ASSESSMENT OF LOW-COST GARMIN OEM GPS RECEIVER FOR SURVEYING APPLICATIONS

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ABSTRACT

The low-cost Garmin GPS product line has been widely used for recreational activities and low-accuracy navigation. This article examines the potential use of a Garmin OEM receiver, GPS 25-HVS, in Geomatics applications. Several static sessions were carried out in the Istanbul Technical University Ayazaga campus, Turkey, to examine the accuracy of the proposed system as a function of occupation time, baseline length, and antenna configuration in differential mode. Collected data were processed by scientific and commercial GPS software packages, namely Bernese GPS Software Version 5.0 and Leica's SKI-Pro software. It is shown that the system can achieve a positioning accuracy in the order of one decimetre or better for short baselines. The same accuracy level was achieved when a relatively longer baseline of 51 km was processed with the Bernese software. This, however, required a relatively longer occupational time. Such initial results are encouraging, as they meet the required accuracy for a number of surveying and GIS tasks while reducing the cost dramatically.

1. INTRODUCTION

GPS has been used in a wide range of applications that require different accuracy and reliability levels. As a result of the improvements in GPS positioning techniques over the last two decades, positioning accuracy in the order of a few centimetres can now be routinely achieved. This, however, requires the availability of expensive geodetic-grade GPS receivers, which are available at about $5,000 and $15,000 for single and dual-frequency units, respectively. More recently, a number of researchers have investigated the potential use of low-cost (less than $1,000) single frequency receivers, with carrier phase capability, in geodetic applications. For example, Masella et al. (1997), Rizos et al. (1998), Masella (1999), Alkan et al. (2005), Söderholm (2005), Saeki and Hori (2006) investigated the performance of low-cost systems in static and/or kinematic modes. They obtained a differential positioning accuracy in the range of 1.5 m (for a 20 km baseline) to a few centimetres in the post-processing mode. The use of the low-cost system in the RTK mode was also investigated by Masella et al. (1997), Masella (1999) and Saeki and Hori (2006).

This paper examines the potential use of a low-cost system, namely Garmin GPS 25-HVS series OEM GPS sensor board, for surveying applications. Such a receiver board is available for a few hundred dollars. The Garmin GPS 25-HVS is a single-frequency receiver, which outputs raw pseudorange and carrier-phase data in the Garmin proprietary format. A series of static tests were carried out to assess the performance of the low-cost system. Various baseline lengths (from approximately 152 m to 51 km) and occupation times (from 30 minutes to 3 hours) were used in the field trials. Collected data were first converted to RINEX format using a computer program developed for this purpose and then processed by both the Bernese scientific GPS software and the SKI-Pro commercial software. It is shown that positioning accuracy at the decimetre-to centimetre-level is possible with such a low-cost system, which meets the requirements of a number of surveying and GIS tasks.

2. SYSTEM DESCRIPTION

The Garmin GPS 25-HVS series OEM GPS sensor board was selected as a low-cost GPS receiver. This single-frequency receiver is a differential-ready 12 parallel-channel receiver, which tracks and uses up to twelve satellites with a default data rate of 1 Hz (programmable from 1 second to 15 minutes). The GPS 25 series offers a compact profile that includes some features such as position, velocity, and time, receiver and satellite status, pulse per second (PPS) timing output, differential GPS capability and raw measurement output for both pseudorange and phase data (i.e. code and carrier phase on L1). The size of the receiver is 46.5 mm x 69.9 mm x 11.4 mm and weighs about 38 grams. More details about its usage and specifications can be found in Garmin (2000). Figure 1 shows the low-cost Garmin OEM GPS receiver.

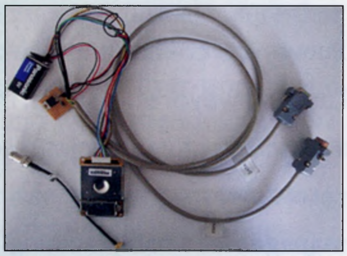

Figure 1. Low-Cost Garmin OEM GPS Receiver.

The Garmin GPS 25 receiver can output raw data through RS 232 serial interface and should be connected to a data logger, a laptop for example. The receiver board has two serial data output ports, one of which provides phase data output while the other normally provides positioning and other information in the NMEA 0183 format. DOS-based Garmin software was used to receive, display and log the raw data (both pseudorange and carrier phase). The program also performs almanac, position and time information upload as well as almanac and ephemeris information download. The system was designed so that the receiver can be used with either low-cost navigational or geodetic GPS antennas. Collected GPS data sets in the Garmin proprietary format were converted to standard RINEX format, which can be imported and processed by the Bernese and SKI-Pro software packages. For this purpose, a RINEX conversion software named GARRIN was developed for the project. This software is running on a Windows-based PC and converts the collected data into a RINEX observation file.

3. STATIC BASELINE TESTS

A series of tests were carried out using geodetic single and dual antennas in order to evaluate the performance of the constituted OEM type GPS receiver on the Ayazaga campus of Istanbul Technical University (ITU) in August 2005, February 2006 and March 2006 in the static mode. One of the International GNSS Service (IGS) stations, TUBI, and one of the continuously operating reference stations, KANT, were used as reference stations. In addition, one of the Ayazaga campus control points was used as a reference point to form a very short baseline of about 152 meters.

For the first and third field trials, Leica GPS System 300 dual-frequency geodetic and Garmin OEM type GPS receivers were connected to a Leica geodetic dual frequency GPS antenna via an antenna splitter. In the second field trial, an Ashtech Z-Xtreme geodetic receiver and Garmin receiver were connected to an Ashtech single frequency GPS antenna via an antenna splitter. In this way, GPS data were collected by the OEM and geodetic receivers under the same conditions, which allows for precise assessment of the low-cost system. Some information about the field trials, including the names of reference and rover stations, approximate occupation times and baseline lengths are summarized in Table 1.

Table 1. Some information about the field trials.

	Reference Station Name	Rover Station Name	Baseline Length	Occupation Time	Data Rate
Trial-1	TUBI KANDILLI (KANT) ITU-1	ITU-2 (OEM)	50.7 km 6.0 km 152 m	42 min. 42 min. 30 min.	1 Hz
Trial-2 ***(Part 1)***	TUBI KANDILLI (KANT)	ITU-1 (OEM)	50.7 km 6.0 km	120 min. 120 min.	1 Hz
Trial-2 ***(Part 2)***	TUBI KANDILLI (KANT)	ITU-1 (OEM)	50.7 km 6.0 km	53 min. 53 min.	1 Hz
Trial-3	TUBI KANDILLI (KANT)	ITU-1 (OEM)	50.7 km 6.0 km	180 min. 180 min.	1 Hz

4. DATA PROCESSING AND ANALYSIS

All the collected data were transferred to standard RINEX format using the developed GARRIN software and then imported to the Bernese and SKI-Pro software packages for processing. All of the baselines given in Table 1 were processed.

BERNESE GPS software: Data were first pre-processed to detect and repair cycle slips (information on how this is handled within the Bernese software can be found in Hugentobler et al., 2006). Unfortunately, because of the way the Garmin GPS 25-HVS receiver handles the GPS signal internally, the initial phase measurement might have a half cycle ambiguity (Williams, 2006). This means that the initial ambiguity parameters will not, in general, be integer numbers. Instead they will be, in general, multiples of half cycles. In addition, if a cycle slip occurs, then the process is repeated and the half cycle ambiguity will, in general, occur (Williams, 2006). To deal with this problem, half cycle-slip detection was carried out within the Bernese software by making some minor modification to the single difference observation files.

After pre-processing, cleaned data sets were processed using the Bernese main parameter estimation program, GPSEST. To ensure high accuracy, pole data and precise IGS orbits were used. Tropospheric path delay was modelled using the Saastamoinen tropospheric model while ionospheric delay was accounted for using a global ionospheric model. All necessary files were downloaded from the Astronomical Institute University of Bern (AIUB) and IGS ftp servers. As stated above, because of the expected occurrence of half cycle ambiguity in the Garmin phase data, only the float solution was used in the estimation of the final station coordinates for all the points occupied by the OEM receivers.

SKI-Pro GPS software: All baselines were processed again with SKI-Pro software. Similar to the Bernese processing, precise orbits were used. In addition, the Saastamoinen and the global ionospheric models were used to account for the tropospheric and ionospheric delays, respectively. Similar to the Bernese solution, the coordinates of the OEM receiver were estimated with a float ambiguity solution.

The final coordinates obtained with both the Bernese and SKI-Pro baseline solutions were compared to their known values. Differences in the latitude, longitude and ellipsoidal height components are shown in Figure 2 for the three field trials. As can be seen from Figure 2, positioning accuracy at the few centimetre-level is possible with the Bernese software package, even for the 51 km baseline. This, however, requires a relatively longer occupation time to allow for the remaining residual errors to average out. This is especially true for the long baselines. In general, all horizontal component errors were less than one decimetre. The only exception was the case of a 51 km baseline with 42-minute occupation time, which had a horizontal error of 14 cm. The same baseline (with the same occupation time) experienced a maximum error of 18 cm on the height component when the Bernese software was used.

The results obtained with the SKI-Pro software were comparable to those obtained with the Bernese software for the short baselines. In contrast, the results for the 51 km

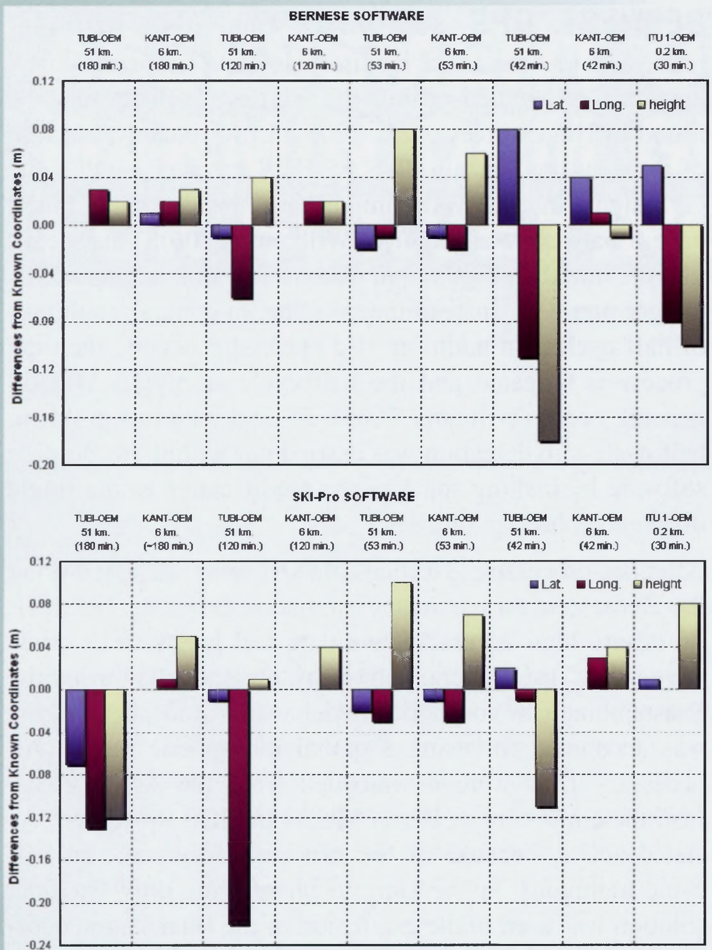

Figure 2. Differences between Known and Estimated OEM Coordinates for all Field Trials.

baseline were relatively poor, especially when the 2-hour and 3-hour sessions were used (Figure 2). This may be attributed to data cleaning (e.g., cycle slip detection and elimination) or poor quality data towards the end of the session.

5. CONCLUSIONS

In this paper, a low-cost positioning system, which utilizes the Garmin GPS 25-HVS receiver board is presented and examined for potential use in surveying applications. Three field trials were carried out to assess the performance of the low-cost positioning. It has been shown that decimetre to centimetre positioning accuracy is routinely obtained for short baselines with both the Bernese and SKI-Pro software packages. The same accuracy level is possible for long baseline with the Bernese software provided that longer occupation time is used. The initial results are encouraging, as they meet the required accuracy for a number of surveying and GIS tasks while reducing the cost dramatically.

ACKNOWLEDGEMENT

This research was funded by ITU Scientific Research Project Unit, under the title *Development of a Positioning System Using OEM GPS Sensor Board and Utilizing in Geodetic Applications*. The authors would like thank the Geodesy Department of Kandilli Observatory and Earthquake Research Institute, Bogazici University, for supplying the KANDILLI (KANT) data. As well, we acknowledge the valuable contributions of Dr. B. Ya_cı and Dr. S. Paker from ITU Electrical and Electronics Engineering Faculty and M. Atalay. The first author would like to gratefully acknowledge the fellowship funding at Ryerson University provided by TUBITAK-The Scientific and Technological Research Council of Turkey. The Bernese software used in this study was purchased though the kind support of NSERC, Geoide NCE, and the Centre for Earth and Environmental Technologies, Ontario Centres of Excellence.

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