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Software Testing of GPS Data Processing

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Abstract— There are different softwares for GPS data processing. Every manufactures of GPS receivers produce their own software for processing the observed field data in order to obtain adjusted results. In most cases these softwares are protected or secured so it cannot be used to process data of other instrument. This research work is oriented to try to get rid of these softwares recommended by GPS receivers manufactures. In this research, the data, which was collected using Leica GPS system 500, were processed using three different softwares: SKI Pro, Trimble Geomatics office (TGO) and Topcon link. The work comprises data entry, adjustment, and processing to produce the required adjusted coordinates. From this research work it can be concluded with that, the observed GPS data can be successfully processed utilizing different software's rather than that recommended by the company.

IndexTerms— GPS, Software, Testing and Processing

I. INTRODUCTION

THE global positioning system (GPS) was developed by the US Department of Defense (DoD) as a navigation system. The first satellite to support the development and testing of the system was placed in orbit in 1978 and fully operated in December 1993 [2]. This system is basically consists of three main components; (i) Space segment; (ii) Control segment; and (iii) User segment.

A. The Space Segment

Consists of 24 satellites operating in 6 orbital planes spaced at 60° interval around the equator. Four additional satellites are held in reserve as spares. The satellites travel in near-circular orbits that have a mean altitude of 20,200km above the earth and an orbital period of 12 sidereal hours. Precise atomic clocks are used in the GPS satellites to control the timing of the signal they transmit.

B. The Control Segment

Consists of five monitoring ground stations at which the signals from the satellites are monitored and their orbits tracked. The tracking information is relayed to the master control station in Colorado Springs. The master control station uses this data to make precise near future predictions of the satellite orbits, and their clock correction parameters.

C. The User Segment

Consists of two categories receivers that are classified by their access to two services that the system provides; The Standard Positioning Service (SPS): Provided on the L1 broadcast frequency at no cost to the user. The Precise Positioning Service (PPS): is broadcast on both L1 and L2 and is only available to receivers having valid cryptographic keys.

II. THE GPS SIGNALS

The GPS satellites continually broadcast a unique signal on two carrier frequencies on a number of different frequencies. But instead of having only one message on one frequency, a number of different messages can be carried on one frequency at the same time.

The carriers, which are transmitted in the L band of microwave radio frequencies, are identified as the L_1 signal with frequency of 1575.42MHz and the L_2 signal at frequency of 1227.60MHz. The L_1 band has frequency of $154 \times f_0$, and L_2 band has a frequency of $120 \times f_0$.

In order for receiver to determine the ground position of the station they occupy. It was necessary to devise a system for accurate measurement of signal travel time from satellite to receiver. This was accomplished with modulating the carrier with *Pseudo Random noise* (PRN) code [5].

Each satellite transmits two different PRN codes. These are: (i) Coarse/Acquisition code or (C/A) code has a frequency of 1.023MHz and a wavelength of 300m. It is accessible to all users.(ii) Precise code or P code has a frequency 10.23MHz and a wavelength of 30m can only be read with receivers that have the proper cryptographic keys. The L_1 signal is modulated with P-code and C/A code, while L_2 is modulated only with P-code.

Navigation message is carried by both L_1 and L_2 frequencies and basically carry information about satellite position and its working status (healthy).

III. FUNDAMENTALS OF GPS POSITIONING

GPS receiver compute distances to four satellites and fixes a position by trilateration [1]. Two fundamental methods are employed by the GPS receivers to determine distances to satellites: *code range* and *carrier phase-shift* measurements.

A. Code Ranging

The distance (R) (known as a *Pseudo Range*) is simply determined by multiplying the speed of light (c) by the time (t), ($R=c \times t$). From the travel time, and the known signal velocity, the distance to the satellite can be computed.

B. Carrier Phase-Shift Measurements

Better accuracy in measuring rang to satellites can be obtained by observing phase shift in GPS signals. In this approach, the phase shift in the signal that occurs from the instant it is transmitted by the satellite, until it received at the ground station, is observed. This procedure yields the fractional cycle of the signal from satellite to receiver. However, it doesn't account for the number of full wavelengths or cycles that occurred as the signal traveled between the satellite and the receiver. This number is called the *integer ambiguity* (N) or simply *ambiguity*.

The total distance can be computed by the summation of the phase measurement, initial ambiguity at first observation, and number of full cycles counted by receiver.

IV. ERROR IN GPS OBSERVATION

Electromagnetic waves can be affected by several sources of error during their transmission. These errors may include:

1. Satellite and receiver clock biases,
2. Ionospheric and tropospheric refraction,
3. Satellite ephemeris errors (orbit errors),
4. Multipathing,
5. Instrument miscentring,
6. Antenna height measurements,
7. Satellite geometry, (Dilution of Precision DOPs) and
8. Selective availability (before May 2000).

V. MEASUREMENTS

In this research work observations of fives points were carried out, in khour-aboanga area in omdurman town, using Leica GPS system 500. One of these points was taken to be a control station and the other four were used as check points. Two GPS receivers of Leica GPS system 500 were used to collect the field data. One of the receivers was use as a reference that located at the control point, while the other receiver was used as a rover that traveling between the other points.

VI. DATA PROCESSING

The observed data was then processed using three different type of software's. (i) Ski-pro; (ii) Trimble Geomatics Office (TGO); and (iii) Topcon Link.

A. Data Processing using SKI-PRO Software

Leica's SKI-Pro software is a comprehensive, automated suite of programs for GPS surveying including post-processing and support of real-time measurements.

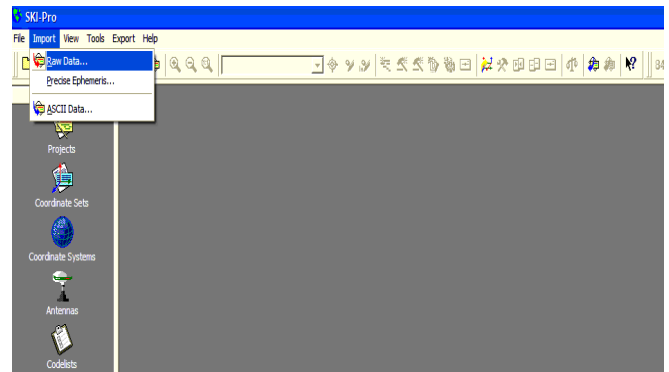


Fig. 1. Importing of data

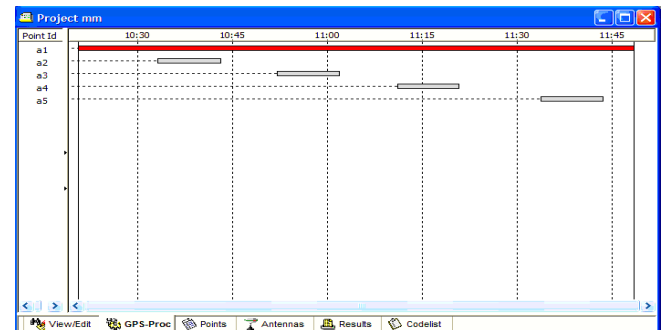


Fig. 2. Horizontal bar of reference point

Point Id	Epoch	Stored Status	Ambiguity Status	Latitude	Longitude	Height
a2	04/27/2009 10:33:10	no	yes	15° 33' 39.94171" N	32° 32' 22.59831" E	382.5029
a3	04/27/2009 10:52:00	no	yes	15° 33' 39.64425" N	32° 32' 20.30735" E	383.1761
a4	04/27/2009 11:11:00	no	yes	15° 33' 39.49732" N	32° 32' 18.11367" E	382.8286
a5	04/27/2009 11:33:40	no	no	15° 33' 42.33987" N	32° 32' 18.13848" E	383.1911

Fig. 3. Geographic coordinates

After the connection of the software protection dongle, the data processing can be done throughout the following step:

1. The SKI-Pro started up and Import Raw data was selected. After switch the import data dialog was opened as shown in fig. 1.

2. Create new project and import the raw data.

3. Processing baselines after selection of the reference point as shown in fig. 2.

4. After the processing run was completed the display will automatically switch to the results and the final adjusted coordinate can be presented as a geographic coordinate by selecting the geographic coordinate icon on the upper right side of the menu, as shown in fig. 3.

B. Data Processing using TGO Software

Trimble Geomatics Office software is a comprehensive, automated suite of programs for GPS surveying including post-processing and support of real-time measurements.

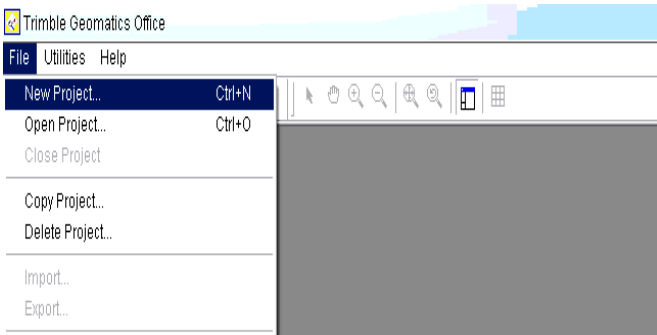


Fig. 4. Open new project

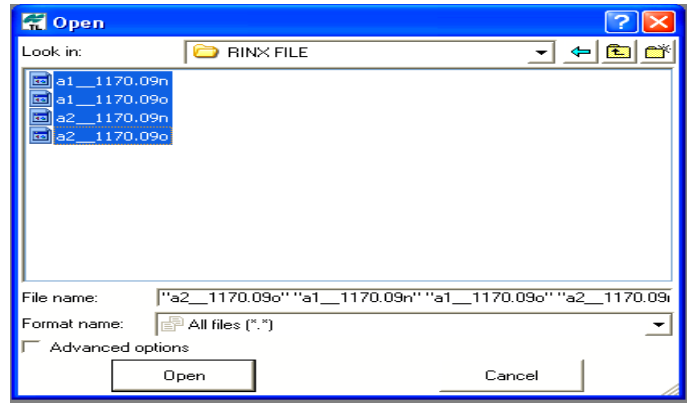


Fig. 6. Open RINX data file

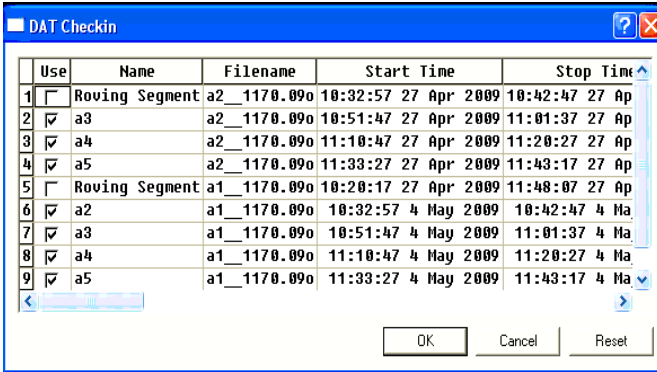


Fig. 5. Data checking dialog.

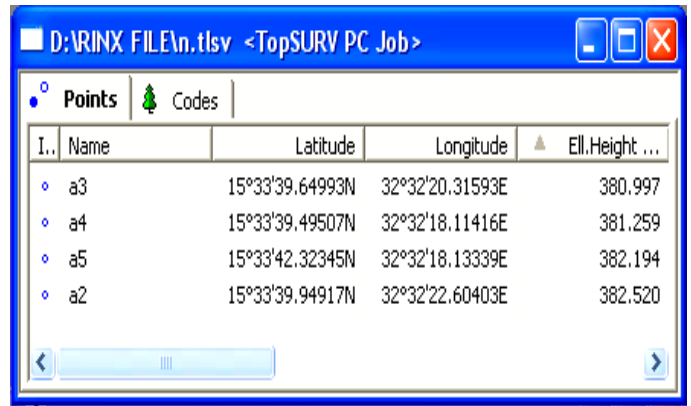


Fig. 7. Adjusted coordinates

Number of Points : 4
 Number of Constrained Points : 0

Adjusted Grid Coordinates

Errors are reported using 1.96σ.

Point Name	Northing	N error	Easting	E error	Elevation	e error	Fix
a1	1720533.828m	0.003m	450614.167m	0.002m	N/A	N/A	
a3	1720431.335m	0.004m	450567.415m	0.004m	N/A	N/A	
a4	1720426.968m	0.004m	450502.070m	0.004m	N/A	N/A	
a5	1720514.328m	0.007m	450502.745m	0.006m	N/A	N/A	

Adjusted Geodetic Coordinates

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
a1	15°33'42.98314"N	0.003m	32°32'21.86954"E	0.002m	382.624m	0.007m	
a3	15°33'39.64416"N	0.004m	32°32'20.30730"E	0.004m	383.166m	0.013m	
a4	15°33'39.49744"N	0.004m	32°32'18.11370"E	0.004m	382.860m	0.011m	
a5	15°33'42.34069"N	0.007m	32°32'18.13002"E	0.006m	382.814m	0.016m	

Fig. 5. Network adjustment report

The field data was processed using TGO software's through the following steps:

1. Creating a project using the project data (master) as shown in fig. 4.
 1. Importing of data files
 2. Processing GPS baselines
 3. Performing a network adjustment.

Initially, the status bar in the bottom left corner of the dialog shows the files being loaded for processing. When the actual processing begins, the status bar shows the form and to stations and results was added to the table as they are completed. The processor then continued with the next baseline until all processing was completed.

Finally adjustment report appeared, as shown fig. 5.

C. Data Processing using TOPCON Software

Topcon software is a comprehensive, automated suite of programs for GPS surveying including post-processing and support of real-time measurements.

In this software it is possible to accept RINX data file. It does not need a connection dongle with the software.

The following steps demonstrate the method that was applied to process GPS data:

The RINX data file was entered as shown in fig. 6.

1. All points were appeared on the screen after selecting all open clicked.
2. For the completion of the data processing, it has to convert RINX file to TOPSURV file by select convert file on the file in the main Toolbar.

For data processing, the word process was pressed in the main tools bar, a menu bar was display. Then compute coordinate was clicked as shown in fig.7.

VII. RESULTS

By referring to the results of the three tests carried out utilizing the three software Ski pro, Trimble Geomatics Office (TGO) and Topcon. The adjusted coordinate of points can be represented as in Table 1.

Table 1: The adjusted coordinate of points

POINT	SOFTWARE	EASTING	NORTHING
a1	SKI PRO.	450614.15	1720533.82
	TGO	450614.15	1720533.82
	TOPCON	450614.15	1720533.82
a2	SKI PRO.	450635.66	1720440.34
	TGO	Fail	Fail
	TOPCON	450635.84	1720440.55
a3	SKI PRO.	450567.41	1720431.33
	TGO	450567.41	1720431.33
	TOPCON	450567.65	1720431.48
a4	SKI PRO.	450502.08	1720426.95
	TGO	450502.08	1720426.95
	TOPCON	450502.08	1720426.89
a5	SKI PRO.	450502.98	1720514.28
	TGO	450502.74	1720514.34
	TOPCON	450502.83	1720513.78

Table 2: Software Comparison

COMPARISON	SKI-PRO	TGO	TOPCON
Speed	Fast	Fast	Very Fast Available
Availability	Not available	Available	
Security	Secured	Not secured	Not secured
Processing Steps	Easy	Complicate	Very easy
The data file used	RINX-File	RINX or DAT File	RINX or Topsurv-File
The data processing	Process all observation methods	Only Process Observation of base line	Process all observation methods
The type of coordinates	1.Geographic (ϕ, λ, h) 2.Cartizian (X, Y, Z) 3.Gridian (E, N, H)	1.Geographic 2.Gridian	1.Geographic

VIII. CONCLUSIONS

Capability and readability of particular GPS software to compute GPS data provided by any type of GPS receiver is one of the problems facing survey engineers. This is so because it through to be that GPS data is only combatable with the recommended software develop by the special company. Moreover some manufacture secure their software by protection dongle key, therefore data cannot be processed without connection of that dongle.

This research work tried to test the capability of different software's to process GPS data observed using any GPS receiver. Also the research examine the obtain results of the same data processed by different type of software.

By referring to the results obtained it could be concluded with the following:

1. The same GPS data can be successfully processed using any available software.
2. The same results of the same data can be obtain using any GPS software regardless of either it recommended by manufacture or not.
3. Processing steps procedures were identical in most software including creating new project, importing data, manipulation, processing and report of information produced.
4. Data in RINX-File format is readable for all GPS processing software.
5. The SKI-Pro. Software provides high speed of data processing compared with other tested software's.
6. The Trimble Geomatics Office software process data only when a baseline is established.
7. RINX-File data has to be converted to TOPSURV-File before processing.
8. A comparative results between the different software can be shown on table () bellow from which it can be noted that TGOoffice software provided better further advantages compared with the other softwares.

RECOMMENDATIONS

This research work is oriented to examine the compatibility of different software to process the GPS field data taking the same data and does not cover all available software's; therefore it can be recommended for further work to:

1. Increasing the area of the work by making additional tests for all available software in the market.
2. Developing independent software to get free of the secured, constraint and expensive software.

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