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Study on GNSS RTK Location Data Resolution Mode

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Abstract. China's landslide disasters present the characteristics of large number, wide distribution and great harm, so the implementation of monitoring and early warning is an important means of proactive prevention of landslide geological disasters after the geological and geomorphological study determines the risk areas. At the present stage, the monitoring means of landslides is mainly surface deformation monitoring, through the deployment of a number of monitoring points on the landslide body, the use of GNSS RTK center solution technology real-time calculation of the precise location, tracking and monitoring of landslides from stability to instability of the whole process. This paper focuses on the constraints of 4G public network for GNSS RTK in practical application, and researches on RTK front-end solving technology to get rid of its constraints and expand its application area.

Keywords: GNSS, RTK, front-end solution, landslides

1. Introduction

Two-thirds of China's land area is mountainous, landslides are the main types of geological hazards, widely distributed, occurring with high frequency, suddenness and serious consequences of damage [1], and the phenomenon of geological landslides exists in a certain degree of episodic and random [2], about 80% of the geological hazards occur outside the scope of the identified potential hazardous sites every year. As the most critical monitoring parameter of landslides, deformation monitoring can provide the basis for early warning, and early warning can reduce or even avoid casualties and property losses [1], with the development of science and technology, deformation monitoring methods are also varied, and have been developed from simple manual periodic measurements to the current intelligent and high-precision real-time measurements, and GNSS RTK is one of them.

GNSS RTK (GNSS, Global Navigation Satellite System, the general name of the global navigation satellite system, RTK, Real-time kinematic, real-time dynamic carrier phase differential technology) technology is a kind of real-time dynamic differential positioning technology that is based on the carrier phase observation quantity, it can real-time provide the three-dimensional positioning results of the measuring station in the specified coordinate system. The basic idea is to place a GNSS receiver on the Base Station in order to continuously observe the satellite and transmit the observation data and station coordinate information to the user station in real time through 4G communication. The user station receives GNSS satellite signals through the GNSS receiver on the one hand, and at the same time receives the observation data transmitted by the Base Station, and then according to the principle of relative positioning, it carries out the data resolution in real time and provides the user station with centimetre-level accuracy [3-4]

2. Analysis of Current Situation

At present, the common GNSS RTK data solving mainly adopts the central solving method, that is, the GNSS Base Station data and GNSS Observation Station data are uniformly uploaded to the Cloud Center Server solving platform, the platform calculates the data through the solving algorithms, and then arrives at the precise position of the Observation Station[5], and its data flow diagram is shown in Fig.1.

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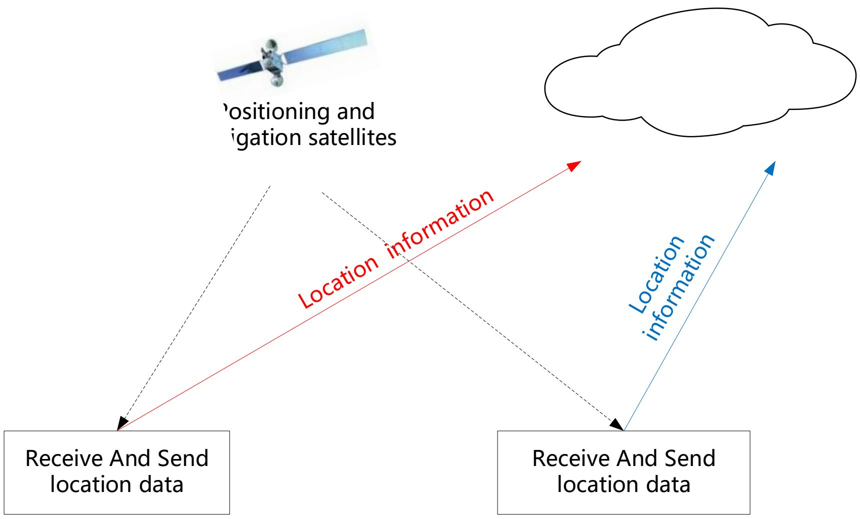

Fig. 1: RTK center solver model data flow diagrams

In this way, because there are the large amount of data, the base station and the Observation Station need to transmit the location data to the Cloud Center Server at 1 kByte/s, so it needs to rely on a good 4G network, if the network is blocked, that will affect the results of solution, and even the solving fails to trigger false alarms, which will lead to the limitation of its application, in addition, the Cloud Center Server solves the problem with a lot of pressure, and it needs to rely on the performance of the powerful servers and resources , so there is a butterfly effect of risk.

3. Description of Solving Modes

Front-end solving has three working modes according to the difference on the communication mode and solving body, which are as follows:

3.1. Weak Front-end Mode

This mode relies on the same 4G public network as the central settlement mode, but the solution algorithm is decentralized from the center to the observation station, and the center only does the forwarding of the observation data from the base station, which greatly reduces the communication pressure of the Cloud Center Server, and also saves the communication tariffs, and the data flow diagram is shown in Fig. 2.

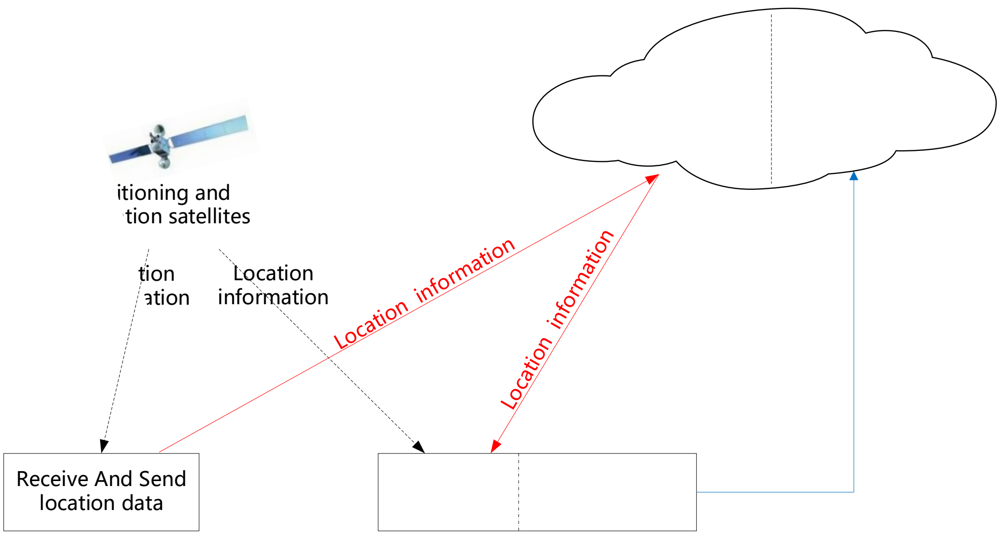

Fig. 2: RTK weak front-end mode data flow diagrams

However, this mode still relies on the 4G network signal, and requires both the Base Station and the Observation Station to be under strong coverage of the 4G network signal in order to work properly.

3.2. Unidirectional Front-end Mode

This mode has got rid of the dependence on the 4G network, through the microwave Ad Hoe Network to achieve the transmission of positioning data between the Base Station and the Observation Station[6-7], the Observation Station receives the positioning data from the Base Station and the positioning data from the satellite, it can carry out the positional solving on its own, and report the high-precision solving results to the Cloud Center Server, the data flow diagram is shown in Figure.3.

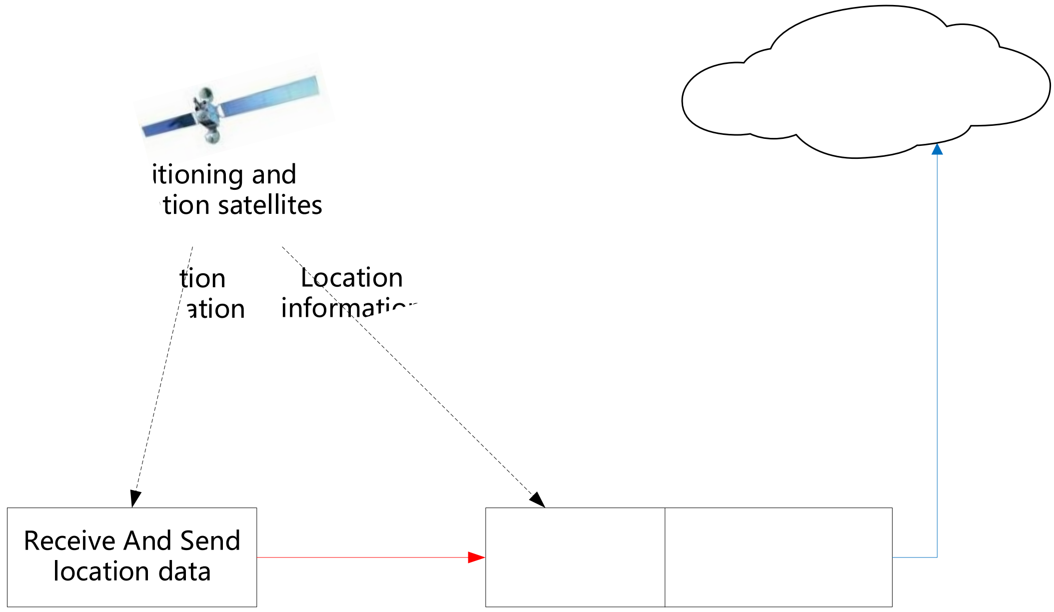

Fig. 3: RTK unidirectional front-end mode data flow diagrams

Since the data volume of the precise positioning information solved by the Observation Station is already very small, it can be uploaded to the Cloud Center Server through BeiDou short message communication, and the global coverage of BeiDou-3 short message communication greatly expands the application area[8].

3.3. Interactive Front-end Mode

This mode is similar to the unidirectional front-end solving mode, which is also solved at the front-end, the difference is that the result of the solved result from the Observation Station is not sent to the Cloud Center Server by itself, but the result is sent back to the Base Station, and the Base Station uploads the result to the Cloud Center Server, and the data flow diagram is shown in Fig. 4:

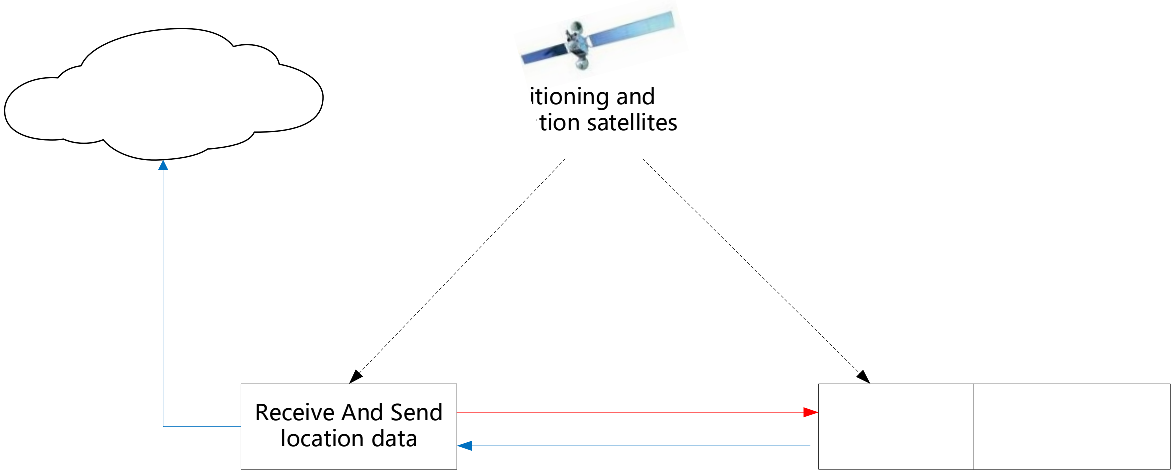

Fig.4: RTK interactive front-end mode data flow diagrams.

Sending the accurate positioning data of the observation station through the Base Station can also be realised through the communication method of BeiDou short message, in addition, since the Base Station and the observation station are theoretically 1:N, the cost can be greatly saved.

4. Comparative Analysis

4.1. Front-end Solving Test Results

The GNSS Observation Station analysed the displacement change information in the three directions of X, Y and Z axes every half an hour and plotted the data into curves, as shown in Fig.5 to Fig.7:

(1) X-axis accuracy: maximum 1mm, minimum 0.1mm

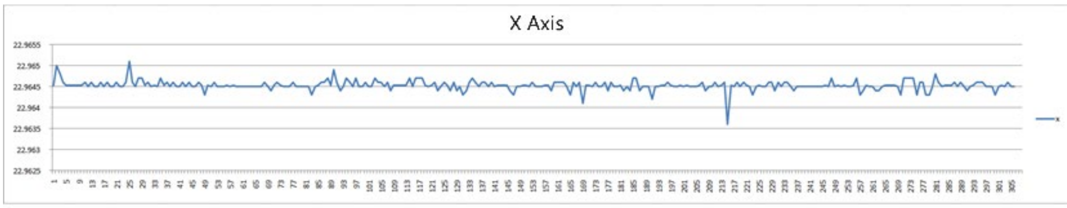

Fig.5: X-axis fluctuation curve

(2) Y-axis accuracy: maximum 0.7mm, minimum 0.1mm

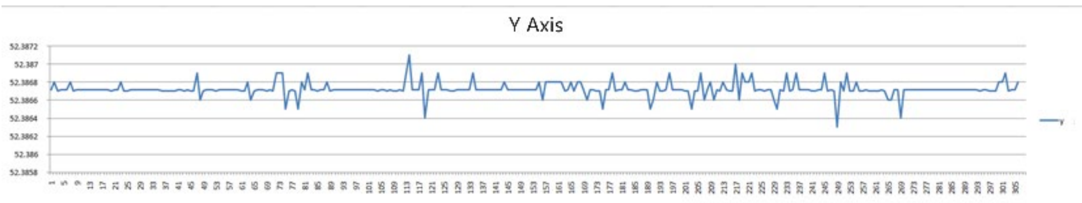

Fig.6: Y-axis fluctuation curve

(3) Z-axis accuracy: maximum 1.5mm minimum 0.1mm

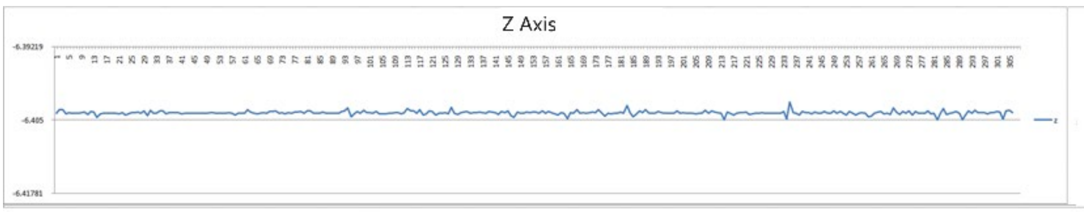

Fig.7: Z-axis fluctuation curve

The above measurements are in line with the industry standard for the center solver mode, which is an XYZ amplitude of ≤2.0mm.

4.2. Comparison of Central and Front-end Models

The center solution mode belongs to the centralized working mode, while the front-end solution mode is decentralized, allowing all observatories to operate independently. The advantages of the front-end solution mode are obvious and are mainly summarized as:

1. embodies fairness and impartiality, reduces the probability of error, and does not lead to errors in the positional solving of a large area of observatories due to the failure of the Cloud Center Server;

2. reduce or get rid of the dependence on the public network, when the public network fails, the Observation Station of the front-end solving mode can still work, avoiding that the public network is paralysed leading to the failure of the Observation Station;

However, compared with the central solution, the front-end solution also has an inconvenient point, that is, if the solution algorithm needs to be updated， it is necessary to upgrade all the observatories.

4.3. Comparison of Front-end Models

There are advantages and disadvantages among the 3 modes of front-end settlement, as shown in the detailed reference to Table 1:

Table 1: Comparison table of front-end solver models

Subjects	Weak model	Unidirectional model	Interactive model
Accuracy	High	High	High
Reliability	Both the Base station and the Observation station depend on the 4G public network link for communication	1.Does not rely on the 4G public network, and can still work normally when the 4G communication link fails 2. Observation Station and Cloud Center Server support multi-link communication to ensure that the positioning data is transmitted to the Cloud Center Server	1.Does not rely on the 4G public network, and can still work normally when the 4G communication link fails 2. Base Station and Cloud Center Server support multi-link communication to ensure that the positioning data is transmitted to the Cloud Center Server
Cost	Both the Base station and the Observation station need to be equipped with communication modules, and communication costs are high	Observation station needs to be equipped with communication module, communication cost is low	Only the Base station needs to be equipped with a communication module, lower communication cost
Complexity	Low	Medium	High
Applications	Wide	Wider	Widest

5. Conclusion

Aiming at the problems encountered in the practical application of GNSS RTK center settlement, this paper proposes the RTK technology of front-end settlement, and through actual testing, the front-end settlement RTK technology can achieve the same positioning accuracy as center settlement, which proves the feasibility of its practical application.

On the basis of this, three front-end settlement modes are proposed and compared and analysed, which can reduce the dependence on the 4G public network, and then greatly expand its application area, especially suitable for the use of high-altitude areas and other areas with poor 4G signal coverage; in particular, the unidirectional and interactive front-end settlement modes directly get rid of the dependence on the 4G public network, and can use the BeiDou short message communication to transmit the high accuracy positioning data after settlement, which greatly expands the GNSS and GNSS positioning data, and also provides a new way for the GNSS to be used. This greatly expands the application area and field of GNSS RTK technology, and the positioning solution of "high accuracy, low cost and high reliability" will undoubtedly be the trend of the future market.

6. References

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