Using a weighted least squares method to estimate of optimum observation for GPS

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Abstract

There are many errors in GPS such as ionosphere effects which represents as atmospheric effects, multi path, satellite geometry, satellite and receiver clock errors and human error…etc. Therefore, to estimate of an error of GPS or adjust observation is to repeat observation or use the method of least squares to get optimum observation or best estimate. For this purpose, ten observations for one point or of the same point at the University of Baghdad near by the Department of Astronomy using the Garmine GPS navigator, (UTM projection, WGS-84 Datum) has shown an accuracy of (15-100) m [1]. Many mathematical processes were used to estimate results written by MATLAB language. In this paper the error was 3854m^2 for easting direction, 4496 m^2 for northing direction.

Keywords: GPS, least squares method.

استخدام طريقة المربعات الأقل لتخمين خطأ نظام التموضع العالمي GPS

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الخلاصة

هناك العديد من الأخطاء في نظام التموضع العالمي مثل تأثيرات ايونسفير التي تتمثل بتأثير الاتموسفير ، تعدد المسار،هندسة الأقمار و أخطاء ساعة القمر و المستلم وكذلك أخطاء الإنسان... الخ . لذلك نستخدم تكرار الرصد أو نستخدم طريقة المربعات الاقل لتخمين خطأ نظام التموضع العالمي أو تعديل الرصد لنحصل على الرصد الأمثل. وقد استخدمت عشر رصدات لنقطة واحدة في حرم جامعة بغداد قرب قسم الفلك باستخدام كارمن الملاحي ، استخدام لغة الماتلاب في كتابة العديد من العمليات الرياضية التي استخدمت في البحث لحساب النتائج، وتم تقدير الخطأ تقريبا ب (3854 م^2) باتجاه الشرق وب(4496 م ^{2}) باتجاه الشمال.

الكلمات المفتاحية: GPS، طريقة المربعات الاقل.

1. Introduction

In this study the weighted least squares method (WLSM) has been used to test ten observations using the Garmine GPS navigator for the same points by repeating of observation to get optimum observation. Where weights ware accuracy of the Garmine GPS navigator by different times, the **WLSM** gives best results by selecting the best real observation, and then minimum error gives the best approximation observation. This means the data or ground points in one observation is better than the other.

2. Material and Method

Position of the sites was determined using a handheld Global Positioning System (GPS). The Etrex vista Garmin Navigator has accuracy of 15 m to 100 m as shown in Fig1.The GPS was used to navigate points by to repeating observations.

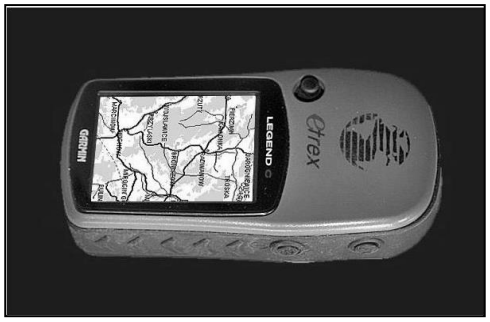

Fig.1 Global Positioning System

Accuracy	15 m to 100 m
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

Table1 specifications of GPS [1]

The **WLSM**, Involves the following steps;

Step1: Number of observation is represented**,** as $z_1, z_2, \ldots\ldots, z_n$

Where n is no. of times of observation.

Step2: extract of residuals values i.e.:$v_1=z_1-z_2, v_2=z_1-z_2, v_3=z_1-z_3$. ……..(1) [3]

The same with of residuals values for other observations.

Step3: Appling the following equation;

$\emptyset = v1^2w1 + v2^2w2 + \cdots + vn^2wn = minimum$…… (2)

Where w: represents a weight or accuracy of GPS.

Stepe4: according to equation (2) if Φ minimize for easting or northing from other observations, easting or northing direction is optimum, see tables 2 and 3. [4].

3. Result

Table 2 and Table 3 show ten observations for the same point by the Garmine GPS navigator,

No. of observations for same point	Easting\ m	Accuracy\m	Error of Easting direction
1at 8.30 pm	0442263	12	20156
2 at 9 pm	0442270	9	759 8
3 at 9.30 pm	0442276	5	3854
4 at 10 pm	0442277	10	3860
5 at 10.30 pm	0442276	7	3854
6 at 11 pm	0442275	4	4028
7 at 11.30 pm	0442279	8	4412
8 at 12 pm	0442282	12	6590
9 at 12.30 am	0442283	12	7676
10 at 1 am	0442282	11	6590

TABLE2 Number of observation for GPS with error of Easting direction

No. of observations for the same point	Northing \m	Accuracy\ m	Error of Northing direction
1at 8.30 pm	3681945	12	18874
2 at 9 pm	3681941	9	11210
3 at 9.30 pm	3681932	5	4496
4 at 10pm	3681936	10	5680
5 at 10.30 pm	3681933	7	4522
6 at 11 pm	3681930	4	4984
7 at 11.30pm	3681929	8	5498
8 at 12 pm	3681928	12	6192
9 at 12.30 am	3681925	12	9354
10 at 1 am	3681924	11	10768

TABLE3 Number of observation for GPS with error of Northing direction

The first column represents no. of observations for the same point, the Easting\m and Northing \m column represents the estimated coordinates (UTM projection, WGS-84 Datum) by GPS. The accuracy m column represents the GPS accuracy at that point during the navigation process**;** error of Easting and Northing direction column represents according to applying equation (2). The ground control points (GCP_s) or no. of observation for same points is illustrated in Figure2.

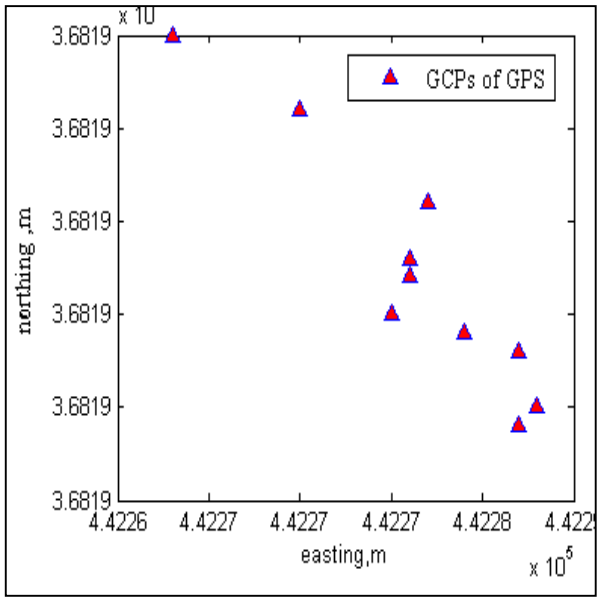

Fig.2 No. of observation for the same points of Garmine GPS navigator

According to step4 the results written in ***MATLAB*** is shown in Table4 below:

Error of Easting direction	3854	0442276 optimum
Error of Northing direction	4496	3681932 optimum

Table4 Error value and optimum observation for easting and northing direction

The statistical data for no. of observation of points are shown in Table 5.

	x	y
Mean	442280	3681900
Standard deviation	6.907	7.576
Variation	47.714	57.410
Minimum	442283	3681924
Maximum	442263	3681945

Table 5 No. of observation for the same points

4. Conclusion

According to Table (2) and Table (3), the error of observation for easting direction (0442276 m) and northing direction (3681932 m) by using equation(2) is lesser than the other error of observation for easting direction and northing direction; then minimizing error(Φ) gives the best approximation of easting and northing direction.

5. REFERENCES

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