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Agricultural Geological Landslide Monitoring Based on Beidou Navigation System

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Abstract: Discuss the application of Beidou navigation system in agricultural geological landslide monitoring. To conduct a simulated monitoring test in a mountainous area in southwestern China, first set up observation points to monitor the data under three sets of plans. The three sets of plans are specifically expressed as GPS single-system dynamic real-time precision single-point positioning technology (PPP), single-system RTK positioning , Single system baseline solution, BDS single system dynamic real-time precision single point positioning technology (PPP), single system RTK positioning, single system baseline solution and GPS / BDS combined dynamic real-time precision single point positioning technology (PPP), combined RTK positioning , Combined baseline solution. Based on the above monitoring, a landslide monitoring system under the Beidou navigation system is set up to analyze the monitoring effect of the Beidou navigation system on geological landslides. Through verification analysis, we know that in the analysis of dynamic precision single-point positioning technology, the accuracy of BDS, GPS / BDS is better than GPS in the same base station monitoring point, in the three directions of ENU, in terms of plane accuracy, point accuracy, GPS / BDS has the best accuracy, followed by BDS, and GPS has the worst; within the set distance range, the convergence time of GPS / BDS is much faster than BDS and GPS; PPP positioning accuracy of BDS system is slightly worse than GPS system, BDS / GPS combined PPP has the best positioning accuracy, reaching the centimeter level. In the real-time dynamic relative positioning analysis, the accuracy of the three schemes of ENU in all three directions is in the millimeter level. The RTK accuracy results under BDS are slightly lower than the GPS system, and the BDS / GPS combined RTK positioning accuracy is the highest. In the static relative positioning analysis, the accuracy obtained by the three schemes is equivalent, which is better than 5mm. Based on the Beidou navigation system positioning analysis technology, the accuracy and reliability required for landslide monitoring can be achieved. The real-time landslide monitoring system under the Beidou navigation system can actually meet the engineering accuracy and reliability requirements of landslide monitoring.

1. Research Background

In the study of ecological environment, the research and prevention of geological disasters has become an important new branch of disaster research. In many types of geological disasters, the impact of geological landslide cannot be ignored. China is one of the countries most seriously affected by geological landslide in the world.

Most landslides usually occur in mountainous areas. When the rock and soil on the mountain slope are affected by various factors, under the action of gravity, they slide along a certain weak surface as a whole or dispersedly, which is what we call landslide phenomenon [1]. Because natural disasters such as landslides, mudslides and collapses have strong concealment, suddenness and destructiveness, so in terms of current technology, it is impossible to completely control them. Only by real-time monitoring of possible geological disasters and accident locations, early warning can be given to reduce accidents and casualties caused by accidents. Therefore, the reliability and effectiveness of the monitoring and early warning system is extremely important, and the monitoring system needs to be further developed and improved [2-3].

The Beidou navigation satellite system is independently developed by China and can provide regional to global navigation and positioning services. The Beidou navigation system is widely used in various fields in China. Hiroomi believes that the geological survey operation management and safety system based on the Beidou navigation satellite system are completely Independent intellectual property rights, with better monitoring effect, can realize real-time display of communication navigation information, communication history and location information query, the communication management department of field investigators can use the system to query the geographic location and work of on-site operators, for On-site operator safety and rescue provide decision support [4]. The field test proves that the system can achieve stable positioning monitoring and effective SMS communication in several natural environments, thus proving the application advantages of the Beidou navigation satellite system in the field geological survey. Yuming Zhang applied satellite navigation technology to the agricultural environment research I have done, and monitored the farmland environment through the experimental setting detection system. The experimental results prove that the system can easily and quickly realize the remote monitoring of soil temperature and humidity and other information, and has the value of promotion [5] . Zhang is based on the study of landslide detection in remote mountainous areas in China. Considering the communication problems in remote areas, he introduced a detection system based on the Beidou system specifically designed to study landslide detection in remote mountainous areas. It has set up an experimental research landslide monitoring system, which is used to study landslide monitoring in the mountainous areas of western China. The experimental results show that the system meets the requirements [6].

Based on the Beidou navigation satellite system, this paper analyzes the three positioning technologies of Beidou system through experiments, namely precision single point positioning (GNSS-PPP), real-time carrier phase relative positioning (GNSS-RTK), and static relative positioning in landslide monitoring. , Proved the applicability of Beidou system in the monitoring system, on this basis, the experiment set up a landslide monitoring system based on Beidou navigation system, the experiment proved the reliability and accuracy of Beidou navigation system in its monitoring, proved Beidou navigation The application of the system to landslide monitoring is completely feasible.

2. Theoretical Basis

2.1. Causes, Characteristics and Types of Geological Landslides

A landslide is a geological phenomenon. When a landslide occurs, rocks and soil move down along the inclined surface [7]. The characteristics of a landslide can be described by the scale of the landslide, the steepness and shape of the landslide, the nature of the rock (ground) in the landslide zone, and the mechanical properties of the landslide formation. The movement of the landslide formation process is divided into several stages: creep deformation, slow deformation, uniform deformation, accelerated deformation and sharp deformation. Each stage has corresponding characteristics and movement mechanisms. The main characteristics of each stage are: in the creep deformation stage: before the landslide occurs, there are invisible small cracks distributed parallel to each other on the top or back of the mountain slope, and the daily change of each monitoring point is very small, usually 0. 01-0.1 mm [8]. Slow deformation stage: strength cracks visible in the deformation body. They are connected in large cracks, gradually forming arc-shaped cracks, and create many smooth shearing parts in the shearing area of the movable sliding body. The daily change of each monitoring point is different, the total change is 0.1 to 1 mm. In the meantime, if it rains, the daily change may increase to 3-5 mm. Uniform deformation stage: an arc-shaped crack ring is formed at the rear end of the deformed body, boundary cracks are formed on both sides, and gradually extend to the free surface of the front edge. The daily variation of the same segment is very close, usually between 1-5mm. Accelerated deformation stage: Displacement of the deformed body is obvious, the cracks at the rear end are closed, and the sound of friction between the rock bodies (ground) is constantly emitted. The daily changes of each monitoring point increase rapidly with time, usually the daily fluctuation range is 5-10 Between millimeters, the maximum fluctuation range can exceed 80 millimeters [9]. The stage of sharp deformation: small stones or rolling stones are constantly on the front surface of the deformed body. The daily variation of the monitoring point at the rear end of the thrust slider or the front end of the traction slider is greater than 100 mm. Landslides have their own characteristics of landslides, and landslides can generally be classified into landslide lithology classification, landslide structure classification, landslide shape classification, and landslide volume classification. In short, the evolution of landslides is the result of a combination of factors, which can be divided into internal factors and external factors. Generally, internal factors have a greater impact. But when the influence value of internal factors reaches the critical point, the influence of external factors will increase, especially in the case of long-term rainfall, the influence of external factors will exceed the influence of internal influences and become the dominant factor. Due to the different size of the landslide body and the change of external factors, the length of each stage of the landslide is different. Generally, the larger the landslide scale, the more obvious the landslide stage. The more external interference, the less important the internal factors.

2.2. Application and Theoretical Analysis of Beidou Navigation System

BeiDouNavigationSatelliteSystem (BDS) is a navigation system developed according to China's basic national conditions, national security needs, our national livelihood construction and China's economic development. It is an important positioning, navigation and timing (PNT) core infrastructure in China [10]. Its main purpose is to provide navigation and positioning services for the world, and provide high-precision space-time services for important strategies such as national economic strategic globalization, national marine strategic globalization, and the Belt and Road strategy. With the continuous improvement and development of China's Beidou satellite navigation system functions, Beidou satellite navigation and positioning technology and related products are widely used in disaster monitoring, transportation, special vehicle management, precision agriculture, forest work, military combat readiness, and power systems. Important areas are gradually closely related to people's lives, which not only provides new vitality for global development, but also enriches the development model of global navigation [11]. The navigation, positioning and positioning services using the Beidou navigation system depend greatly on the quality of observations of the transmitted satellite signals in terms of accuracy, reliability, and availability, and the quality of the observation data is the basis for high-precision navigation, positioning, and timing.

In addition to meeting military needs, the Beidou system is also widely used to provide efficient navigation, positioning and timing services for civilian use. The Beidou satellite navigation system is mainly composed of three parts, namely space satellite, ground monitoring station and user terminal. Among them, the space satellite is composed of three different types of satellites, namely 5 geostationary satellites, 27 medium-orbit satellites and 3 tilted geostationary satellites [12]. The space positions of the geostationary satellites are 58.75 °, 80 °, 110.5 °, 140 °, and 160 ° east longitude, respectively. The medium-orbit satellite also consists of three orbital planes separated by 120 °. The principle of Beidou real-time monitoring technology is that the main control station, injection station and monitoring station constitute the ground monitoring part. The main control station is the core part of the system. It provides scientific management and necessary control for the operation of the Beidou system, processes massive data from global monitoring stations, and finally generates navigation messages, integrity information and packages into products. Then the master control station will complete the signal injection to the satellite through the injection station. The monitoring station mainly monitors the signals from the satellites, and realizes the monitoring, orbit determination and timing of the satellites through a series of complicated work [13]. Because the Beidou system has completed the compatibility with other systems, user equipment can use satellite signals to perform algorithm calculations and finally obtain the latitude, longitude, elevation, and time information of the equipment.

At present, the Beidou navigation satellite system uses three real-time precision positioning technologies, namely precision single-point positioning (GNSS-PPP), real-time carrier phase relative positioning (GNSS-RTK), and static relative positioning. First, we briefly introduce real-time precision point positioning, which is a high-precision positioning method based on the correction information in the state space domain. This method works by receiving information from the global navigation satellite system receiver, that is, the dual-frequency code and Carrier relative observations, according to the precise orbit calculation method, calculate the satellite orbit and clock difference, and correct the error through the error model to perform single-station absolute positioning. Secondly, the real-time dynamic relative positioning (GNSS-RTK) mentioned in this article is a real-time differential positioning technology based on carrier phase observation. The principle of this positioning technology is to first set up a signal reference station and a signal receiver on the reference station. The signal receiver makes observations, observes all visible satellites, and at the same time transmits the data to the mobile base station via the data link in real time [14]. The rover calculates the three-dimensional coordinates of the rover in real time according to the principles and methods of relative positioning with the data observed by itself and the data transmitted by the reference station, with an accuracy of up to centimeter level. Finally, the relative positioning of the static carrier phase is mentioned. This is also a high-precision differential positioning method, which usually uses the difference in the observation range and processes it with the original observation. Because the receiver's position does not move, through continuous observation, enough redundant observation data can be obtained to improve the positioning accuracy, and the static baseline positioning method is used for calculation. To study the application of Beidou navigation system in geological landslides, the essence is to analyze the practicability and accuracy of these three precise positioning techniques in geological landslides, so that the Beidou system can be used. Therefore, this paper first analyzes the application of three precise positioning techniques in landslide detection, demonstrates the applicability of Beidou system to landslide detection, and builds on this basis a monitoring system based on Beidou system to monitor geological landslides.

3. Experiment

3.1. Research Object

This article mainly analyzes two problems: Problem 1: Beidou Precision Single Point Positioning (GNSS-PPP), Real-time Carrier Phase Relative Positioning (GNSS-RTK), and Static Relative Positioning Method to detect the accuracy of landslide detection to verify the Beidou system 's monitoring of landslides applicability. Question 2: On the basis of applicability, based on the Beidou navigation system, a low-cost, efficient and economical real-time landslide monitoring system, namely the Beidou Cloud monitoring system, is built, and the performance of the system is analyzed and verified by taking a mountainous landslide as an example.

3.2. Test Plan

Test plan 1 In order to verify the applicability and accuracy of the Beidou system positioning technology in landslide monitoring, a real-time data collection PS-1 point was set in a large mountainous landslide area, real-time data collection for 24 hours at a sampling rate of 1s, and precision The track and precision clock difference solution are dynamically solved, and the following three schemes are compared and verified:

Option A: Analysis of GPS single-system dynamic real-time precision single-point positioning technology (PPP), single-system RTK positioning, and single-system baseline solution.

Option B: Analysis of BDS single-system dynamic real-time precision single-point positioning technology (PPP), single-system RTK positioning, and single-system baseline solution.

Option C: Analysis of GPS / BDS combined dynamic real-time precision single-point positioning technology (PPP), combined RTK positioning, combined baseline solution. Test plan two: Set up two small-scale Beidou landslide automated remote monitoring stations (B1, B2) in the area. The B1 monitoring point is established near the main slip line with a relatively high landslide risk, and a reference point monitoring station is established in the stable area. That is the B2 monitoring point.

In order to enhance the stability of the observing station, the base of the observing station is a reinforced concrete structure, and the selected location area has a wide field of view. Its working process is to collect real-time groundwater level, rainfall, water temperature, surface displacement, deep deformation and other geological environments from the monitoring reference station. Characteristic data, according to the need of regular control or remote control, use the signal receiving system and data processing system to upload information to achieve cloud storage, on the cloud server, through parallel multi-threaded algorithm, realize Beidou real-time rapid positioning and accurate positioning after the event, create calculations The cloud uses high-performance database technology to use the website to detect and publish information to achieve cloud publishing. The main steps are as follows:

First: Monitoring reference station setting: Perform overall analysis based on factors such as the geographical location of the selected mountain area, mountain structure, landslide area, etc., select a suitable location to set the monitoring station reference point, on the one hand, prevent the monitoring work caused by unreasonable site selection Can't proceed smoothly, on the other hand to avoid inaccurate data due to site selection.

Second: Dynamic data collection and detection point settings: first set up automatic monitoring equipment, adjust the equipment, establish a data collection and transmission system, the monitoring equipment scans and collects information in real time, and realizes accurate positioning monitoring. On the one hand, it guarantees the timeliness of landslide monitoring work. On the other hand, avoid unnecessary safety accidents caused by improper operation.

Third: Signal receiving station setting: In order to ensure the accuracy and completeness of the reception quality of the monitoring data, the signal receiving station should try not to be located in an area that will interfere with signal reception or damage signal quality. Set up the receiving station in the height of any interference. Fourth: Establish a data processing system and software receiving platform. The first is to pass the detection information into the computer software for data processing through the preliminary data transmission and reception, and the received monitoring data is transmitted to the computer system through the signal receiving device, and the processing software calculates and organizes the relevant data, and then forms the image , Curve, three-dimensional model and list monitoring data are uploaded to the cloud data processing center for analysis and processing to draw conclusions. In order to realize the analysis of comparative results, this experiment still uses three schemes: Scheme A: BDS single system monitoring and positioning; Scheme B: GPS single system monitoring and positioning; Scheme C: BDS / GPS combined monitoring and positioning. In order to make the experimental data more reliable and objective, this monitoring uses medium and long-term monitoring, with a monitoring period of 15 days.

3.3. Notes for Testing

Before the experiment, the geographical characteristics and climate information of the experiment area should be analyzed to make the setting of each base station and receiving point reasonable and safe.

Before conducting data observation and research, it is necessary to test the performance of related hardware and software to ensure their normal operation, so as to reduce errors caused by unreasonable use of system tools.

Make sure that all data is input into the computer for analysis, and then re-check the data to ensure the accuracy of data transmission.

4. Experimental Results

4.1. Applicability and Precision Analysis of Dynamic Precision Single-point Positioning in Landslide Monitoring

The average accuracy and average convergence time of the PS-1 site under the three schemes are shown in Table 1 and Table 2 .

Table 1. Average progress statistics table of PS-1 station

Average accuracy(cm)	Plan A	Plan B	Plan C
E direction	12.5	6.2	2.1
N direction	10	4.2	2.1
U direction	6.5	6.1	4.2
Plane accuracy	16.7	8.2	3.0
Point accuracy	12.5	6.3	2.4

Table 2. Statistical table of average convergence time of PS-1 station

Average convergence time	PlanA	Plan B	Plan C
<20cm	24min	12min	5min
<15cm	-	18min	8min
<10cm	-		18min

As can be seen from Table 1, at the same base station monitoring point, in the three directions of ENU, the accuracy of BDS, GPS / BDS is better than GPS, in terms of plane accuracy, point accuracy, GPS / BDS accuracy is the best, BDS In short, GPS is the worst. It can be seen from Table 2 that within the set distance range, the convergence time of GPS / BDS is much faster than that of BDS and GPS. It can be seen from the synthesis that Schemes 2 and 3 have better accuracy and faster convergence time. Among these three schemes, scheme 3 has the highest positioning accuracy and the shortest convergence time. Scheme 3 has the advantages of fast convergence speed and high positioning accuracy. The PPP positioning accuracy of the BDS system is slightly worse than that of the GPS system, and the PPP positioning accuracy of the BDS / GPS combination is the best, reaching the centimeter level.

4.2. Applicability and Accuracy Analysis of Real-time Dynamic Relative Positioning in Landslide Monitoring

Figure 1 shows the GPS, BDS, GPS / BDS real-time dynamic relative positioning accuracy results during the monitoring period.

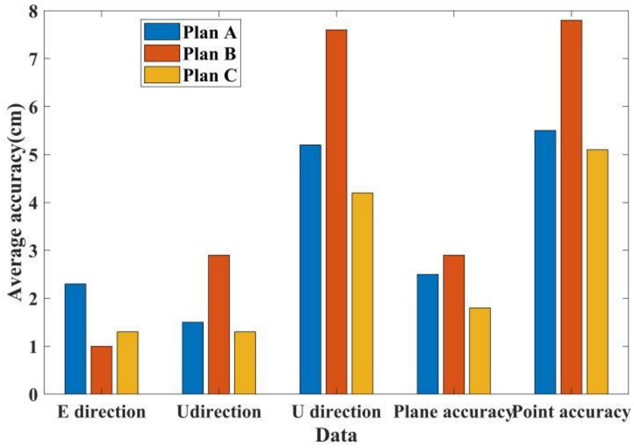

Figure 1. Average progress statistics table of PS-1 station

As can be seen from Figure 1, the accuracy of the three directions of the ENU of the three schemes is in the millimeter level. The three schemes have the highest accuracy. The RTK accuracy results under BDS are slightly lower than the GPS system. The BDS / GPS combined RTK positioning accuracy is the highest because of its visible satellites. The number is more than a single system, and the satellite configuration is also better.

4.3. Applicability and Accuracy Analysis of Static Relative Positioning Method in Landslide Monitoring

Figure 2 shows the results of GPS, BDS, and GPS / BDS static relative positioning accuracy during the monitoring period.

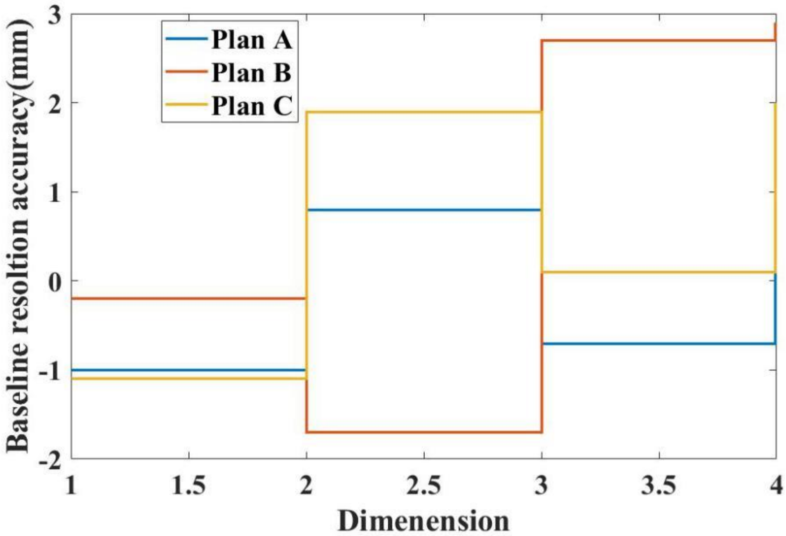

Figure 2. Baseline calculation accuracy statistics table

It can be seen from Figure 2 that the positioning accuracy obtained by the three schemes is in the order of millimeters. The calculation example shows that when the baseline is short (<1km), the accuracy obtained by the three schemes is equivalent, which is better than 5mm.

4.4. Analysis of Beidou Cloud System on Landslide Monitoring Experiment

Figure 3 shows the statistical results of ENU direction monitoring accuracy under three schemes during the monitoring period.

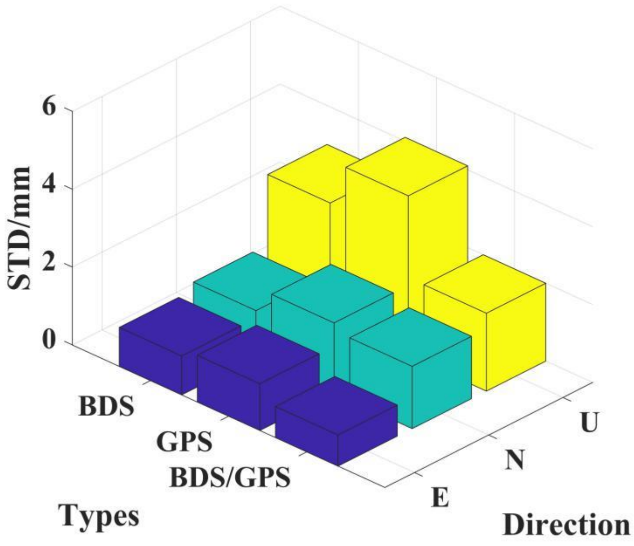

Figure 3. Statistical results of ENU direction monitoring accuracy under three schemes

From Figure 3, we can see that in Scheme A, the internal coincidence accuracy in the E direction is better than 2mm, the internal coincidence accuracy in the N direction is better than 2mm, and the internal coincidence accuracy in the U direction is better than 3mm. The internal coincidence accuracy in the three directions of E, N, and U are all in the millimeter range; from Scheme B, we can get a similar conclusion, that is, the three directions are all in the millimeter level, where the E and N directions are better than 2mm and the U direction Better than 5mm, scheme C has the best accuracy, and the accuracy in all three directions of ENU is optimal. In scheme C, the internal coincidence accuracy in the three directions is lower than the results of the previous two schemes. It can be seen that in the inspection of scheme C, the internal coincidence accuracy in the three directions of E, N, and U reaches the most excellent. According to the comparison results of the experimental scheme, under the conditions of good observation conditions, the best monitoring accuracy effect is the BDS / GPS combination, followed by the BDS single system effect, and the GPS effect is the worst.

Figure 4 shows the horizontal displacement of the landslide observed under the Beidou Cloud Monitoring System and the automatic detection system

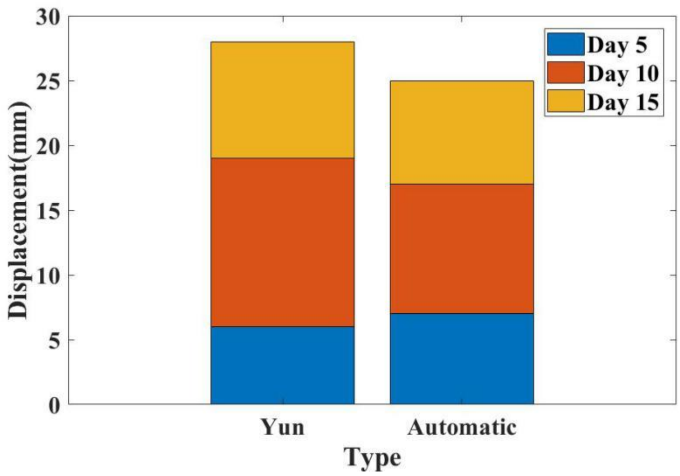

Figure 4. Landslide displacement change

It can be seen from Figure 4 that in the horizontal displacement change detection of the landslide, the total horizontal displacement of the landslide based on the Beidou Cloud system is 28 mm, and the total displacement detected by the conventional automatic detector is 25 mm. The coincidence error of the two monitoring methods in the horizontal direction is 3mm. From this we can see that the Beidou cloud monitoring system can detect very small changes. Even when the monitoring point is deformed by millimeters, the Beidou monitoring system can still be easily identified in real time.

5. Analysis and Discussion

5.1. Analysis of Experimental Results

Based on the analysis of the specific three aspects of the Beidou positioning method, the following conclusions can be drawn: First of all, the accuracy of the static baseline network calculation (in millimeters) is high among the three positioning methods, which can be applied to the stage of slow deformation and uniform velocity deformation monitoring of Accurate check and reduction of landslide monitoring results can be used as a periodic monitoring technique, usually given a period of time solution, and requires a long observation time (generally greater than 2 hours), applied to real-time landslide monitoring has certain limitation. Secondly, when the landslide enters the dangerous period (accelerated deformation stage and sharp deformation stage) and needs real-time monitoring, GNSS-RTK technology can be selected. In real-time calculation, GNSS-RTK technology has higher accuracy (millimeter to centimeter level) and reliability than

GNSS-PPP. However, the GNSS-RTK technology needs stable reference station data. When the observation environment is severe during the rapid deformation period and the reference station is destroyed, the GNSS-PPP technology can play the advantage of single station solution without reference. Numerical calculation results show that: GNSS-PPP, GNSS-RTK and static baseline network positioning technology methods are suitable for high-precision landslide disaster monitoring.Among them, after GNSS-PPP technology is initialized, the positioning accuracy can reach centimeter level, and RTK positioning technology is real-time The landslide monitoring accuracy can reach millimeter level, and the post-processing static baseline network positioning accuracy can be better than 5mm; the accuracy index results of the three technologies of different systems indicate that under the GPS / BDS dual system combination mode, GNSS-PPP technology and GNSS-RTK technology positioning Compared with single-system results, the accuracy and reliability are significantly improved. The single-system and double-system accuracy results of the static baseline solution are comparable. In practical applications, the multi-system combination mode can overcome the problems of insufficient number of satellites in the monitoring area and poor satellite geometry, and can improve the monitoring accuracy and reliability to a certain extent. By comparing the experimental results of dynamic slow change monitoring between GNSS-PPP and GNSS-RTK technology, it can be seen that GNSS-RTK technology can more effectively describe the displacement change of the sliding body, and the accuracy of monitoring displacement is millimeter level, which can be applied to The landslide slide is under constant speed and acceleration monitoring stage; in actual application, different technical methods can be deployed according to the stage of the landslide.In the stable stage of the landslide, the static baseline method can be used for periodic monitoring.When the landslide activity enters the acceleration stage, it can be used GNSS-RTK technology is used for effective monitoring. In the case where the reference station is damaged and the landslide is nearing slippage, the GNSS-PPP technology can be used for single station operation without the advantage of reference for supplementary monitoring [15]. By comparing and analyzing the application performance of the three precise positioning technologies in landslide monitoring, the results of the comparison show that the real-time high-precision positioning based on the Beidou system is fully suitable for landslide monitoring. Based on the analysis of Beidou positioning technology in the first stage, by constructing Beidouyun base station monitoring points and comparing the accuracy and precision of the three schemes of landslide monitoring, this paper believes that the developed Beidouyun landslide real-time monitoring system can achieve millimeter-level monitoring The accuracy meets the engineering accuracy and reliability requirements of landslide monitoring.

5.2. Discuss

China is one of the countries in the world most affected by landslides. Once in the rainy season and other seasons prone to landslides, the impact will be very large. Landslides need to have internal and external factors. The internal factors are mainly related to the movement of the earth, which leads to mountain slopes or artificial slopes. These mountain slopes or artificial slopes produce a certain slope and vibration under the weight of rock, water and vibration, thereby producing smooth surfaces and sliding bodies. Sliding space, topography and geological structure are the internal factors of landslide formation. The external factors are mainly rainfall, earthquakes and certain human activities, and the climatic conditions and ecological environment are external stimuli. Usually, weak rocks or hard layers (such as cohesive soil, loose and other loose sedimentary soils and involved sandstones, slate, mud) form soil or soil under the action of tectonic force, water, weather and other possible external forces Mud, smooth surface or sliding area. When the slope direction of the rock layer is the same as the slope, the weak surface in the slope is consistent with the slope direction and less than the slope angle, and manual excavation, etc., it is easy to expose the weak surface and form a main body that is easy to slide, and has a good sliding space. Due to intense heavy rain or long-term rainfall, a large amount of surface water entering the rock and soil body increases the burden on the slope and increases the physical strength of the soil and soil. The cracks in the rock joints are filled with water and saturated. Under the effect of hydrostatic pressure, the actual stress decreases. At this time, the overlying rock and soil body slides along the weak sliding surface under its own gravity, and finally forms a landslide. According to research, the relationship between landslides and rainfall is extremely close, and most landslides occur during the rainy season. China's mountainous areas are widely distributed, and landslide disasters often occur under the conditions of natural geological influence, rainfall and human factors. In the study of geological landslides, the main problem is the monitoring and prediction of landslides. The purpose of monitoring is to predict information more accurately to reduce the risk of geological landslides. Due to the complexity of the landslide problem, landslide prediction is still a global problem.

The Beidou system, as a scientific research system independently researched and developed by China, is of great significance to China's economic development. The Beidou satellite navigation system, as an important national strategic resource, will play an important role in maintaining and updating the coordinate frame, maintaining marine sovereignty and rights, and building military projects. The PreidisePoint positioning (PPP) technology based on the Beidou satellite navigation system has been widely used in high-precision measurement, low-orbit satellite orbit detection, aviation research, marine inspection, surface modification monitoring and monitoring. The Beidou satellite navigation system can not only promote the improvement of modern transportation systems, but also promote the development and improvement of precision agriculture, mining safety production, marine environment monitoring, air transportation and rescue. In areas of major geological landslides and areas with frequent ground subsidence, the Beidou satellite navigation system can be used as a technical support to establish a real-time disaster monitoring system. This system can not only accelerate the improvement of China's geological disaster monitoring network, but also improve the country's monitoring efficiency of geological disasters. And early warning capabilities to promote the rapid development of related industries. On the one hand, the continuous improvement and development of the Beidou satellite navigation system has made outstanding contributions to all walks of life in our country. On the other hand, natural disasters caused by environmental problems frequently occur, threatening the safety of people ’s lives and property. The development of navigation systems plays an active role in the monitoring of geological landslides and other natural disasters. Accurate monitoring and timely transmission of information reduce the losses caused by disasters. On the other hand, we must also take precautions and strengthen environmental protection Together with geological conservation and protection, we share a green mountain with green water.

6. Conclusion

(1) This article compares the accuracy and number of visible satellites of three precision positioning technologies (PPP, RTK and static baseline network solution) under single system and combination through case analysis and comparison of mathematical models. The precision of the technical method is analyzed in depth, and finally the technical adaptability is discussed according to the deformation characteristics of the landslide.

(2) Through the design experiment, the continuous operation and accuracy analysis of the landslide system, we can see that the real-time landslide monitoring system based on the Beidou navigation system has accurate and timely monitoring information and its design is called the

traditional GPS system for further optimization. The use improves the efficiency of data storage and calculation, thus forming a set of practical and powerful landslide monitoring system.

(3) By analyzing the experimental data, we can conclude that GPS is slightly inferior to the BDS detection system in terms of monitoring accuracy. Therefore, we can use BDS to solve the problem of low positioning accuracy, which can further improve the accuracy and reliability of landslide monitoring. With the development and maturity of technology, applications based on the Beidou satellite navigation system will radiate new power, especially the arrival of the era of big data, an application platform based on big data cloud and high-precision positioning will be generated across industries and regions. . As the core of the platform, the Beidou navigation system, as the entrance and data collection terminal for sensing everything, becomes the perception layer and network layer of big data, and plays a key role.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Jiao, Juying, Wang, Zhijie, Wei, Yanhong, Su, Yuan, Cao, Binting, & Li, Yujin.(2017). "Characteristics of Erosion Sediment Yield with Extreme Rainstorms in Yanhe Watershed Based on Field Measurement",Transactions of the Chinese Society of Agricultural Engineering,33(13), pp.159-167.DOI: 10.11975/j.issn.1002-6819.2017.13.021

[2] G. Duan, R. Niu, L. Peng, & J. Fu. (2017)."A Landslide Displacement Prediction Research Based on Optimization- Parameter Arima Model under the inducing Factors",Geomatics & Information Science of Wuhan University, 42(4), pp.531-536. DOI:10.13203/j.whugis20140913

[3] Hua LI. (2018)."Tunnel Deformation Monitoring Based on Vision Assistant", Journal of Mechanical Engineering, 54(1), pp.90. https://doi.org/10.3901/JME.2018.01.090

[4] Hiroomi NAKAZATO, Hidekazu TAGASHIRA, Tasuku NAGAE, Ryoichi TOMETSUKA, & Junichi KABAMOTO. (2018)."Wireless Sensors for Monitoring Landslide with Multiple Slip Surfaces", Journal of the Japan Landslide Society, 55(5), pp.223-231. https://doi.org/10.3313/jls.55.223

[5] Yuming Zhang, Xinli Hu, Dwayne D. Tannant, Guangcheng Zhang, & Fulin Tan.(2018). "Field Monitoring and Deformation Characteristics of A Landslide with Piles in the Three Gorges Reservoir Area", Landslides, 15(5), pp.581-592. https://doi.org/10.1007/s10346-018-0945-9

[6] Zhang, Guijun, Zhao, Li, Zhang, Pengtao, Zhang, Yigong, & Wei, Minghuan. (2017)."Cultivated Land Resource Security Evaluation and Consolidation Division Based on Farmland Classification", Nongye Gongcheng Xuebao/transactions of the Chinese Society of Agricultural Engineering, 33(16), pp.248-255. DOI:10.11975/j.issn.1002-6819.2017.16.033

[7] J.-Y. Yu, X.-D. Shao, B.-F. Yan, & P. Zhu. (2016)."Research and Development on Global Navigation Satellite System Technology for Bridge Health Monitoring", China Journal of

Highway & Transport, 29(4), pp.30-41. http://zgglxb.chd.edu.cn/EN/Y2016/V29/I4/30

[8] *Xiaohui Yuan , Reem Atassi, Geological Landslide Disaster Monitoring Based on Wireless Network Technology, International Journal of Wireless and Ad Hoc Communication, 2021, Vol. 2, No. 1, pp: 21-32. https://doi.org/10.54216/IJWAC.020102*

[9] *Cai-Cong Wu, Peng Qiao, Jing Zhao, Jie Wang, & Ya-Ping Cai. (2016).“Evaluating Model and Beidou Based Management System for Scale Operation of Cotton-pickers”, Positioning, 7(1), pp.21-31. https://doi.org/10.4236/pos.2016.71002*

[10] *Ooi Ghee Leng, Tan Pin Siang, Lin Meei-Ling, Wang Kuo-Lung, Zhang,Qian, & Wang Yu-Hsing. (2016).“Near Real-time Landslide Monitoring with the Smart Soil Particles”, Japanese Geotechnical Society Special Publication, 2(28), pp.1031-1034. https://doi.org/10.3208/jgssp.HKG-05*

[11] *Sonia Jenifer Rayen, Survey On Smart Cane For Visually Impaired Using IOT, Journal of Cognitive Human-Computer Interaction, 2021, Vol. 1, No. 2, pp: 81 – 85. https://doi.org/10.54216/JCHCI.010205*

[12] *L. Kang, X. Lu, X. Wang, C. He, & Y. Rao. (2018).“Navigation Signal Chip Domain Assessment on Beidou Navigation System”, Journal of Electronics & Information Technology, 40(4), pp.1002-1006. DOI:10.11999/JEIT170591*

[13] *Shaojie Zhang, Luqiang Zhao, Ricardo Delgado-Tellez, & Hongjun Bao. (2016).“A Physics-based Probabilistic Forecasting Model for Rainfall-induced Shallow Landslides at Regional Scale”, Natural Hazards & Earth System Sciences, 18(3), pp.1-17. https://doi.org/10.5194/nhess-2016-348*

[14] *X. Wang, Y. Zhang, M. Xu, B. Xing, & H. Zeng. (2017).“Development of Integrated Network Platform for Heterogeneous Agricultural Information Remote Monitoring Terminal”,Nongye Gongcheng Xuebao/transactions of the Chinese Society of Agricultural Engineering,33(23),pp. 211-218.*

[15] *Rajalakshmi, M., Saravanan, V., Arunprasad, V., A., C., Khalaf, O. I. et al. (2022). Machine Learning for Modeling and Control of Industrial Clarifier Process. Intelligent Automation & Soft Computing, 32(1), 339-359. https://doi.org/10.32604/iasc.2022.021696*