Design and Implementation of Positioning Software System based on Non-navigation Satellites

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ABSTRACT

As life needs increase, people become more dependent on location services. Although the established Global Navigation Satellite System (GNSS) can provide accurate Position, Speed, and Time (PVT) information, the existing GNSS signals are so vulnerable to multipath effects, occlusion and other complex environments that there are functional failures sometimes. The study of other positioning technologies as a backup system for GNSS has broad prospects. Among them, non-navigation satellite signals have the advantages such as wide coverage, high signal strength, and strong anti-interference. Based on existing satellite resources, only a small amount of capital investment can provide positioning services.

At present, the basic positioning algorithm based on non-navigation satellites has basically been verified. However, due to a series of problems for instance data processing and orbit prediction, and it cannot fully realize the positioning function as a result of low execution efficiency and a lot of manual assistance operation requirements. In view of the problems mentioned above, designing and developing a software system based on non-navigation satellite positioning has important theoretical significance and application value.

This subject has completed the algorithm design and software development of the positioning software system based on non-navigation satellites. The research content mainly includes the following points:

(1) The realization of the key technologies of Doppler frequency extraction and processing. This system firstly preprocesses the digital signal of the collected Low-Orbit (LEO) communication satellites, and then uses the local carrier correlation and Maximum Likelihood Estimation (MLE) method to extract the time and Doppler frequency information of the burst satellite signal. Finally, according to the characteristics of time sequence, the function of clustering Doppler information belonging to different satellites is realized.

(2) The implemention of satellite number recognition function. This system uses

the Two-Line Element Set (TLE) file and the SGP4 model to realize the prediction of the satellite's position, speed and visibility within the time range, and completes the function of automatically matching the extracted Doppler information with the satellite that sent the signal.

(3) The implementation of key postioning technologies based on non-navigation satellite signals. The system uses the relationship between the Least Square (LS) solution of the positioning equation and the characteristics of Doppler information and satellite distribution to obtain the best time correction term, so as to obtain each group of burst signals with smaller time-errors. Then, a program for autonomously selecting the appropriate distribution of epoch information was established, and the positioning method based on multi-epoch instant Doppler was completed, and the output information was used to finish positioning self-integrity supervision.

(4) Based on non-navigation satellite software design and hardware platform construction. The research of this subject developed a Windows platform C-based back-end algorithm implementation program for the entire positioning system, and greatly optimized its performance. In addition, the research uses Qt to develop a software interface program based on C++ for the entire system, then builds the hardware platform of the system and establishs an effective linkage between software and hardware. The host computer visually displays configuration information and Doppler frequency figures for the operator and positioning results in the map in order to make the software convenient for users to operate during processing.

(5) Tested the key indicators of the positioning system. The Time To First Fix (TTFF) and other key positioning indicators of the system were tested and analyzed in various aspects. The research demonstrates the availability of the non-navigation satellite positioning system, and makes bold predictions about the system’s application and prospects.

The test results show that the combination of the software platform designed and the hardware platform in this article can independently realize the positioning function with an accuracy better than 200 meters after being verified by actual signals. In summary, this article has completed the design and development of a software system

based on non-navigation satellite signal positioning, verified the validity and feasibility of multi-epoch instantaneous Doppler positioning, and tested the key indicators of the system. The analysis proves that the system can provide good positioning services based on the existing non-navigation satellite signals and has great development prospects.

Keywords: Non-navigation satellite; Positioning software; Instantaneous Doppler positioning; Time to first fix;