Research on Virtual Reference Station (VRS) Technology and Differential Correction Information

Zongbao Zhang[1], Changzuo Geng[2], Dong Chen[1]

[1]Shenzhen Power Supply Co, Ltd, Shenzhen, Guangdong, 518001, China

[2]Nari Technology Co., Ltd., Nanjing 211106, China

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Abstract: With the continuous operation of reference stations for various purposes, the system has been built one after another. The network RTK (carrier real-time dynamic positioning technology) composed of multi-base stations has emerged, which solves the limitation of conventional RTK. Although some of these systematic errors can be weakened by the model, their residual cannot be ignored. Conventional RTK has some problems in practical application. Differential technology can only eliminate common errors between reference stations and user stations under certain conditions. The emergence of VRS (Virtual Reference Station) technology in network RTK has greatly improved the effective distance of RTK technology. The VRS is characterized by continuous operation of multiple reference station networks and long-distance high-precision real-time positioning. While ensuring that the distance between the base stations cannot be too long and the user's positioning accuracy is at the same time, it is also necessary to consider the range of user operations that the system can cover.

1. Introduction

Global positioning system has global, all-weather, continuous, real-time and accurate navigation and positioning functions. It can provide users anywhere in the world with three-dimensional position, three-dimensional velocity and other information at any time. When using absolute positioning or single point positioning [1]. Its accuracy will be affected by many factors such as satellite orbit error, clock error, ionospheric error and tropospheric error [2]. In the effective coverage of network RTK, users even use single frequency receivers. The influence of ionosphere can also be improved in a short time, and the ambiguity of the whole cycle can be quickly calculated [3]. Although some of these systematic errors can be weakened by the model, the residuals are still not negligible. The error increases as the baseline length increases, and the reliability decreases as the baseline length increases [4]. Conventional RTK has problems in practical applications. Differential technology can only eliminate common errors between the base station and the subscriber station under certain conditions. The emergence of virtual reference station technology in the network RTK greatly improves the effective distance of the RTK technology. The relative positioning accuracy of the medium and long baseline is greatly improved.

In order to eliminate and attenuate satellite orbit errors, ionospheric effects, tropospheric effects, and errors due to policies. The development and application of differential positioning technology developed in recent years has received widespread attention and rapid development [5]. The way data is transmitted is limited, and users need to establish base stations themselves, which increases the cost. The VRS technology better overcomes the aforementioned drawbacks of conventional RTK technology and has been rapidly developed. The core technology is how to effectively integrate the corrections of all reference stations to make accurate corrections to the rover. VRS technology has the advantages of strong versatility, simple operation and reliable performance [6]. It has increasingly become the most successful and widely used solution in the field of network RTK. In intelligent transportation system, traffic information collection, vehicle dispatching control, vehicle monitoring and emergency rescue, etc. [7]. It is necessary to grasp the position information of vehicles dynamically, real-time, accurately and continuously. The basic idea of difference is to observe at the base station [8]. The pseudo-range correction from the reference station to the satellite is calculated by using the known precise coordinates of the reference station, and sent regularly. This paper focuses on the generation method of VRS differential correction based on multi-base station network and the research of differential correction information.

2. Difference Model of VRS Based on Grid Center Point

The use of positioning, no matter what method is adopted, is achieved by observing satellites to obtain certain observations. The coordinates of all reference stations are known because the observed values of reference stations and mobile stations are the sum of geometric distances and various systematic errors. GPS satellite navigation and positioning is based on the principle of passive ranging. That is to say, the GPS receiver passively measures the propagation delay of navigation and positioning signals from GPS satellites. For Beidou system, it adopts the same code division multiple access technology as GPS system. The processing method is similar to GPS, and the satellite with the highest altitude can be selected as the reference satellite. The distance between the pseudorange measurement and the ionospheric effect distance deviation of the carrier phase measurement is the same [9]. Therefore, the ionospheric effect distance deviation of the carrier phase observation is used to correct the ionospheric effect distance deviation in the pseudorange measurement. After the VRS is established, dynamic users can obtain more accurate positioning results by real-time relative positioning with VRS using conventional RTK technology.

Within a certain spatial range, the satellite ephemeris error and atmospheric error of the base station and the rover are spatially correlated. Making a difference can greatly reduce these errors. In a multi-base station network, the data center receives the original observation data of each reference station in real time, and once the approximate coordinates sent by the rover are received, a VRS is generated at the coordinates. Due to the influence of frequency division multiple access (FDMA) technology, double-difference ambiguity and single-difference ambiguity can not be separated when constructing double-difference observations. The spatial characteristics of ionospheric electron density determine the spatial correlation of ionospheric delay. When the distance between the two observatories is not too far, the satellite will move to the two observatories. The atmospheric conditions along the propagation path of electromagnetic waves are very similar. Generate VRS virtual observations or send VRS virtual observations corrections directly to user stations. In order to achieve high precision real-time positioning.

In VRS measurement, the calculation of correction number is the key to this technology, which is similar to the general network RTK method. That is to say, the deviation based on distance correlation on all reference stations is corrected to VRS by interpolation method. The interruption of error sequence is due to the fact that only 2964 fixed solutions have been solved by TBC software. The epoch number is 2938 with pseudorange differential positioning. The accuracy of pseudo-range differential positioning results of virtual reference stations at grid centers is shown in Table 1.

Table 1 Grid center point virtual reference station pseudorange differential positioning result accuracy

Direction component	Average value	Average absolute error	Unit weight error
Level	0.32	0.23	0.32
Vertical	0.07	0.41	0.47

In order to verify the correctness and validity of the mathematical model, the linear combination interpolation method is applied to simulate the experiment. The VRS phase observation consists of the non-difference observation value of the main reference station, the geometric configuration value and the error correction number on the baseline between the VRS and the main reference station. Data processing and control center is the core of the whole system. It also has the functions of data processing and communication control. VRS phase observation is still a relative observation. For mobile users, the calculation of VRS phase observation is the same as that of conventional reference station. Data collected from high-precision static GPS observation networks that have been performed in a region. The precise coordinates of the control points of the GPS observation network are obtained by the adjustment processing. According to the requirements of VRS, select some control points as the reference site. Users generally cannot obtain meteorological elements along the signal propagation path. The meteorological elements of the metrology station at any elevation are estimated by using the meteorological elements at the mean sea level according to a certain mathematical model.

3. Error Source Analysis of VRS System

The reference station network uses the exact coordinates of the reference station as known information to improve the fixation of the full-circumference ambiguity between the reference stations. The continuous operation reference station is responsible for collecting data and transmitting it to the data processing center for processing in real time through the communication line. Even if the meteorological elements are measured at the station, they cannot represent meteorological elements along the signal propagation path, and there are representative errors. The mobile subscriber receiver includes a GPS receiver and a wireless modem. VRS is highly versatile and can be used with any conventional RTK receiver. For the rover in the network of the reference station, the atmospheric delay between it and a reference station can be calculated more accurately based on the atmospheric delay information between the surrounding reference stations, and the whole-circumference ambiguity is solved [10]. The correction error of tropospheric effect deviation distance with GPS is the sum of mathematical model error and meteorological representative error of tropospheric effect deviation correction.

Because the receiver uses a crystal oscillator, the clock difference is quite large. The key of VRS technology is how to simulate VRS observations. Linear combination method is based on single difference combination between baselines in VRS network. After the post-processing program, 6417 epochs were calculated, and the packet loss rate was 3.9%. The error sequence of components of the corresponding pseudorange differential positioning results is shown in Figure 1.

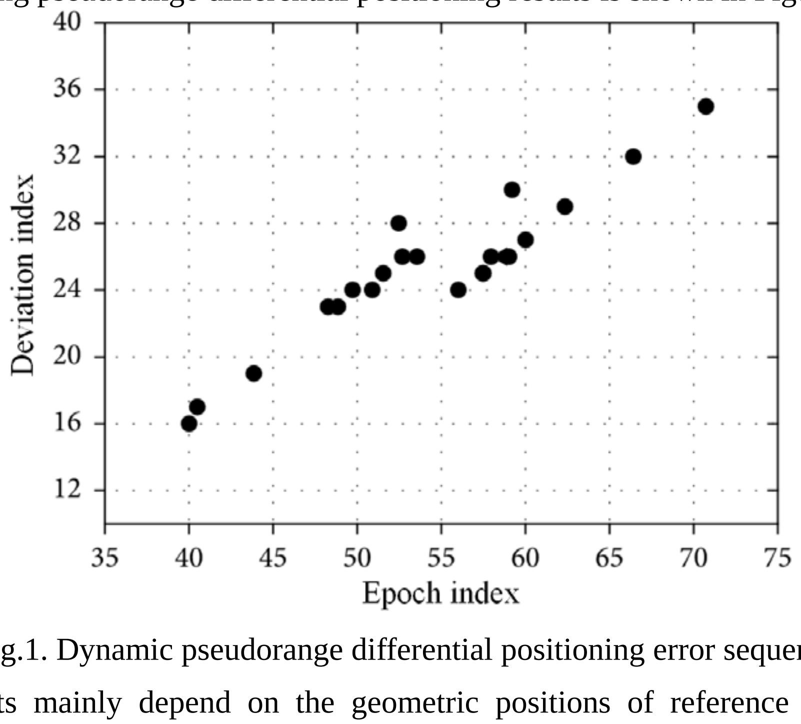

Fig.1. Dynamic pseudorange differential positioning error sequence

The coefficients mainly depend on the geometric positions of reference stations in mobile stations and VRS networks. At the same time, it is also related to the location of GPS satellite, the selection of main reference station and reference satellite. Clock error mainly includes receiver clock error and satellite clock error. Orbital errors and ionospheric delays can be largely eliminated. Tropospheric delay, multipath effect and observation noise will also be reduced. Therefore, the receiver clock is not easy to model, it mainly relies on double difference cancellation, otherwise it must introduce precise clock frequency. The online solution of the whole week ambiguity between reference stations is the basis of network RTK. When the ionospheric delay in the VRS network does not have spatial linearity, the accuracy of interpolation is low.

The multipath effect error refers to the station star distance error caused by the indirect wave generated by the reflection of the signal by the ground and the ground object, and the destructive interference of the direct wave directly reaching the receiver. The rover should be located in the graph formed by the base station in the VRS network to ensure that the sum of all coefficients does not exceed one. As a result, multipath effects and observed noise will be diminished. In order to achieve high accuracy and real-time positioning, the VRS observation value can be simulated or the correction number of the VRS virtual observation value can be sent directly to the mobile station. When the baseline is short, under sTable atmospheric conditions. The vapor content, atmospheric pressure and temperature at both ends of the baseline are similar. The receiver clock has low stability, fast frequency drift speed and acceleration, and is unsTable. Once virtual observations are simulated, VRS can be used as a common reference station.

4. Conclusion

VRS is characterized by continuous operation of multi-reference station network, long-distance high-precision real-time positioning. This requires that the system has the ability to process large amounts of data of reference station in real time, receive raw data in real time and transmit differential information. VRS technology is a positioning system which integrates Ineternet technology, wireless communication technology, computer network management technology and GPS positioning technology. This paper mainly studies the core algorithm of network RTK technology based on VRS. It mainly includes the online fixation of medium and long baseline ambiguity and the generation and release of differential information of VRS network. When building a network RTK system. While ensuring that the distance between the base stations cannot be too long and the user's positioning accuracy is at the same time. Also consider the range of user operations that the system can cover. The VRS is characterized by continuous operation of multiple reference station networks and long-distance high-precision real-time positioning. If the distance between the reference stations is too large, the residual of the integrated deviation of the user stations will be significantly increased. This is also where it needs to be perfected.

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