Đánh giá kỹ thuật định vị động thời gian thực với máy thu GPS/GLONASS giá rẻ, một tần số

Evaluation of Real-Time Kinematic Positioning with Low-Cost, Single-Frequency GPS/GLONASS Receivers

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Tóm tắt

Kỹ thuật định vị động thời gian thực (RTK) với các máy thu giá rẻ, một tần số được xem như là một lựa chọn phù hợp cho việc định vị chính xác với chi phí đầu tư thấp. Gần đây, các máy thu nhiều hệ vệ tinh, giá rẻ, một tần số được sản xuất. Việc sử dụng kỹ thuật định vị RTK với các máy thu này có thể là sự lựa chọn tốt hơn cho các ứng dụng định vị cần độ chính xác cao hơn và cho những khu vực ít nhận được tín hiệu GPS hoặc tín hiệu GPS bị yếu. Mục đích của nghiên cứu này là đánh giá độ chính xác của kỹ thuật định vị RTK với các máy thu giá rẻ, một tần số, sử dụng tín hiệu của hệ thống vệ tinh GPS và GLONASS, cụ thể là máy thu NV08C-CSM-BRD. Các thí nghiệm với trạm động đứng yên và di chuyển đã được thực hiện. Kết quả thí nghiệm cho thấy sai lệch vị trí khi trạm động đứng yên chỉ khoảng 5 mm. Trong các thí nghiệm khi trạm động di chuyển chậm dọc theo một hình vuông định trước nhiều vòng, sai lệch vị trí giữa các vòng di chuyển của trạm động trên cùng một đường đi trong khoảng 12 mm. Điều này cho thấy tiềm năng lớn của việc sử dụng các máy thu nhiều hệ thống vệ tinh, giá rẻ, một tần số cho nhiều ứng dụng trong nông nghiệp và môi trường ở Đồng bằng sông Cửu Long cũng như ở Việt Nam.

Từ khóa: Định vị chính xác, giá rẻ, một tần số, RTK, GPS/GLONASS

Abstract

Real-Time Kinematic (RTK) technique with low-cost, single-frequency GNSS receivers has recently been considered as a reasonable choice for more precise positioning with lower investment cost. With the recent release of very low-cost single-frequency multi-constellation receivers, using RTK technique with these receivers can be a better choice for more precise positioning and for areas where few GPS satellites are visible or GPS signal is weak. The aim of this study is to evaluate the precision of RTK positioning with low-cost, single-frequency GPS/GLONASS receivers, namely NV08C-CSM. Experiments with a static and a moving rover were performed. Experimental results showed a static precision of only about 5 mm for a still rover. In kinematic positioning experiments, the rover moved slowly along a square route for a few times. Its calculated positions aligned well with the moving route and a deviation in tracked positions of about 12 mm was observed. This indicates promising utilization of low-cost single-frequency GPS/GLONASS receivers for various agricultural and environmental applications in the Mekong Delta, Vietnam.

Keywords: Low-cost, single-frequency, GPS/GLONASS, RTK, precise positioning

Chữ viết tắt

RTK	Real-Time Kinematic
GNSS	Global Navigation Satellite System

1. Introduction

Global Navigation Satellite System (GNSS) plays a significant role in many applications, especially in surveying and navigation. However, there are many factors which affect the precision of GNSS positioning system. To improve the precision of the positioning system, several techniques have been suggested, among which RTK (Real Time Kinematic) has been regarded as one of the best techniques that can provide up to centimeter-level accuracy in real time [1]. Recently, RTK technique has been applied to low-cost receivers in order to reduce the cost of precision positioning systems [2]–[4].

Thanks to the development of GNSS receiver manufacturing technologies, many low-cost single-frequency multi-constellation receivers have been released and marketed. These receivers can provide raw measurement data required by RTK technique; thus foster the study and successful application of low-cost single-frequency multi-constellation receivers [5]–[9]. However, these studies have used expensive receivers and antennas. This approach would not be suitable for low-cost positioning applications.

The objective of this study is to evaluate the precision of RTK positioning technique using low-cost, single-frequency GPS/GLONASS receivers, namely NV08C-CSM-BRD with the self-built base station. The results of the study is important to evaluate the possibility to use low-cost single-frequency multi-constellation receivers for the precision positioning applications in order to reduce the equipment investment cost and be suitable for using conditions in Vietnam.

2. Materials and methods

2.1 Materials

2.1.1) Hardware

NV08C-CSM-BRD receivers were used to evaluate in this study. These are low-cost, single-frequency, multi-constellation receivers that can collect the signals of GPS, GLONASS, Galileo, Compass and SBAS. Several key features of NV08C-CSM-BRD receiver are shown in Table 1 [10]. To reduce the equipment cost, using low-cost antennas and low-cost receivers should be concerned in order to implement the precision positioning applications. In this study, Trimble Bullet GG and Garmin GA 38 were used. Some of their specifications and their price are listed in Table 2 [11], [12].

2.1.2) Software

To implement RTK technique, the library package RTKLIB ver. 2.4.2 developed by Takasu et al. (2009) was employed [13]. RTKLIB is an open source program package for standard and precise positioning algorithms with GNSS. It consists of a portable program library and several APs (application programs) utilizing the library. The library also supports various positioning modes for both real-time and post-processing (Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Static, PPP-Kinematic, PPP-Fixed), many external communication protocols (Serial, TCP/IP, local log file, NTRIP, FTP/HTTP), and graphical user interfaces for various purposes such as real-time positioning (RTKNAVI), communication (STRSVR), post-processing analysis (RTKPOST), etc.

2.2 Methods

To evaluate the precision positioning using RTK technique with low-cost single-frequency NV08C-CSM-BRD, two experiments were conducted. The first experiment called "static positioning" was conducted to evaluate the positioning precision of a still rover. The second experiment was used to evaluate the positioning deviation of a moving rover along a square route. This experiment is thus called "Kinematic positioning".

Table 1. Key features of NV08C-CSM-BRD receiver

Frequency	L1
GNSS systems	GPS, GLONASS, GALILEO, COMPASS, SBAS
Number of channels	32
Update rates	1/2/5/10 Hz
Raw data	Pseudo range, Carrier phase, Doppler
Data protocol	NMEA 0183, BINR, RTCM SC-104
Dimensions	50mm x 30mm x 7mm
Price	$80

Table 2. Information about Trimble Bullet GG and Garmin GA 38 antennas

	Trimble Bullet GG	Garmin GA 38
Frequency	L1	L1
Constellations	GPS + GLONASS	GPS + GLONASS
Gain	30 dB	27 dB
Dimensions	77.5mm x 66.2mm	91.6mm x 49.5mm
Price	$75	$70

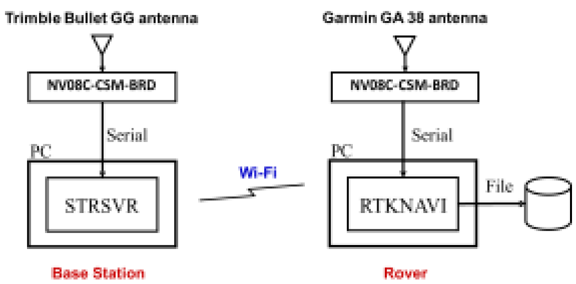


Fig. 1 *Experimental setup.*

Fig. 2 *The location of the base station and the test field of the rover.*

In an RTK technique setup, a base station with known position is required. Because of incomplete positioning infrastructure, there are no base station available to send free correction signals. Therefore, a self-built base station is required to utilize this technique. The position of the base station was determined in a static positioning experiment in our previous study described in [14]. At the base station, Trimble Bullet GG antenna was used and placed on the roof of a building. STRSVR application program of RTKLIB was executed in a laptop at the base station to collect GNSS signals and send them to the rover via Wi-Fi connection. At the rover, RKTNAVI application program of RTKLIB was executed to receive simultaneously GNSS signals from receiver and correction signals from the base station to calculate the precise position of the rover. The experimental setup is shown in Fig. 1.

Two experiments were conducted at College of Engineering Technology, Can Tho University, Vietnam from April to June 2015. The location of the base station and the test field of the rover are shown in a Google Earth view in Fig. 2. The distance between the rover and the base station is about 30 meters.

3. Experimental results

To compare objectively experimental results, experiments were performed at the same place (Volleyball court) and at a certain time in experimental days (from 9 o'clock to 12 o'clock, GMT+7).

3.1 Static Positioning

After completion of RTK setup and finding the FIX solution, the rover continued to stand still in one position and its position data were recorded about 6 minutes to assess the position precision. This experiment was performed 5 times on different days and position deviation of the experiment are presented in Table 3. The radius deviation average was 2.7 cm and the smallest and largest deviation were 2 cm (Fig. 3a) and 4 cm (Fig. 3b) respectively.

3.2 Kinematic Positioning

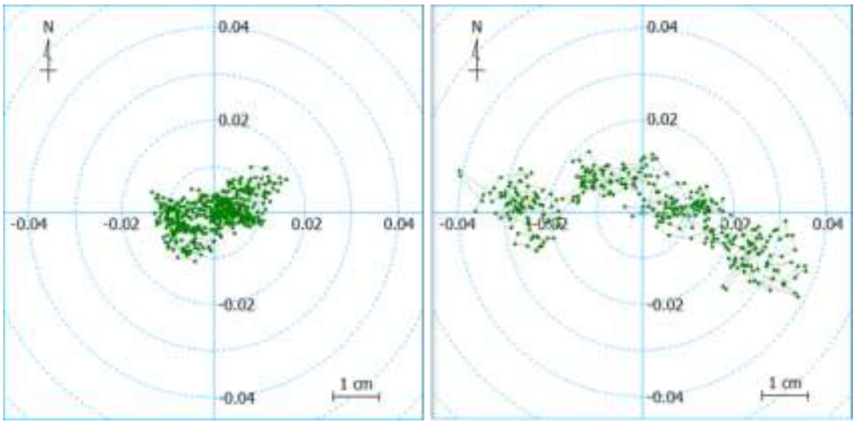
The kinematic positioning experiment used to evaluate the position deviation of the rover when it was moved along a square route which are the border lines of one half of the area of a volleyball court. This experiment was repeated 6 times on different days on the same route. Each time, the rover was moved from 5 to 10 turns. RTKPLOT application was used to create a plot of the calculated positions of the moving rover from which the position deviation of different turns can also be manually calculated as shown in Fig. 4. The calculated deviations from all experiments are summarized in Table 4.

Table 3. The position deviation of static positioning experiment

Date	Time (GPST)	Samples	Deviation (cm)
2015/4/09	03:18:01 – 03:23:41	341	3
2015/4/12	03:44:18 – 03:50:18	361	4
2015/4/15	02:56:56 – 03:03:44	409	2
2015/4/16	03:32:43 – 03:37:16	334	3
2015/5/06	03:08:01 – 03:16:01	481	2

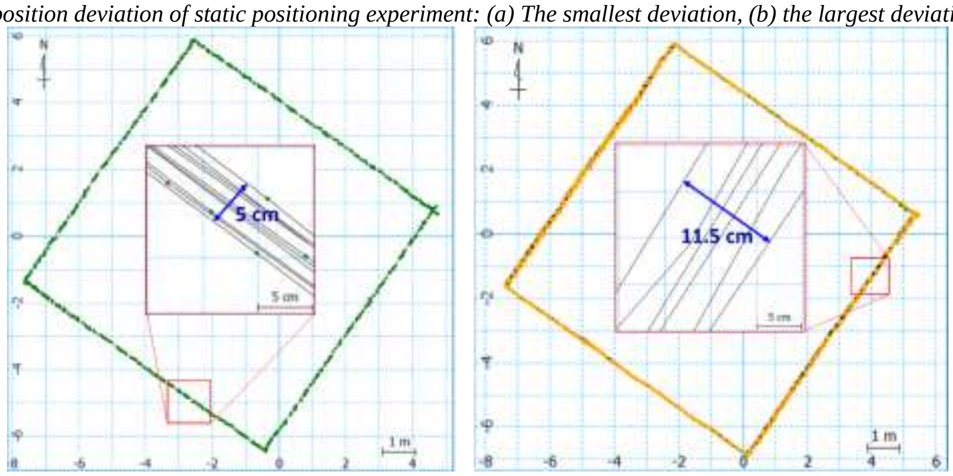
Table 4. The position deviation of kinematic positioning experiment

Date	Time (GPST)	FIX rate (%)	Deviation (cm)
2015/4/09	03:20:17 - 03:36:08	100	5
2015/4/15	03:16:36 - 03:53:24	99,5	6,5
2015/4/16	03:36:50 - 03:41:57	100	6,5
2015/5/06	02:01:30 - 02:18:17	8,1	11,5
2015/5/06	03:15:00 - 03:34:40	72,5	7,5
2015/6/06	03:22:00 - 03:36:14	93,3	6



(a) (b)

Fig. 3 *The position deviation of static positioning experiment: (a) The smallest deviation, (b) the largest deviation.*



(a) (b)

Fig. 4 *The position deviation of kinematic positioning experiment: (a) The smallest deviation, (b) the largest deviation.*

The results showed that up to 5 times, the FIX rate of experiments reached over 70% (two times of which, the FIX rate were 100%). The smallest deviation and the largest deviation of these experiments were 5 cm in the first experiment (Fig. 4a) and 11.5 cm in the fourth experiment (Fig. 4b) respectively. It is interesting to note that with the smallest FIX rate of just 8.1% in the fourth experiment, the positioning deviation was only about 11.5 cm.

4. Conclusions

In this study, RTK positioning technique using low-cost single-frequency multi-constellation NV08C-CSM-BRD receivers with the self-built base station was evaluated in static and kinematic positioning experiments. The kinematic positioning results have shown that the tracked positions of the rover well aligned with the moving route of the rover, and the largest position deviation of the rover was 12 centimeter. In addition, the position of a still rover could be obtained with the precision of about 4 centimeter within 6 minutes. These results indicate that it is feasible to implement the precision positioning applications with low investment costs by using low-cost single-frequency multi-constellation receivers as NV08C-CSM-BRD.

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