THE USE OF GPS FOR GIS APPLICATIONS

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ABSTRACT

During the last decade, the demand for GIS in management and design applications has greatly increased. The realization of a GIS in many application areas still suffers from data acquisition problems. To be of value of the user, a GIS must be updated regularly, so that the information in the data base correctly represents the real world. However, the acquisition of up-to-date GIS data by conventional survey techniques is prohibitive in cost and has therefor limited the applicability and usefulness of GIS to potential users. Described in this paper is an attempt to overcome this problem. The present work focuses on the use of GPS for GIS applications which has entered a new age with the operational capability of GPS system as well the developments in GPS receiver technology and processing strategies. The current status of GPS methods and accuracies are reviewed in the context of GIS applications. A combination of GPS survey and GIS techniques were employed to construct a digital database for use in the study area and to get a topographic map for the same area.

Keywords: GPS, Surveying, DGPS, GIS, Digitizing.

GLOBAL POSITIONING SYSTEM: TECHNOLOGY REVIEW

Definition

GPS is a satellite-based navigation and positioning system developed by the U.S. Department of Defence. It uses a ground receiver to determine location by the triangulating between several satellites in known positions. The GPS ground receiver measures the distance between itself and each satellite by recording the amount of time it takes for a radio signal to travel from the satellite to the receiver and by knowing the speed at which the signal travels (186,000 miles per second).By knowing the exact locations of the satellites, and its exact distance from each of those satellites, the GPS receiver is able to calculate its own position precisely [1].

The impact of GPS on Surveying

GPS was conceived primarily to serve military user requirements and cannot as such satisfy all of civilian user expectations [2]. In the beginning of the 1980's, the first civil GPS users could be found in Geodesy [3]. The NAVASTAR Global Positioning System (GPS) is revolutionizing the surveying and mapping industry. It has provided a new tool for performing very precise, homogeneous geodetic control surveys, but more importantly, it is being used in a multitude of applications to provide positioning information during the collection of Geographic Information System (GIS) attribute data [4].

The high precision of GPS carrier phase measurements, together with appropriate adjustment algorithms, provide an adequate tool for a variety of tasks in Surveying and Mapping [5]. The impact of the Global Positioning System (GPS) on the Surveying and Mapping community has already become significant, while its use in Geographical Information Systems (GISs) is just beginning to be realized [6]. The GPS has already made a major impact into the field of Surveying and Georeferencing [7].

Technology review

The GPS is divided into three segments: space segment, control segment, and user segment. Table 1 defines the inputs, the functions, and products of each segment.

The space segment consists of the satellite vehicles which its configuration consists of 24 satellites in six orbital planes with an inclination of 55 degrees.Twenty one satellites are active and three are spares. The satellites are approximately 20,000 km above the earth and complete each orbit of the earth in 12 hours.

The control segment is responsible for operating the global positioning systems. It consists of five control stations, spaced almost evenly around the world. All five stations track the GPS signals for use in controlling the satellites and predicting their orbits. Three stations are capable of transmitting data back up to the satellites, including new ephemerides, clock corrections and other broadcast message data and command telemetry. The station located at the Falcon Air Force station near Colorado Springs is the Master Control Station.

Table 1 The space, control, and user segments of GPS

Segment	Input	Function	Product
Space	Navigation Message.	Generate and Transmit Code , Carrier Phases,and Navigation Message.	P Codes, C/A Codes, L1, L2 Carrier, Navigation Message.
Control	P Code, Observations, and Time (UTC).	Produce GPS time, Predict Ephemeris, and Manage Space Vehicles.	Navigation Message.
User	Code Observation, Carrier Phase Observation and Navigation Message.	Navigation Solution and Surveying Solution.	Position, Velocity, and Time.

Every satellite transmits two frequencies for positioning: 1575.42 MHz and 1227.60 MHz. The two carriers, called L1 and L2, are coherent and modulated by various signals. The C/A, P, and Y codes are pseudo-random noise (PRN) codes consisting of a series of plus and minus ones that are modulated onto the L1 and L2 carriers. The range (distance) to each satellite is determined by either interpreting the PRN codes or by measuring the phase shift of the carrier wave. If the PRN codes are used a pseudo-range is determined by measuring the time shift between the received code and a similar code generated within the receiver. Measuring the phase shifts produces a more precise range, however, it is a major problem to determine the full number of wavelengths between the receiver and the satellite. A second problem with using the phase measurements is to ensure that the integer count is maintained throughout the observations (i.e. there are no cycle slips).

The user segment consists of the receivers and associated computer software for receiving the satellite signals and computing position, velocity and time. There are many methods of survey techniques which have been developed to take advantage of the GPS's capabilities. Some of them are static, Rapid static, Pseudo static, semi kinematic, kinematic and navigation differentially corrected.

We've got distance measurements to some satellites whose positions we know exactly. We'll see how that translates into fixing our position. Suppose a receiver determines that it is 23,000 kilometres from a particular satellite. That one measurement really narrows down where in the universe that receiver could possibly be. It tells us it is somewhere on the surface of an imaginary sphere that's centered on that satellite and that has a radius of 23,000 kilometres. If it measures its distance to a second satellite and finds that it's 26,000 kilometres from

Table 2 Comparing conventional digitizing with GPS digitizing

Conventional	GPS
Accuracy dependent on scale. Suitable for massive data collection. Tracking speed controlled by user. Suitable for objects that can be seen from aerial photography.	Accuracy not dependent on scale. Suitable for selective updating. Tracking speed controlled by speed limit and traffic. Can also be used for small objects.

Indirect link between GPS and GIS is that the GPS receiver records data in its own storage using its own format. This data is later translated to various GIS data formats. The translated data is then loaded into the GIS filing system.

APPLICATION

Data of this application was captured using GPS as a real digitizer for a certain district in Canada. The data was obtained with an Ashtech dual frequency receiver. The accuracy is defined by the root mean square (RMS) in the original file. The format of the original file is longitude, latitude and height. The original data file was converted to the format of cartesian coordinates (x, y and z). The first line in this file should be ignored as it represents the size of the World Geodetic System (WGS84) ellipsoid which is used in GPS. Data of this application was kept on a floppy disk.

The used postprocessing software is called "Prism". It is a product of the Ashtech company. The software can perform static, kinematic and pseudo-kinematic GPS Surveying. It can also perform the GPS network adjustment. A secondary part of the software is to perform all kinds of datum transformation. The cartesian format data was analyzed by using Surfer version 4, Golden software to get a topographic map. The final results are shown in Figure 1 and 2.

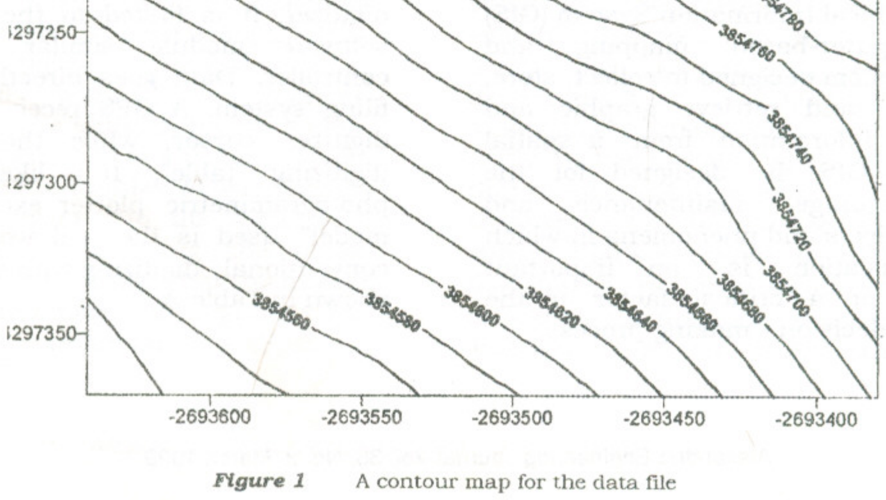

Figure 1 A contour map for the data file

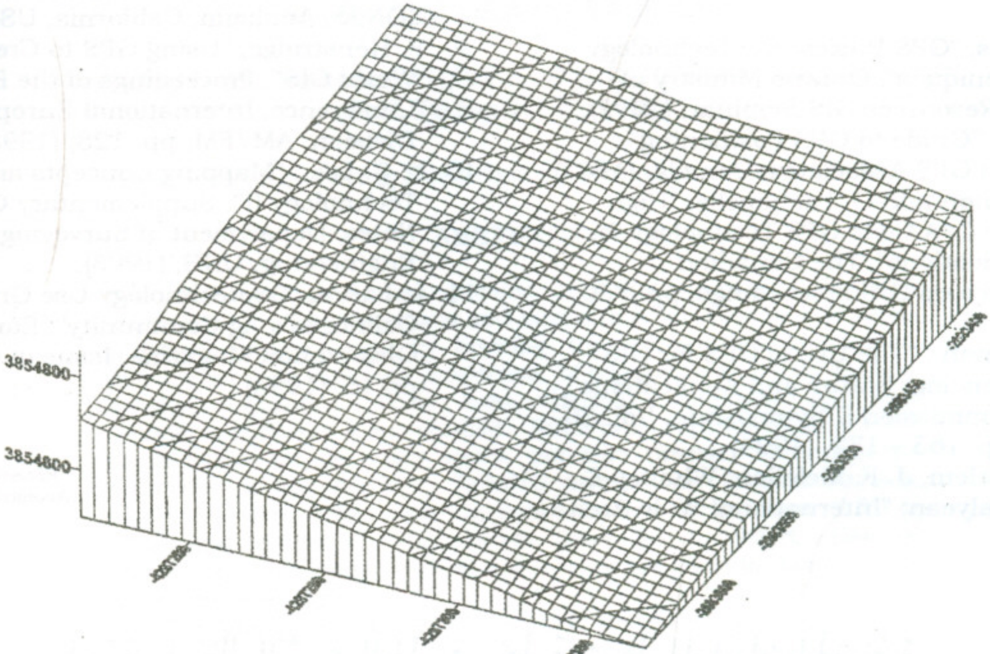

Figure 2 Surface of the contour map

CONCLUSIONS

GPS is a rapidly maturing technology that is being used in many GIS applications. It is moving away from a control survey tool to one that is used for positioning of GIS entities. New receivers and software systems are appearing in the market place at an exponential rate.

In conclusion, a combination of GPS survey and GIS techniques were employed to construct a digital data base for use the study area and to get a topographic map for the same area. GPS positioning can be used to set up an overall control network. Digital land base information is preferable, since it can be input directly into the GIS, eliminating the costs and potential in accuracies of data conversion.

The integration of GPS and GIS has allowed the updating to be more efficient and will, in future, allow surveys to be based on a spatial reference system thus eliminating the need to set up a costly network. GPS is an operational system that will benefit the users of GIS data bases in collecting accurate geographic coordinates for creating, updating or maintaining their own GIS data bases.

Finally, it can be said that GIS and GPS technology has continued to develop at a rapid pace. The use of GPS in GIS can be summarized in these points: as a real - world digitizer, for data retrieved and analysis, for tracking moving objects and for ground truthing.

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إستخدام نظام التثبيت العالمى فى تطبيقات نظم المعلومات الجغرافية

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ملخص البحث:

خلال العقد الماضى زاد الطلب على استخدام نظم المعلومات الجغرافية فى كثير من المجالات التطبيقية فى المجتمع. ولكن كثير من تطبيقات نظم المعلومات الجغرافية مازالت تعانى من مشاكل تجميع وتحصيل البينات. ولكى يستفيد المستخدم من أى نظام معلوماتى جغرافى، يجب تحديث البيانات بهذا النظام أولاً بأول حتى تمثل البيانات الواقع الحالى. فى هذا البحث تم تقديم محاولة للتغلب على هذه المشكلة وذلك بالربط بين نظام التثبيت العالمى كمصدر هام للبيانات ونظم المعلومات الجغرافية كوسيلة معاصرة وقوية لتحليل البينات. تم عرض طرق نظام التثبيت العالمى والدقة التى وصل إليها فى تحديد مواقع المعالم المختلفة، وعمل تطبيق مباشر على بيانات رصدت بأحدث أجهزة هذا النظام بمنطقة معينة بدولة كندا. أجرى الربط بين نظام التثبيت العالمى ونظم المعلومات الجغرافية من تحليل جزئى للبينات من خلال تقنيات ملحقة بالمستقبلات التى تم الرصد بها، ثم استُكمل تحليل البيانات بتقنيات أخرى على الكمبيوتر وتم أستنتاج خرائط طبوغرافية لمنطقة الدراسة.