Test Method of Real-time Kinematic and Its Application in Terminal Positioning Performance test

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Abstract. The real-time kinematic technology has been widely used in positioning terminals. The principle, test method of the real-time kinematic technology and its application in terminal positioning test are presented in this paper. A virtual drive test system is developed by using the real-time kinematic technology, and the positioning performance of the terminal is tested under different road sections. The test results show that the system can evaluate the terminals performance under the real application scenarios very well.

1. Introduction

With the rapid development of satellite positioning technology, the demand for high-precision position information is gradually increasing. At present, the most widely used high-precision positioning technology is real-time kinematic (RTK).

Because of its high positioning accuracy, RTK technology has been widely used in various equipments and the relevant test standards have been released [1] [2]. RTK technology can also be used in terminal positioning performance test to obtain high precision position reference. The principle and the test method of RTK will be introduced and also the application of RTK Technology in terminal positioning performance test will be presented.

2. Principle of RTK System

The RTK system mainly consists of a reference station, a mobile station and the data link between them. Its principle is to place a high-precision receiver at the reference station to continuously observe the satellites. A wireless data communication link is established between the reference station and the mobile station. While receiving the satellite signal, the mobile station receiver receives the observation data (pseudo range, phase and known data) from the reference station through the communication terminal, and obtains the mobile station position real time or through post-processing. RTK technology makes use of the spatial correlation of observation errors between the base station and the mobile station, and removes most of the errors in the observation data of the mobile station through difference, so as to achieve high-precision positioning.[3]
When the distance between the mobile station and the base station is small, generally less than 10km, the space related errors such as ephemeris error, troposphere delay and ionosphere delay are small, which can be eliminated or weakened by difference.

RTK technology has been applied in many industries, such as precision agriculture, disaster monitoring, precise timing and so on.

3. RTK Test Method

At present, there are mainly three ways to evaluate the positioning performance of GNSS terminals, using satellite navigation signal simulator in the laboratory, using outdoor receiving antenna and using record and playback instruments to carry out virtual drive test. [4][5] RTK test solutions are also mainly these three ways.

The simulation test is to simulate the standardized satellite signal scenario and the synchronous differential correction information by the navigation signal simulator. There are usually two test modes, single user mode and dual user mode which are shown in Figure 2. This method can evaluate the terminal positioning performance except the antenna.

Because the standardized scenarios of the navigation signal simulator are simplified by real satellite signal scenarios, the real environment cannot be completely simulated, such as weather, road conditions, buildings around and so on. So the positioning performance under the actual working environment cannot be completely reflected by simulation test. In order to evaluate the performance under real environment, outdoor receiving antenna located in a fixed and calibrated position can be used to receive satellite signals. Generally, it needs to be tested in the baseline field where the position is accurately
calibrated. The RTK equipment under test receives the real satellite signals and the differential correction information from the reference station at the same time for positioning as shown in Figure 2.

![Figure 3 RTK outdoor test system](image)

Using the satellite signal record and playback instrument to collect the satellite signal of the real environment and play it back in the laboratory to carry out the virtual drive test is a compromise solution to the above two methods. Virtual drive test can rebuild test scenarios in the laboratory close to the real environment. Before test, the satellite signal, differential correction information, and the position reference should be obtained through record period.

![Figure 4. RTK virtual drive test system](image)

4. Application of RTK in Terminal Positioning Performance Test
The previous chapter mainly introduces how to test the positioning performance of RTK terminal. As a high-precision positioning method, RTK itself can also be used in the terminal positioning performance test to obtain the reference location in virtual drive test.

![Figure 5. Application of RTK in virtual drive test](image)
RTK base station obtains the common error correction such as atmospheric delay and clock error by continuously observing GNSS satellite signal, and uses wireless link to communicate with mobile station. The RTK mobile station with integrated inertial navigation uses the difference correction quantity from the base station to obtain dynamic positioning with high accuracy. And the integrated inertial navigation can enhance the positioning reliability and accuracy in the urban canyon, tunnel and other sheltered environment. So the real-time/ post-processed high-precision position is obtained by the RTK mobile station during the record period. While during the record period, the control terminal server extracts the positioning reference recorded in advance, compares it with the output of the tested equipment, and produces the corresponding test results.

We record the scenario of a general urban road, the area near the Olympic Sports Center of Beijing and Anhua Bridge of Beijing using the virtual drive test system with RTK, and the positioning performance of four terminals are evaluated under this scenario.

In order to evaluate the performance difference under worse scenarios, we chose the area near the Hangtian Bridge of Beijing. The road conditions in this section are more complex, the multi-path effect is more obvious, and their impact on the terminal positioning performance is greater.

![Figure 6. Test results in general urban road](image)

![Figure 7. Test results in interchange scenario](image)
From the above test results, it can be observed that using the satellite signal scenarios of different road sections recorded by our test system can better reflect the terminal positioning performance differences in different situations.

In the actual application scenario, the satellite signal is reflected by the high-rise buildings and the road conditions, for example, the speed of the vehicle, the turns, viaducts, etc. So the satellite signal reaches the receive antenna through more complex multiple paths. The scenarios used in virtual drive test which are affected by the road conditions and weather, are more complex than the scenario models in satellite simulator. Therefore, virtual drive test reflects the positioning performance of equipment in various real scenarios, which can be used as an effective supplement to simulator test and widely used in terminal positioning performance evaluation. The RTK positioning technology plays an important role in this system. Generally speaking, as a positioning reference, its positioning accuracy is generally about 10 times better than that of the equipment under test. In our system, an integrated positioning method using RTK and inertial navigation is applied in the mobile station to acquire positioning reference. After data post-processing, the positioning accuracy can achieve centimeter level, so the system can be used to evaluate the terminals with positioning accuracies of decimeter level and below.

5 Conclusion
RTK positioning performance can be evaluated through three ways, simulation test, outdoor test and virtual drive test. Because of its high positioning accuracy, RTK technology can provide location reference for terminal virtual drive test. From the test results, virtual drive test is an effective supplement to the simulation test method, because the test scenarios can better reflect the impact of real buildings, road conditions, weather, etc., they can better reflect the real user experience of the terminals.

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