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The basic principles, characteristics and application of different GNSS localization methods are reviewed

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Abstract

The basic principles and application of GNSS positioning method are introduced. From shallow to deep, through the analysis of relatively simple standard single point positioning deficiencies, step by step extended to high precision wide-field real-time precision positioning. At present, the commonly used positioning methods of GNSS include standard single point positioning, precision single point positioning, wide-field real-time precision positioning, static relative positioning, dynamic relative positioning, wide-field differential positioning and other ways. This paper will summarize and summarize the basic principles and applications of each positioning method.

Keywords

Single point positioning, Wide area, Real-time, Precision positioning, Static relative positioning, Dynamic relative positioning.

1. Preface

In June 2020, with the launch of the 55th satellite of China's Beidou navigation Satellite System, the deployment of the third-generation Beidou navigation Satellite System, namely the Beidou-3 constellation, was completed, marking new development and breakthroughs in the global satellite navigation system.It provides more data and means to handle various satellite parameters, resulting in GNSS faster and accurate positioning of the satellite.

At present, the commonly used positioning methods of GNSS include standard single point positioning, precision single point positioning, wide-field real-time precision positioning, static relative positioning, dynamic relative positioning, wide-field differential positioning and other ways. This paper will summarize and summarize the basic principles and applications of each positioning method.

main body

2. Standard single point positioning

Single point positioning is also known as absolute positioning. The positioning principle of standard single point positioning is to determine the satellite clock difference through the carrier phase, a satellite, and determine the receiver coordinates in the form of square rendezvous.The ionospheric delay and receiver clock difference are corrected by model correction, and the distance obtained by this method is called pseudo distance in the form pi=（Xi-X）2+（Yi-Y）2+（Zi-Z）2-cVtr+cVts-（Vion）i-（Vtrop）ISince the ranging code itself is small in frequency, the benchmark frequency f0=10.23MHZ, which leads to the ionosphere delay and tropospheric delay, so through the standard single point positioning distance error is usually about 10m, and does not apply to the measurement error requirements, but because of the characteristics of the positioning, the cost is low, usually used in civil navigation for precision requirement is not high.

3. Precision Single Point Positioning (PPP)

Unlike standard single point localization, precision single point localization is measured by means of carrier phase, L1The frequency f of the carrier1=154 x f0=1575.42MHZ L2The frequency f of the carrier2=120 x f0=1227.60MHZ, the frequency of the carrier is much greater than the base frequency, so the propagation distance is greatly increased. Obviously, if we use the carrier as a range signal, the range accuracy is greatly improved.At the same time, the high-precision satellite satellite calendar and satellite clock difference provided by IGS and other organizations are used for high-precision single-point positioning.

The observation equation for its carrier phase is as follows = (Xi-X) 2+ (Yi-Y) 2+ (Zi-Z) 2-cVtr+cVts- (Vion) i- (Vtrop) i-Nλ+bR-bSThe + Upper formula is a non-linear expression, its main purpose is to make the observation equation appear relatively concise, and actually need to use the Taylor series expansion as a linearized form. Some key issues in the precision single-point localization observation equation are briefly described below

(1) Satellite coordinates and satellite clock difference

International GNSS service organization IGS can provide high precision satellite coordinates and satellite clock difference information, but because IGS provides precision satellite calendar satellite clock difference accuracy is only 3ns, cannot meet the precision single positioning of 0.2ns to 0.3ns, so IGS established real-time working group, using the global real-time tracking station data, produce real-time products, make the satellite orbit error of 5cm, satellite clock difference 0.3ns.

(2) The ionizing layer is delayed Vion

The ionospheric delay, V, in EqionIt refers to the ionosphere delay correction of the carrier phase observation value.In just take into account f2In the case, the group delay correction size is the same as for the ranging code, with the opposite sign

(3) An introduction to the whole-week ambiguity of N in Eq

The carrier phase signal is actually a cosine wave, with the whole cycle part and less than the full cycle part, and the receiver can detect the carrier signal less than the full cycle part, and cannot detect the full cycle part, which is called the full cycle ambiguity.However, in the data processing process of precision single-point positioning, the hardware delay and the whole week ambiguity parameter cannot be effectively separated, and the decimal part destroys the ambiguity of the whole week.Only simultaneously containing b can be usedRAnd bSObservations of.At this point, the precision single-point positioning will either only seek the floating-point solution (but doing this will affect the positioning accuracy and convergence time), or use the observation data on several surrounding reference stations to try to estimate the hardware delay and eliminate it, so as to maintain the integer characteristics of the ambiguity parameter of the whole week.

(4) Correction required to be imposed

Including solid tide correction, ocean load tide correction, earth rotation correction, antenna phase center deviation correction, antenna phase winding, relativistic effect correction of satellite bell, etc

(5) Extensions and Applications

At present, the short message technology unique to China's Beidou navigation System is a means to realize precision single-point measurement in time. Short message communication conducts two-way information transmission with the help of static satellites It has the advantages of fast communication response, strong anti-interference ability and good confidentiality.The biggest advantage for the measurement is that we can use RTS to correct the characteristics of the data time correlation, through the calendar difference correction data simplification scheme for precision single point positioning, the current 3 D positioning accuracy can reach 0.3~0.4m

4. Relative localization

This paper briefly introduces the ranging principle of carrier phase and the ambiguity of the whole week. The disadvantages of precise single point positioning in determining the fuzzy part of the whole week can be corrected and eliminated by relative positioning. We know that there is satellite clock difference V in the distance equationtr, Receiver clock difference Vts, Iospheric delay Vion, Conpospheric delay Vtrop, The ambiguity degree of the whole week is N.Using two close receiver receive satellite signal at the same time, you can know the two sets of signal satellite clock difference, ionosphere delay and troposphere delay is almost equal, we use two groups of observation equation for a difference can eliminate the parameters, at the same time observe within the same interval of satellite signals, secondary difference between the receiver clock difference, so as to reduce the irrelevant parameters, convenient to estimate the whole week ambiguity N.While the two groups of distance vectors find the difference, we get the distance vector between the receiver (called the baseline vector), and the positioning method is called the relative positioning.Relative positioning is divided into static relative positioning and dynamic relative positioning.

（1）Static relative positioning

If there is no detectable change in the position in the fixed coordinate system, or although there is a detectable change, but because the change is slow, even in a period (generally hours to days) negligible, only in the second retest (interval from months to years), so the baseline vector during the whole period can be considered a fixed set of constants.Determining these baseline vectors is called a static relative localization.

（2）Dynamic relative positioning

If in a period of time, the position of the fixed point in the coordinate system changes significantly, the position of each observation moment is different, in the data processing, the baseline vector of each epoch need to be a set of unknown parameters, determine the instantaneous position of these carriers at different moments is called dynamic positioning

Therefore, the fundamental difference between static relative positioning and dynamic relative positioning lies in whether the baseline vector in a time period changes significantly compared with the tolerance, and whether the pending point coordinates of each epoch can be regarded as a constant set of unknowns in the process of data processing.In the static relative positioning, the positioning accuracy of the pending point can be improved by a huge amount of redundant observation, so it is widely used in precision engineering measurement, geodetic measurement and other fields.Dynamic relative positioning is applied to areas with low precision requirements, such as transportation.

5. Wide domain difference localization

Similar to relative positioning, wide-field differential positioning is also composed of two close receiver observation system, different, the wide differential positioning of one of the receiver is known, therefore, we can through the correction to estimate the coordinates of unknown point, when the unknown point plus correction, coordinate accuracy will be greatly improved (real-time navigation accuracy can improve 3 to 4 times), this is the GNSS wide differential positioning principle, generally known point is fixed, we call the point is the base station, unknown point is called mobile station.According to the type of correction number provided, we can divide the difference mode into position difference and distance difference.

Position difference: Due to the existence of error, the position of the single-point positioned reference point P 'and the actual reference point P generally do not coincide. We take the vector P' P as the correction vector.When the reference station transmits the position vector to the user, we call this mode the position difference.

Distance difference: Also due to the error, the distance between the reference point to the satellite is not equal to the actual distance, we will be the observation distance P0The difference value P between the and the actual distance P0-P It is sent to the user through the reference station, and the difference method is called the distance difference.

Due to the high accuracy of wide-range difference and real-time satellite dynamics, it is widely used in surveying and mapping activities.

Wide-area real-time precision positioning

Wide-area real-time precision positioning technology, in fact is wide-field differential positioning technology and precision single point positioning technology fusion and extension, wide-field real-time precision positioning technology integrates advanced GNSS real-time data processing system, network and communication technology, real-time precision positioning accuracy up to 1m, the following is the principle of wide-area real-time precision positioning technology.

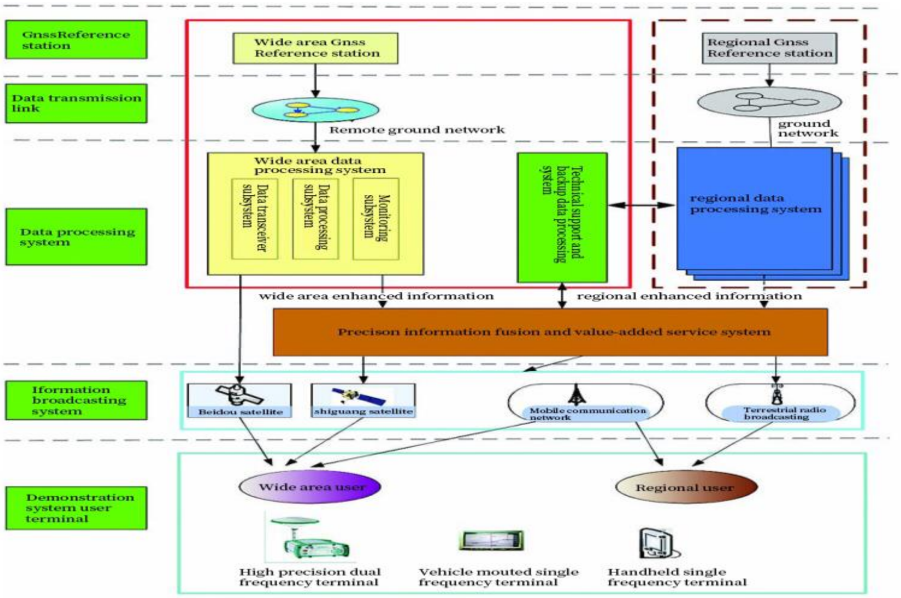

Figure1:workflow

6. Sum up

GNSS system has been an indispensable part of China's construction into a strong science and technology country in the new era. GNSS positioning technology has been applied to all aspects of society. In life, we use standard single point positioning for car navigation, takeout delivery, taxi and other aspects to make life more convenient and fast.Higher-precision wide-field differential positioning and wide-area precision positioning have been used in all aspects of measurement activities, including the construction of high-level control network and high-precision engineering measurement, providing a technical foundation for the construction of digital city.However, in the measurement of the average side length is not large enough, the accuracy of GNSS technology is particularly obvious, which requires a more optimized positioning method or leveling method. I believe that this day will not be too far away.

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