Accuracy Assessment for 3-D Target Coordinates Estimation Using GPS & Total Station

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Abstract

The Target coordinates estimation in the real world (3-D) was important applications in the geodesy and many remote sensing applications, for this purpose, the GPS/DGPS, and the Total Station were used to create and estimate the new target coordinate. In this paper, the Total Station Leica 1200 with Garmin navigator GPS were used to extract the 3-D coordinates of target from the measurement of TS position. For six point for one station. The Garmine GPS navigator was use to find the coordinates for each points and the total station position. Many mathematical process were used to evaluate the results of accuracy using written subroutines in Matlab (version 7.4.0 R 2007a) environmental.

Keyword: Atmospheric correction, the Total Station Leica 1200 ,GPS

تقييم دقة إيجاد إحداثيات هدف في الفضاء الثلاثي باستخدام نظام التموضع العالمي والمحطة المتكاملة

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الخلاصة

يعد إيجاد إحداثيات الأهداف في العالم الحقيقي (الفضاء الثلاثي) من التطبيقات المهمة للأغراض المساحية ونظم الاستشعار عن بعد، ويستخدم لهذا الغرض نظم التموضع العالمية سواء كانت الملاحية منها أو التفاضلية بالإضافة إلى المحطات المتكاملة. في هذا البحث تم استخدام المحطة المتكاملة من نوع TS1200 لاخذ القياس لستة نقاط في واحدة، استخدم جهاز التموضع من نوع Garmin لأجل إيجاد إحداثيات النقاط المقاسة بواسطة المحطة المتكاملة بالاضافة الى قياس إحداثيات موضع المحطة. لقد استخدمت بالبحث طرق رياضية متعددة لغرض استخراج قيمة الدقة واستخرجت النتائج من خلال برامج مكتوبة بلغة Matlab (version) 7.4.0 R 2007a.

1. Introduction

The Global Positioning System (GPS) navigation system positioning is one of the most popular topics in civilian applications. Normally, GPS can be used to collect the land use change information successfully and quickly. However, GPS doesn't work due to the overhead obstructions, such as in urban areas or under trees. Then, all conventional terrestrial survey methods, such as total station (TS), can be used to aid GPS Since the collected land use change information using either GPS or total station system will be entered to an existed land management system. Hence, the land use change styles of the interested region could be classified into a certain number of groups from the point view of Geographic Information System (GIS). In order to reduce the field surveying works of GPS and/or (TS), it is necessary to design an optimized and effective field surveying procedure by means of analyzing the land use change styles and environmental characteristics of the interested region.**[1] [2].**

2.The Devices Used

The Etrex vista Garmin Navigator GPS and Total Station Leica TPS1200 have been used in order to extract the coordinates of targets. The GPS was used to navigate the total station coordinates as well as the measured point in the TS, where the TS used to estimate the target (reflector) coordinates. Tables 1 and 2, figures 2 and 3 shown the devises used and their specifications.

Figure 1- The Etrex Vista GarmiNavigator GPS

Figure 2- The Leica Total Station TPS120

3. Region of Interest

Study area located in the middle of Iraqi country (i.e. Baghdad University Compass), Latitude (33º 16' 55.6") to (33º 16' 4.5") N, Longitude (44º 22' 11.8") to (44º 23' 20.4") E. The project site is Deanery College of science, The area of the site is 52m wide, 100m long and 8.71height, The test site's scene is pictured with a digital camera in Figure (3)

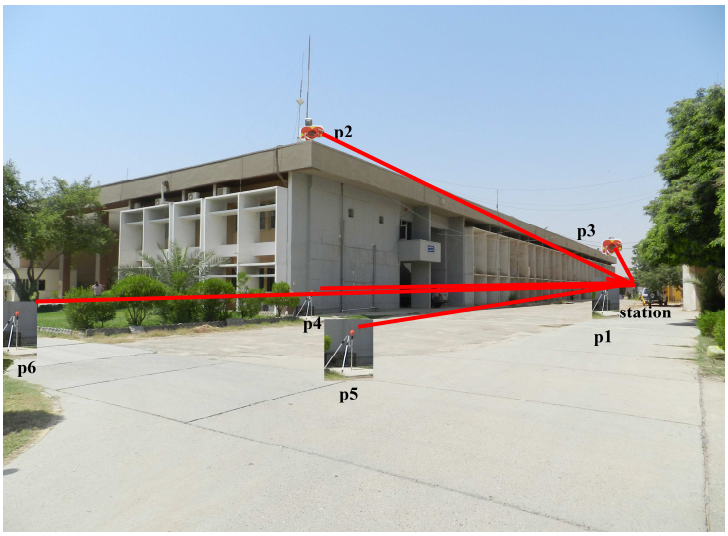

Figure 3- Station-1 Location

Table 1- Specifications of the Etrex Vista Garmin Navigator GPS, [3]

Accuracy	(about 15 to 100m).
Unit dimensions, WxHxD:	2.0" x 4.4" x 1.2" (5.1 x 11.2 x 3.0 cm)
Display size, WxH:	1.1" x 2.1" (2.8 x 5.4 cm)
Display resolution, WxH:	160 x 288 pixels
Display type:	4 level gray LCD
Weight:	5.3 oz (150 g) with batteries
Battery:	2 AA batteries (not included)
Battery life:	12 hours

Table 2- Specifications Of The Total Station Leica TPS1200, [4]

1.Angle Measurement	
Accuracy Hz, V	1''
Display resolution (standard deviation, ISO 17123-3):	0.1'' (0.1 mgon)
Compensator Working range	4' (0.07 gon)
Setting accuracy	0.5'' (0.2 mgon)
2.Distance Measurement (average atmospheric conditions)	
Range Round prism (GPR1):	3000m
Range 360° reflector (GRZ4):	1500m
Range Mini prism (GMP101)	1200 m
Shortest measurable distance	1.5 m
Measurement Time	~ 1.5 s
Accuracy	1 mm+1ppm
3.Telescope	
Magnification	30 x
Free objective aperture	40 mm
Field of view	1°30' (1.66 gon) / 2.7 m at 100 m

4. Result And Discussion

In this paper the Total Station and GPS were used to estimate the coordinates system for a one station, the station consist of 6 measurements points. The table and figure represent the station 1 measurements and the figure. The TS1 m column represents the estimated coordinates (UTM projection, WGS-84 Datum) by TS for each reflector point in the station. The GPS m column represents the navigated coordinates by the GPS in the reflector position. The accuracy m column represents the GPS accuracy at that point during the navigation. The Sat. No. column represents the number of captured satellite at that point. Finally, the last column show the point height in m.

Station -1 Specification

Data: 3-6-2011
Height T.S. 1.30 m
Height ref. 1.30 m
on deanery h. ref. 0.00 m
height of denary 8.71m
9.51am
The station corr. E=0442270 m , N=3681777 m
H=33.24 m, A=6 m, Number of sat=5,

Table 3- The Coordinates Of TS And GPS For Station 1

N0.		TS1 m		GPS m	Accuracy m	Sat. No.	Height m	
1	E	0442289.575	E	0442268	7	5	33.24	E
	N	3681934.203	N	3681901				N
	h	33.796	h	33.24				h
2	E	442299.267	E	0442302.3	5	6	42.41	E
	N	3681921.486	N	3681900.75				N
	h	42.714	h	42.41				h
3	E	0442201.112	E	442206.63	5	5	41.95	E
	N	3681940.524	N	3681910.89				N
	h	42.280	h	41.95				h
4	E	0442276.457	E	0442303	7	4	33.24	E
	N	3681905.008	N	3681888				N
	h	33.835	h	33.24				h
5	E	0442291.039	E	0442312	5	4	33.24	E
	N	3681900.587	N	3681883				N
	h	33.861	h	33.24				h
6	E	0442283.471	E	0442317	4	5	33.24	E
	N	3681892.592	N	3681869				N
	h	33.820	h	33.24				h

A subroutines written in matlab used to correct the measurements from atmospheric errors according to Leica Geosystems correction tools for infrared total station given as, **[5]**,

$$\Delta D = 283.04 - \left[\frac{0.29195 * P}{(1+\alpha-t)} - \frac{4.126*10^{-4} * H}{(1+\alpha-t)} * 10^{x} \right] (1)$$

Where;
ΔD = atmospheric correction [ppm] for each km
p = air pressure [mbar]
t = air temperature [°C]
H = relative humidity [%]
α = 1 / 273.16

$$x = \frac{7.5 * t}{237.3 + t} + 0.7857 \quad (2)$$

Table 4, represents the weathering condition at the data of measurements,

Table 4- The Weathering Parameters at Date of Measurements For Station -1

Max tem. C°	Min tem. C°	Pressure mbs	Relativity humidity
40	22	500	35-40

According to available parameters and from applying equations 1 and 2, the weathering correction value ΔD= 21.681 m within the 1 km. Calculate the coordinates measurements difference between the TS1 and GPS values with out correction. The difference values for each point given the table (5).

Table 5- The Difference Values For Station -1

No.	Δ E, m	Δ N, m	Δ h, m
1	21.5750	33.2030	0.5560
2	3.0330	20.7360	0.3040
3	5.5180	29.6340	0.3300
4	26.5430	17.0080	0.5950
5	20.9610	17.5870	0.6210
6	33.5290	23.5920	0.5800

After applying the atmospheric correction to difference results the values for Δ E, and Δ N, can be given in table (6), note that the value of Δ h dose not corrected because the navigator measurements for h was already high error. The distance between points and TS were ranged (110-184 m), so, the correction value can be given as 3.142455.

Table 6- The Difference Values After Atmospherics Correction For Station -1

No.	**Δ E, m**	**Δ N, m**	**Δ h, m**
1	18.43255	30.06055	0.556
2	-0.10946	17.59355	0.304
3	2.375545	26.49155	0.33
4	23.40055	13.86555	0.595
5	17.81855	14.44455	0.6210
6	30.38655	20.44955	0.58

From table 6, the error in Northing coordinates was greater than the error in the Easting direction. This was due to the GPS navigation errors which was out of scope of this paper. The average error in Easting direction was 15.3840475 m. The error value was not small this was due to many factors influencing the measurements.

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