so obvious achievements on minimizing errors.

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5 APPLICATION OF LEAST-SQUARE COLLOCATION IN GPS ELEVATION FITTING

GPS elevation fitting system, a generalized and relative concept, generates different elevation systems for the measurement of different coordinates. Elevation system is closely related to elevations, thus resulting in the emergence of many different elevation systems. Based on above analysis of the principles of GPS elevation fitting and least-square collocation, the work further studied why it was necessary to apply least-square collocation in GPS elevation fitting. Least square algorithm in fact is a very common data fitting method in data optimization field. Its main function is to reduce calculation errors and avoid problems during data calculation. In practical measuring process, GPS elevation fitting usually adopts normal-height fitting system and multiplication curve fitting to conduct calculation. In fact, least-square collocation method is more suitable for GPS elevation fitting, and it helps to minimize measuring errors. Besides, least-square collocation method can easily figure out some unknown data in the elevation measuring process. Meanwhile, this method can carry out proper configuration for calculation errors in elevation fitting process. So it can figure out the best data collocation, ensuring that the calculation result is maximumly close to accurate data in using measurement data. In GPS elevation fitting, multiplication curve fitting method is used for calculation, and least-square collocation is applied to rematch the calculation errors, thus figuring out the minimum error ratio and corresponding error data. Therefore, a comparison list of best error ratio can be generated, thus achieving the most accurate data

6 CONCLUSIONS

Through the analysis of GPS measurement technology and GPS elevation fitting principles, the work concluded that it was essential to minimize error data and make perfect collocation of errors in practical application. In practical GPS elevation fitting, multiplication curve fitting is usually applied to make use of normal-height system. GPS elevation fitting, an important research field, can better achieve the application of GPS through analyzing its principle of data measurement. Besides, it can effectively minimize or avoid errors. Least-square collocation is to figure out the best treatment function in order to obtain corresponding mathematical optimization more precisely, thus achieving the application of least-square collocation in GPS elevation fitting.

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