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A solution using a 3G mobile network for RTK positioning

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Abstract

This paper proposes a solution transmitting data from the base station and rover station server via 3G mobile network for RTK positioning of high precision with low cost. The data from the GPS receiver is transmitted to the server and is processed by the module RTKNAVI of software RTKLIB. The authors use this system to establish a topographic map. With distance from the base station to the rover station about 2 km, RMS of coordinates is $\delta x = \pm 25$mm, $\delta y = \pm 9$mm, $\delta H = \pm 39$mm The results show that this solution meets the requirements of precision for large scale topographic, cadastral mapping, construction surveying and ITS systems. Besides, this solution has overcome disadvantages depending on the complexity of the terrain and objects of conventional RTK systems

Keywords: RTK GPS, 3G mobile network, RTKLib, fieldbook, Hydrographics surveying, ITS

1. Introduction

In [1], [2] we have introduced and experimented a system of RTK GNSS using 3G telecommunications network self-designed. This system works effectively and accurately within 10km of range. In this paper, a result of the application of this system to measure large scale topographic map is presented. To do this, an APP on Android (ClientInternet.apk) to replace fieldbook in traditional RTK system was developed (fig. 1). This APP can allow users to receive and store baseline vector (local geodetic coordinate – ΔE, ΔN, ΔU) between base and rover station in case the coordinate of base station is not exactly and the coordinate of rover station is automatically calculated after determining the coordinate of base station. Especially, the new application can automatically store fixed solutions and remove float solutions when rover is stopped. This design supports to increase the accuracy of positioning by choosing the best fixed solution and users can focus to hold GPS antenna straightly. Users can import base station to APP with various format as cartesian coordinates in WGS84 datum (X, Y, Z), Geodetic coordinates in WGS84 datum (B, L ,h) or TM coordinates in VN2000 datum (x, y, H). The coordinate of rover station will be calculated with same format, respectively, basing on ΔE, ΔN, ΔU from server. It is more convenient and easier to positioning when using this APP. All processed data are stored in smartphone and are sent to data centre when needed.

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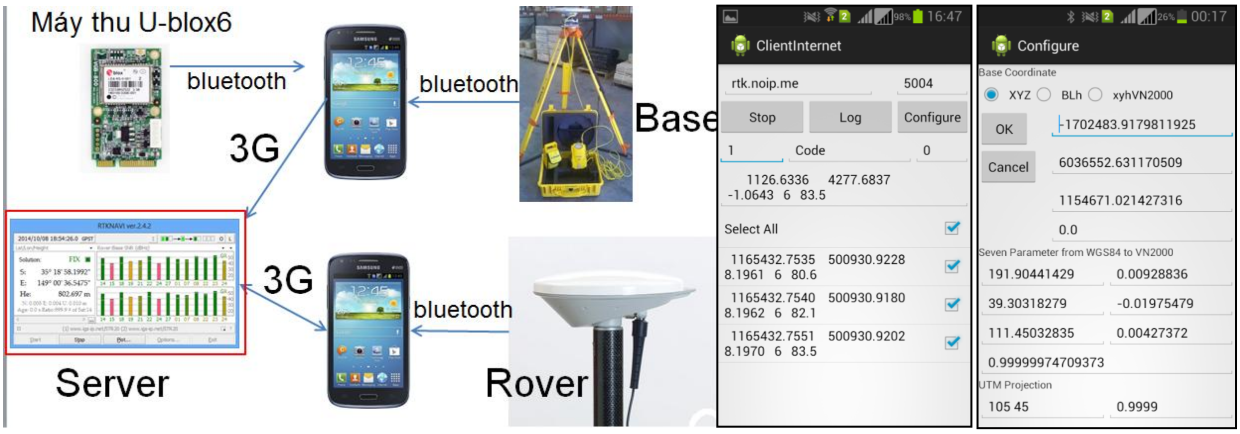

Fig. 1. Diagram of device connecting for RTK technique using 3G mobile networks and APP ClientInternet.apk display

2. Experiment and data processing

2.1. Experiment

The experiments were conducted in campus 2 of HCMUT at Di An District, Binh Duong Province. There were 2 experiments: the first experiment was using this system to survey topographic map of courtyard in campus in 2 days (01/5/2015, 04/5/2015) and the second experiment was checking 23 control points in this area (in 07/5/2016) (figure 2). The base station is placed on the 3rd national control point named 646686 in Asian high way 1 (AH1). The distance from base station to rover is about 2.0km and the use of UHF RTK system is not feasible because of dense buildings... (figure 2). The experimental area was ensured good satellite visibility and enough satellites over all time. All collected data is presented on the TM projection referred to VN2000 national datum (central meridian is 105˚45' and scale factor at central meridian is 0.9999), and orthometic height of points are referred to Hon Dau – Hai Phong. After that, they were compared with the digital topographic map with scale of 1:500 which is published by Southern Natural Resources and Environment Company in 2014.

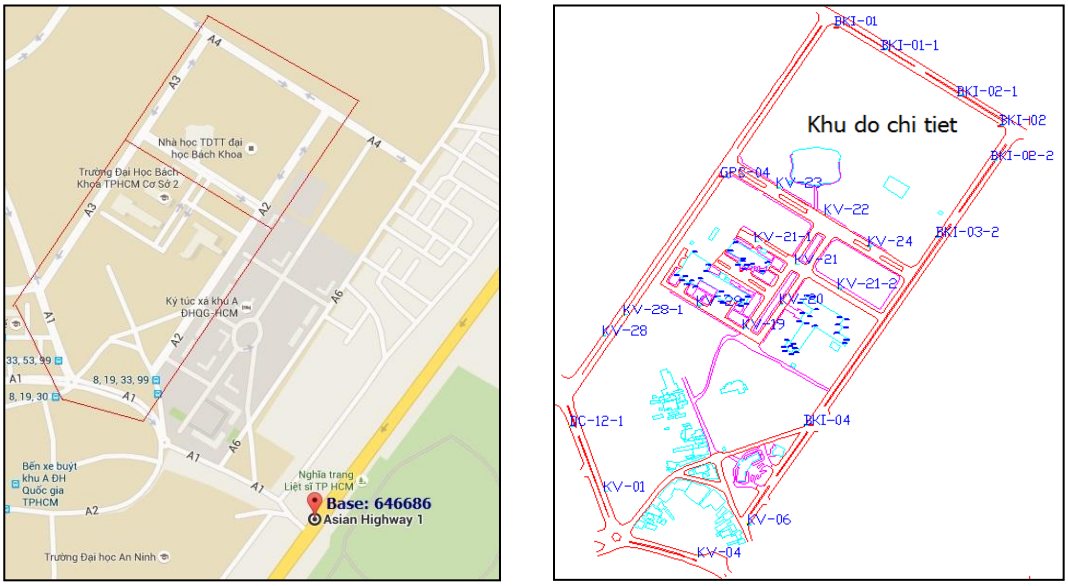

Fig. 2. Map of experimental area

2.2. Data processing

Totally, there are 597 points collected for two days (214 points on March 1st and 383 points on March 4th). Fixed solutions were performed quickly because of good satellite visibility, the others were performed slower (from 30 seconds to 1 minute) because of near buildings.

All points collected by the RTK system were overlaid with the 1:500 scale digital topographic map on AutoCAD 2007 software (fig. 3). In figure 3, objects in topographic map (made by total station) is thin and dark.

The others were processed from RTK results are white, bold and light. The maps established by two methods are similar.

For vertical checking, all of collected data are used to build DEM and compared with DEM built by total station. In fig. 3, contours drawn from total station data and RTK data are nearly similar. The cause of the difference between the two contour groups is due to the density of points collected by RTK method is less and topographic feature changed by building work (the campus is under construction). First, total station data are denser than RTK data. Second, there are changing contruction in the end of 2014. However the contours of 12.0 12.5 13.0 13.5 14.0 14.5 15.0 surveyed by total station data (blue arrow) and RTK data (yellow arrow) are near with SW to NE direction.

In addition, there are 23 control points located on A1 A2 A3 A4 roads with easy transportation and clear view of the sky were rechecked. These points were measured by total station and adjusted by least square method

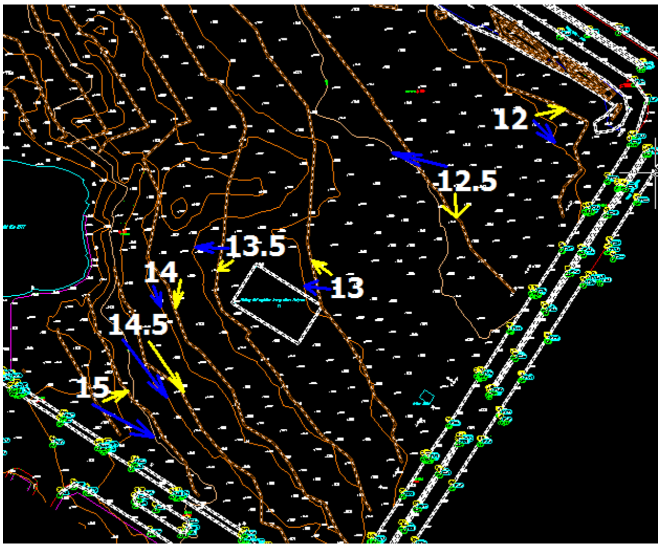

Fig 1. A comparison of map made by total station and RTK GPS

Table 1 presents the differences of horizontal coordinates x, y and orthometic height H between two methods: total station and the RTK system. Results of positions show that differences of horizontal and vertical coordinates are less than 3 cm and 7 cm, respectively. Some positions has the differences more than 4 cm (BKI-03-2 is 7.8 cm, BKI-02-1 is 4.0cm, KV-21-1 is 6.2cm). It can be acceptable accuracy because these benchmarks were determined position by the total station just set on the face right mode (not the face left mode).

Assuming that data measured by total station are correct. Standard deviation of RTK results is determined by formulas:

$$\delta_x = \pm\sqrt{\frac{\sum_1^n (x_i - \hat{x}_i)^2}{n}} \tag{1}$$

$$\delta_y = \pm\sqrt{\frac{\sum_1^n (y_i - \hat{y}_i)^2}{n}} \tag{2}$$

$$\delta_H = \pm\sqrt{\frac{\sum_1^n \left(H_i - \hat{H}_i\right)^2}{n}} \tag{3}$$

Where δ_x, δ_y, δH are horizontal standard deviation and vertical deviation, respectively. xi yi Hi are horizontal coordinate and orthometic height of benchmark i that are determined by the RTK system, respectively. $\hat{x}_i$ $\hat{y}_i$ $\hat{H}_i$ are horizontal coordinates and orthometic height of benchmark i that are determined by the total station. n is the number of control points rechecked. Although the number of benchmark is 23 points, but they are evenly distributed on large experimental area, so standard deviation of RTK results are reliable.

From formula (1) (2) (3), horizontal and vertical standard deviation are δx = ±25mm, δy = ±9mm, δH = ±39mm, respectively. They shows that accuracy of coordinates mabe by RTK system is adaptive for locating topographic detail.

Table 1. Comparison of coordinates made by total station (TS) and RTK positioning

No	ID	x_TS(m)	y_ TS (m)	H_TS (m)	x_GPS (m)	y_GPS (m)	H GPS (m)	Δx mm	Δy mm	ΔH mm
1	KV-06	1203016.670	615155.200	23.232	1203016.675	615155.210	23.204	5	10	-28
2	BKI-04	1203182.490	615244.820	19.081	1203182.500	615244.830	19.062	10	10	-19
3	BKI-03-2	1203496.620	615450.220	12.780	1203496.698	615450.220	12.824	78	0	44
4	BKI-02-2	1203625.180	615541.600	12.291	1203625.171	615541.602	12.347	-9	2	56
5	BKI-02	1203683.294	615550.664	12.153	1203683.303	615550.656	12.176	9	-8	23
6	BKI-02-1	1203733.120	615488.560	12.142	1203733.080	615488.565	12.164	-40	5	22
7	BKI-01-1	1203810.260	615369.670	12.270	1203810.250	615369.677	12.313	-10	7	43
8	BKI-01	1203848.260	615293.080	12.463	1203848.258	615293.080	12.468	-2	0	5
9	KV-23	1203578.910	615201.260	16.990	1203578.913	615201.272	17.010	3	12	20
10	KV-22	1203534.560	615276.150	16.116	1203534.560	615276.155	16.133	0	5	17
11	KV-24	1203481.080	615344.010	15.089	1203481.085	615344.015	15.101	5	5	12
12	KV-21	1203450.780	615230.160	17.854	1203450.791	615230.160	17.851	11	0	-3
13	KV-21-1	1203488.620	615167.770	18.380	1203488.682	615167.776	18.453	62	6	73
14	KV-21-2	1203410.300	615297.380	16.890	1203410.321	615297.385	16.924	21	5	34
15	KV-20	1203384.370	615205.860	19.477	1203384.390	615205.866	19.473	20	6	-4
16	KV-19	1203344.670	615147.400	21.351	1203344.667	615147.412	21.363	-3	12	12
17	KV-29	1203381.250	615075.580	22.710	1203381.263	615075.587	22.653	13	7	-57
18	KV-28-1	1203366.740	614961.530	27.100	1203366.766	614961.546	27.038	26	16	-62
19	KV-28	1203332.050	614928.280	28.326	1203332.059	614928.267	28.250	9	-13	-76
20	DC-12-1	1203181.380	614877.240	31.640	1203181.380	614877.251	31.610	0	11	-30
21	KV-01	1203072.150	614931.140	29.580	1203072.142	614931.154	29.550	-8	14	-30
22	KV-04	1202964.230	615077.290	25.155	1202964.229	615077.289	25.114	-1	-1	-41
23	GPS-04	1203597.128	615119.255	19.609	1203597.131	615119.268	19.570	3	13	-39

3. Results Analysing

Experimental results show that the RTK system using the mobile Internet for streaming GPS data has several advantages than RTK system using UHF: i) Our RTK system is good and effective operation even if the topographic and geographic feature between the base station and rover stations is complicated; 2) The equipment used in this RTK system available on the market, the system easy to replace, compact, low cost, capable of measuring continuous RTK in one day and especially allows using of many rover receiver simultaneously...

According to normative [6][7], in 1/200 scale of cadastral map, horizontal standard deviation of the detail point referred to the nearest control point is less more 5cm and in 1/500 scale of topographic map, standard deviation of the detail point referred to the nearest control point is less more 25cm for hozirontal coordinates and less more 12.5cm for vertical coordinate. Base on δx = ±25mm, δy = ±9mm, δH = ±39mm, the RTK system set up by ourselves is available for measuring large scale of topographic and cadastral map with operation range of 5km.

4. Conclusion

Solution of using 3G telecommunications network to transmit measured data in the RTK system is feasible and effective. The authors have proposed a complete RTK system at a low cost, compact, especially the system is designed specifically for the purpose of measuring in detail of large scale mapping. The accuracy of the positioning of the system to ensure the accuracy required of large scale mapping, positioning construction, hydrographic surveying as well as the monitoring of mobile objects with high precision.

References

Lê Trung Chơn et al, *The experimental results of the RTK GPS measurement using 3G mobile network and internet*, Journal of Science and Technology, Vol 16, No.K3- 2013, pp

Trịnh Đình Vũ et al., *A solution fo data transmission via internet to measure RTK*. GIS-IDEAS 2014 International Symposium, pp 157-162, Da Nang, Dec., 2014

Tomoji Takasu and Akio Yasuda, *Development of the low-cost RTK-GPS receiver with an open source program package RTKLIB*, Laboratory of Satellite Navigation, Tokyo University of Marine Science and Technology.

Tomoji Takasu and Akio Yasuda, *Kalman-Filter-Based Integer Ambiguity Resolution Strategy for Long-Baseline RTK with Ionosphere and Troposphere Estimation*, Tokyo University of Marine Science and Technology, Japan.

Tomoji Takasu and support, *RTKLIB ver. 2.4.2* Manual, April 29, 2013.

RTKLIB: *An open source program package for GNSS positioning*, http://www.rtklib.com

Cục Đo đạc Bản đồ nhà nước, *Quy phạm đo vẽ bản đồ địa hình tỷ lệ 1/500, 1/1000, 1/2000, 1/500*. Hà Nội, 1990