

Simulation Research on Multi-user Navigation under the Environment of Real-time Constellation

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Abstract. In the general simulation system of navigation, the real-time capability of traditional signal source is not strong, and the unity problem of navigation terminal remains. To solve the problem, the new navigation system is constructed which includes GPS/BDS navigation receiver, signal simulation software and receiver simulation software. The system sets up real-time constellation environment based on real-time on-orbit ephemeris and almanac and meets requirements of multi navigation terminal. Finally, navigation evaluation software analysis and verifies the validity and practicability of the navigation simulation system.

Introduction

GNSS satellite navigation technology has been widely used in various industries, a large number of test is needed in the research and validation phase of evaluating various aspects of navigation performance. In the navigation system, depending on the advantage of high reliability and flexibility, GNSS satellite navigation signal source is widely used in navigation signal simulation [1,2]. Traditional signal source of navigation environment is based on a fixed reference epoch constellation information, it has hysteresis problem in the process of test. At the same time, both hardware receiver and software receiver, can only correspond to a simple navigation terminal. If the navigation system includes ps, planes, and other types of users, it is difficult to calculate and evaluate every use the pedestrians, cars, shir meanwhile.

According to this, this paper builds a real-time navigation environment based on real-time update of the latest reference epoch constellation information, solving the problem of navigation signal simulation of hysteresis. For navigation system containing multi-user, by building navigation environment consisting of multi-user and receiver simulation software meeting the requirement of multi navigation terminal, the unity problem of navigation terminal is solved.

Architecture of navigation simulation system

Navigation simulation system consists of GPS/BDS navigation receiver, signal simulation software, receiver simulation software and navigation evaluation software. Among them, the BDS/GPS navigation receiver is used to obtain real-time BDS/GPS satellite ephemeris and almanac; Based on real-time ephemeris and almanac, signal simulation software builds the real-time constellation environment and generates the observed data and the navigation message; By parsing observation data and navigation message and combined with the characteristics of multi-user and navigation environment, receiver simulation software can obtain navigation calculating value; navigation evaluation software evaluates navigation simulation system by comparing basic navigation information got from signal simulation software and calculating navigation information

got from receiver simulation software. System architecture as shown in Fig. 1.

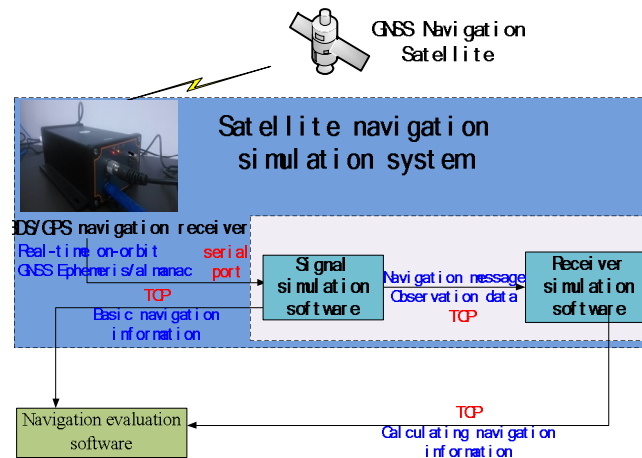


Fig. 1 Architecture of Satellite navigation simulation system

Real-time constellation environment building

BDS/GPS navigation receiver gets real-time on-orbit ephemeris and almanac as source of real-time satellite constellation information simulation module. Then, Signal simulation software combines satellite orbit simulation module, space environment simulation module, user trajectory simulation module, observation data and navigation message simulation module. Finally, navigation message and observation data under real-time constellation environment is generated [3].

Real-time satellite constellation information simulation module. In view of the characteristic of BDS/GPS navigation receiver that can output real-time satellite ephemeris and almanac, the satellite ephemeris and almanac output by navigation receiver is passed to signal simulation software via a serial port. Signal simulation software resolves satellite real-time ephemeris and almanac and get the latest reference epoch of satellite constellation information.

When choosing source of satellite constellation information, it is flexible to choose satellite ephemeris or almanac. It meets the requirement that worldwide users can obtain real-time satellite constellation information.

Satellite orbit simulation module. Regarding real-time reference epoch of satellite constellation information as basic value, with the simulation time goes on, the recursion of satellite constellation information is continuous. Through ephemeris parameters fitting method and the interpolation algorithm, real-time satellite ephemeris parameters can be recursived.

Space environment simulation module. Space environment simulation mainly includes the ionosphere delay, tropospheric delay, relativistic effects.

The effects of the ionosphere on GPS signal is mainly manifested in time delay. Ionosphere delay simulation includes 4 kinds of models: 8 parameters Klobuchar model, 14 Klobuchar model, constant model, the electron density of integral module.

Large transmission time delay happens when electromagnetic wave goes through the troposphere. Tropospheric delay simulation model includes 4 kinds of models: Hopfield model, improved Hopfield model, Saastamoinen model, constant model.

Due to the influence of relativistic effects, satellite clock error will be produced. Relativistic effects model is built to simulate the satellite clock error.

User trajectory generation module. The user motion of signal simulation software includes: static motion, linear motion, circular motion, attitude movement and so on. The user model of signal simulation software includes: Pedestrian model, car model, ship model, satellite model and so on. In order to increase the flexibility of the user motion, actual carrier trajectory can be saved in prescribed format. And it can be simulated as movement of the user.

Multi-user navigation simulation

In order to have multi-user navigation simulation, not only the source of the multi-user navigation satellite signal is required, also the receiver as navigation terminal which can deal with navigation satellite signal is necessary.

Generation of multi-user navigation satellite signal. Due to the constraints of hardware of radio frequency signal, the traditional signal source usually simulate a single user's navigation satellite signal at the frequency of 1Hz. Considering the demand of multi-user navigation satellite signal, signal simulation software designed in this paper generates multi-user navigation message and the observed data. Signal simulation software can simulate up to 50 users' navigation message and the observed data at the frequency of 1Hz synchronously.

Transmission of navigation satellite signal. Because there is no radio frequency module of satellite signal, so transmission of navigation satellite signal is rely on network different from the traditional transmission using electromagnetic wave [4]. Therefore, it is better to choose the TCP network transmission with higher reliability. Test results show that it is reliable to transmit 50 users' navigation message and observational data at the frequency of 1Hz.

Navigation terminal simulation. The traditional navigation receiver as a single navigation terminal decode a single user's navigation satellite signal once a time. Due to the signal simulation software sending multi-users' navigation message and observation data in the way of TCP transmission synchronously, thus the receiver simulation software is required to handle up to 50 users' navigation message and observation data synchronously

The traditional navigation receiver receives satellite signal via radio frequency and handles to get navigation information. And the receiver simulation software used in this paper receives simulated satellite signal including navigation message and observation data via network. Therefore, the resolved navigation information ignores trapping error, tracking error and dynamic characteristics of the user in the actual environment.

In order to be similar to the actual receiver, in the process of calculating navigation information, tropospheric delay model, ionosphere delay model, the relativistic effect correction model is required. Besides, environment error simulation model of the user terminal is added to the calculating process. Environment error simulation model includes environment of white noise, environment of urban road, environment of urban canyon, environment of shaded forest. In view of the inaccuracy of ionosphere and troposphere delay simulation model, combined with the actual engineering experience [5], ionosphere and troposphere residual simulation model is built [6]. In view of the dynamic characteristics of the user, dynamic characteristics residual simulation model is built according to influence of the user's velocity and acceleration.

According to selection of the user, different positioning mode are optional. In addition to the difference of navigation calculating model, the difference of DOP value for GPS positioning mode and BDS positioning mode mainly affects the results of positioning results. According to the combination of error simulation model, standard deviation of user range error can be obtained. Finally, navigation terminal can get positioning results.

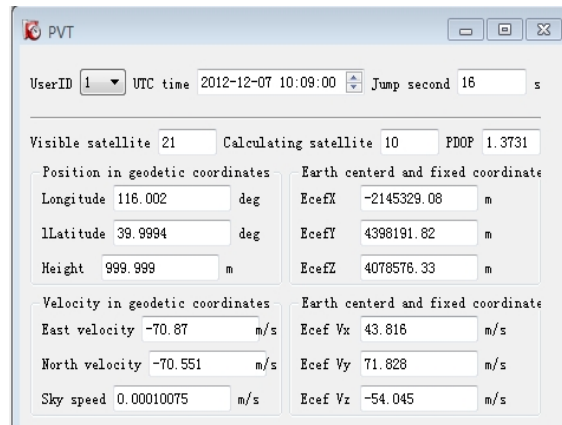


Fig. 2 Information of calculated navigation

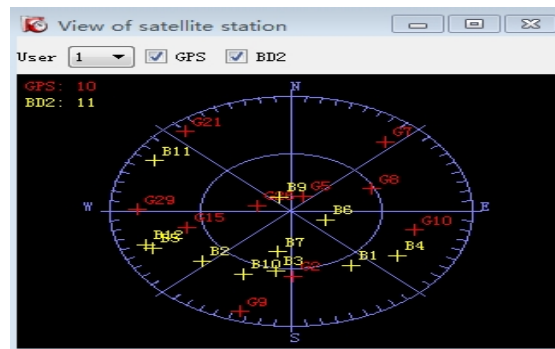


Fig. 3 View of satellite station

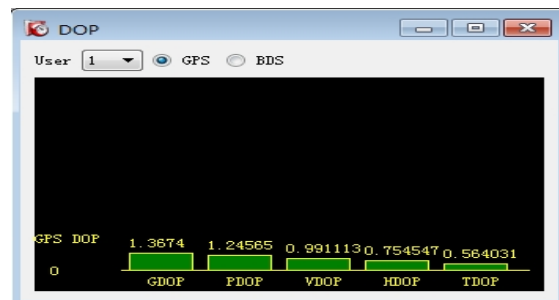


Fig. 4 Information of calculated DOP

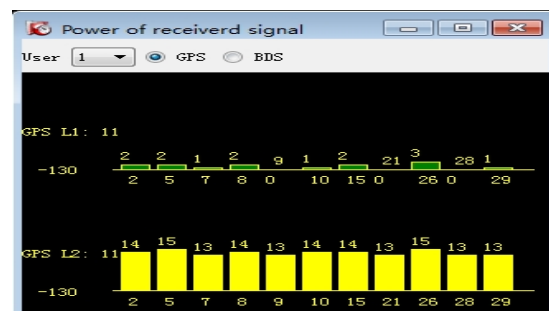


Fig. 5 Power of received signal

Verification of navigation performance

Navigation evaluation software is built to analyze the navigation information.

Transmission of navigation information. Signal simulation software as generation of navigation signal outputs multi-users' navigation information as basic value. The time and position information

is sent to navigate evaluation software via TCP network transmission. And receiver simulation software also sends time and position information to navigation evaluation software via TCP network transmission.

Summary

According to the principle of satellite navigation, a navigation simulation system is designed. The system builds architecture including the generation of real-time navigation signal, multi-user navigation terminal which is used to get navigation information and the evaluation of navigation information. Comprehensive test and specification is done on the navigation system. This paper possesses certain reference meaning for research on GPS/BDS integrated system.

References

- [1]Xu Zongfei. Study on unmanned aerial vehicle navigation system based on GPS radio frequency navigation source [J]. Computer measurement and control , 2010 , 18(3):655-657.
- [2]Shu Zhan. Research on navigation signal simulator software with multi-system[J]. Journal of electronic design engineering , 2014 , 22(13):48-51.
- [3]Liu Shushi. Analysis and simulation on Navigation satellite signal [D]. Beijing: institute of technology of equipment command , 2007 .
- [4] Fan Changxin, Cao Lina. Communication principle [M]. Beijing: national defence industry press , 2009 .
- [5] Xie Gang. Theory of global navigation satellite system. Beijing: electronic industry press , 2009.
- [6] Xie Shijie, Han Mingfeng. Theory of the influence of the ionosphere on GPS [J]. heilongjiang province, surveying and mapping engineering , 2000(3) : 9-15.