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Accurate Three Dimensional Coordinates Measurements Using Differential GPS Real Time Kinematic Mode

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Abstract

The accurate 3-D coordinate's measurements of the global positioning systems are essential in many fields and applications. The GPS has numerous applications such as: Frequency Counters, Geographic Information Systems, Intelligent Vehicle Highway Systems, Car Navigation Systems, Emergency Systems, Aviations, Astronomical Pointing Control, and Atmospheric Sounding using GPS signals, tracking of wild animals, GPS Aid for the Blind, Recorded Position Information, Airborne Gravimetry and other uses. In this paper, the RTK DGPS mode has been used to create precise 3-D coordinates values for four rover stations in Baghdad university camp. The HiPer-II Receiver of global positioning system was used to navigate the coordinate value. The results will be compare with the Google Earth viewer coordinates values, the comparison shows that absolute error was few millimeters between actual and measured coordinate's values.

Keywords: DGPS, RTK, GPS.

القياسات الدقيقة في الأبعاد الثلاثية باستخدام أسلوب الوقت الحقيقي الحركي لنظام التموضع التفاضلي العالمي

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الخلاصة

ان القياسات الدقيقة للاحداثيات الجغرافية ثلاثية الابعاد لنظم التموضع العالمي ضرورية في العديد من المجالات والتطبيقات. إن هذه التطبيقات كثيرة ومتعددة مثل، نظم المعلومات الجغرافية، نظم الطرق السريعة والسيارات، نظم الإنذار المبكر، الاستخدامات الفضائية، الخ. في هذا البحث، تم استخدام نظام التموضع التفاضلي العالمي بأسلوب الوقت الحركي الحقيقي لغرض إيجاد الإحداثيات الدقيقة لأربعة نقاط جوالة في مجمع جامعة بغداد. الجهاز المستخدم هو جهاز هايبر ٢ بمنظومة أقمار نافستارGPS. المقارنة اوضحت بان مقدار الخطأ المطلق كان بضعة مليمترات بين القيم الحقيقية والمقاسة.

1. Introduction

The use of Global Positioning System (GPS) technology is expanding rapidly, and is playing an increasingly important role in many areas, consisting of transportation, navigation, agriculture and geographical records systems, [1]. The DGPS system is a new generation of GPS application, it can consider as powerful toll in accurate three dimensional coordinates measurements and coordinates navigation. The major system application is in the ground locations and surveying. In the field work,

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the DGPS system is operate in two major modes, which are (Static S, and Real Time Kinematics RTK modes), the static mode is essential for the RTK mode also.

2. Differential Global Positioning System (DGPS)

Differential GPS is defining as a technique that improves the solution accuracy while removing of errors. It was introduced to satisfy the nee of positioning and distance measuring applications that required higher accuracies than stand-alone Standard Positioning Service (sps),[2]. DGPS receiver utilizes records from one or extra stationary base-station GPS receivers at correctly recognized locations. The bottom station GPS receiver calculates a position from the satellite alerts. This role will not be the same as the known region, however since the absolute location is known, the error from the GPS satellite signals can be computed. This error records is transmitted to the rover GPS receiver. The rover receiver computes positions from the GPS satellites and then improves the accuracy using the error or differential correction information. The basic concept of DGPS is illustrated in Figure-1[3, 4].

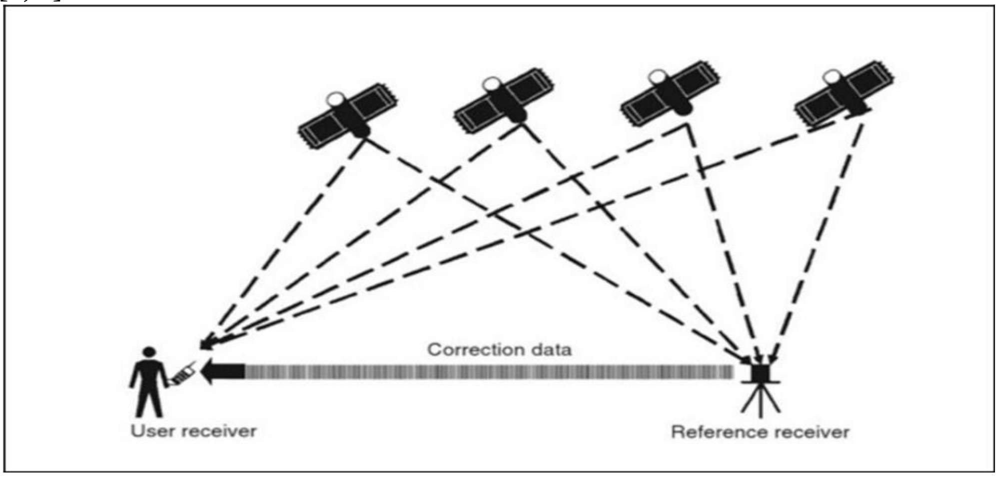

Figure 1-the Basic Principle of Differential GPS, [4]

3. Types of Receivers

Commercial GPS receivers can be divided into four kinds, in step with their receiving skills these are: unmarried-frequency code receivers, single-frequency provider-smoothed code receivers, unmarried-frequency code and carrier receivers, and dual-frequency receivers. Unmarried-frequency receivers get admission to the L1 frequency best, even as dual-frequency receivers get right of entry to each the L1 and the L2 frequencies, [5]. Another distinction is related to the technical of the channels multichannel receiver, sequential receiver and multiplexing receiver .In the end a classification is viable with admire to the user network, (e.g. Army receiver, civilian receiver, geodetic/ survey receiver and navigation receiver). The navigation receivers are the standard low-price the accuracy variety of up to ten m, while geodetic / survey receivers are high-cost the accuracy less than 1cm, [6].

4. Types of GPS survey methods

In general, can be divided survey methods into two main groups, static and kinematic survey methods, as classify in Figure-2

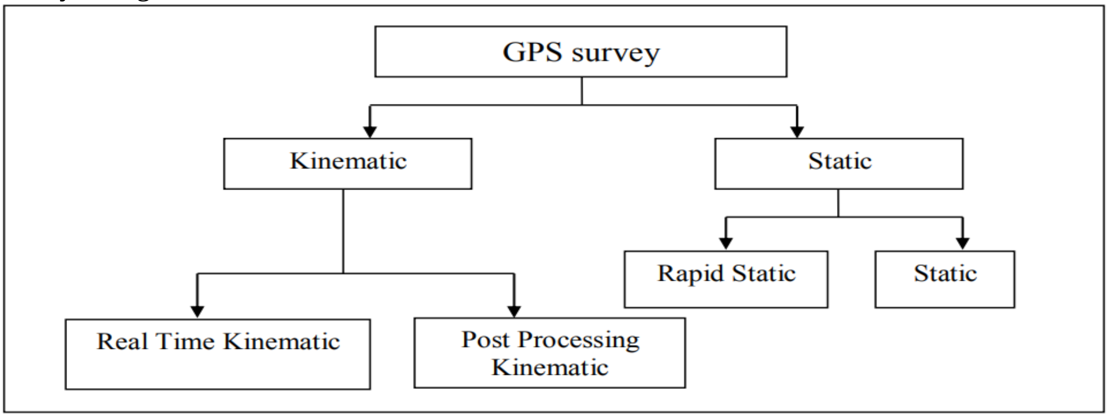

Figure 2-Types of DGPS surv

5. Real Time Kinematic Surveying

The RTK method uses and processes carrier phase observations for positioning, On the ground that provider section observations produce extra precise positions than code measurements, spatial positions obtained from RTK are of higher exceptional, with a precision so as of 1 cm, [7]. As it's far widely known, positioning detail factors and alertness works typically require a good deal time and effort. As a way to reap precise consequences from this approach at least 5 satellites need to be observed simultaneously, which may be taken into consideration because the simplest shortcoming, [6]. In RTK mode, one GPS receiver located on a station is kept static (reference station) all through the complete remark session, whilst the alternative receiver moves among rover station points whose spatial positions are to be determined. Reference receiver has a radio transmitter aimed to ship phase commentary corrections to rover receiver which is also prepared with radio modem to establish a hyperlink with the reference station, [8,9], shown in Figure-3 which illustrates a normal shape of RTK.

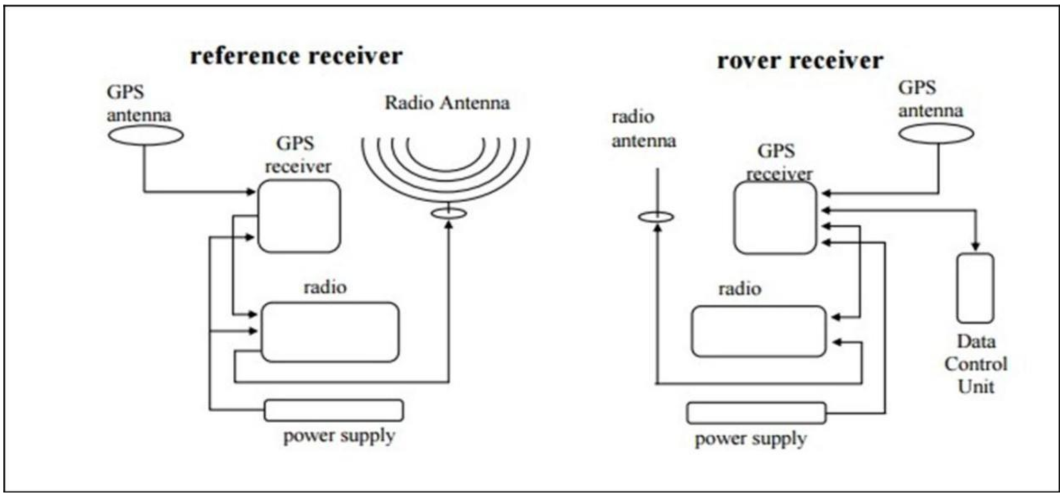

Figure 3-shape of the RTK, [7]

The radio modem used in this system differs from the ones used in GPS in that this radio modem has to update the correction information dispatched to a rover in 0.5-2 seconds, [7], [9]. As shown in the Figure-4 which illustrates the RTK-DGPS system.

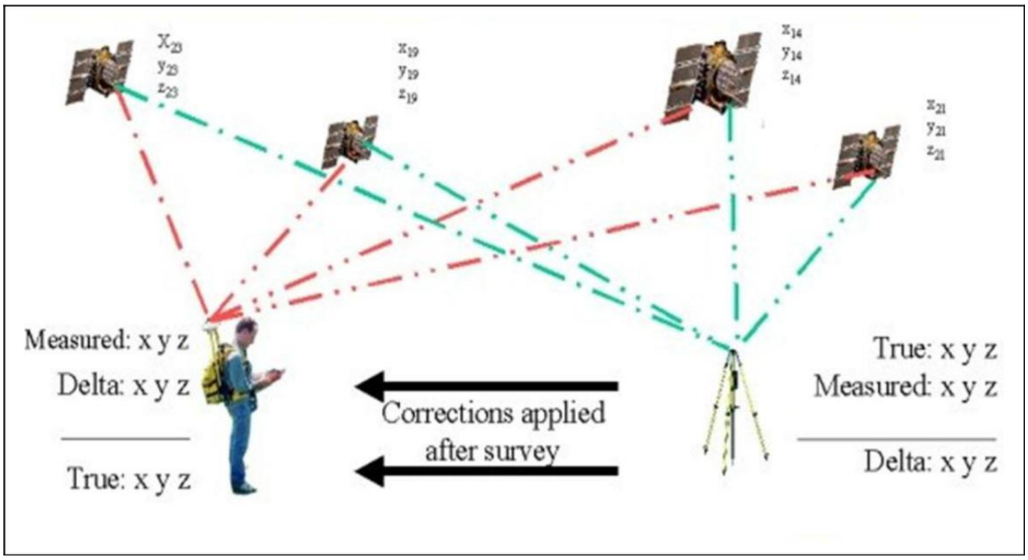

Figure 4-the RTK-DGPS System, [10]

6. The RTK, DGPS Field Work

Study region located in the middle of the Iraqi country (i.e. Baghdad University Compass), Longitude (33º 16' 55.6") to (33º 16' 4.5") N, Latitude (44º 22' 11.8") to (44º 23' 20.4") E. The major features in this area are buildings of different heights; representing the colleges and their departments, some green (bush) areas and trees. The major characteristics of the studied area are the systematic shapes of targets and noticed highness of many buildings. In all GPS application, the use of GPS it self yield many error in PWV due to the ground coordinates errors, for this reasons, we select the differential global positioning system DGPS Topcon Hyper-II belong to remote sensing unit to reduce the metrological errors as more as possible. Also, for this type of research, To ensure accuracy network of base stations must be constructed in the university then RTK mode used for points measurements within this network. So Points are few and clustered (more points should be taken with enough distance among them for accuracy comparison). The description of the four rover points is given in the Table- 1 as well as the coordinates of Base Point, Figure- 5 illustrate a satellite image for the base and four rover points in the Baghdad university camp / college of science buildings.

Table 1-The Rover Points Description and Coordinates of Base Point

Rover Points	
Points Description	Position No.
Above Computer Department, in front of the football stadium	1
Above Computer Department, in front of the woman's college of science	2
Above Geology Department, in front of the Computer Department	3
Above Physics Department, in front of the Chemistry Department	4

Figure 5-a Satellite Image for Base & Rover Points Locations

The Topcon Hyper-II receivers collect the position of rover point as (Lat. Long., degree) and the highest from the see level m. The data were rearranged according to the station position. The Base coordinate was pickup through duration of 3 hours in order to achieve high accuracy at 2-11-2016 Above Computer Department, Baghdad university camp. After 36 hours the base coordinates. Value has been corrected using the OPUS Online Positioning User Service. Values are constant for all positions, i.e. the highest of Base receiver and its projection to the ground was denoted, so this position was used for all Rover task. Only used rover points coordinates should be determined, (Above Computer Department, in front of the football stadium), Note, the duration of picking all Rover points is 60 second for all stations.

Table 2-the Base Point Coordinates

Base Point, Above Computer Department	
Date of Collection	2 Nov.
Duration of Collection	3 hr.
Easting, m	442239.179
Northing, m	3681735.544
Elevation, m	42.633

Table 3-Example of the Data of Station No. 1

Point	North (m)	East (m)	Elev. (m)	Date	Diff. North m	Diff. East m	Result Diff m
Rov1	3681754.9	442207.73	42.842	02-Nov	0.013	0.0328	0.0352823
Rov5	3681754.9	442207.68	42.833	03-Nov	0.02	0.0122	0.0234273
Rov9	3681754.9	442207.7	42.829	06-Nov	0.015	0.0088	0.0173908
Rov13	3681754.9	442207.65	42.834	08-Nov	0.039	0.0432	0.0582
Rov17	3681754.9	442207.69	42.837	10-Nov	0.008	0.0032	0.0086163
Rov21	3681754.9	442207.62	42.836	13-Nov	0.022	0.0752	0.078352
Rov25	3681754.9	442207.72	42.826	04-Dec	0.002	0.0228	0.0228876
Rov29	3681754.9	442207.72	42.827	06-Dec	0.037	0.0248	0.0445426
Rov33	3681754.9	442207.69	42.829	08-Dec	0.029	0.0052	0.0294625
Rov37	3681754.9	442207.62	42.826	13-Dec	0.011	0.0752	0.0760003
Rov41	3681754.9	442207.67	42.836	15-Dec	0.003	0.0202	0.0204216
Rov45	3681754.9	442207.71	42.83	17-Dec	0.015	0.0188	0.0240508

7. Accuracy Assessment

In order to test the accuracy of the coordinate's measurements, the user need to a reference source of coordinates system. The origin projection of the Topcon Hyper-II receivers is (Lat. Long., h), Datum WGS-84. For this small area of interest, the confident projection for this case is UTM, Datum WGS-84. The reference coordinate system is the Google Earth software, and by comparing the position of these buildings, the errors are of few millimeters.

8. Conclusion

The field of survey consists of one Main Basepoint and 4 rover points as measurement stations, the navigation days are 57 for all stations. The UTM coordinates values for each rover point are rearranged as the difference from the mean for East and North coordinates values. Therefore, the resultant variation is calculated using the Pythagoras formula

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