ISSN [Online]: 2583-2654

GPS Integration Techniques

Nuli Namassivaya
Associate Professor, Dept. of ECE,
Maturi Venkata Subba Rao (MVSR) Engineering College,
Nadergul, Hyderabad – 501 510. India.

Abstract: GPS has found its way into many applications, mainly as a result of its accuracy, global availability, and cost-effectiveness. Unfortunately, however, there exist some situations in which part of the GPS signal may be obstructed to the extent that the GPS receiver may not "see" enough satellites for positioning. Examples of those situations are positioning in urban canyons and deep open-pit mining. This signal-obstruction problem, however, was successfully overcome by integrating GPS with other positioning systems. In fact, reported results showed that the performance of the integrated system is better than either system alone. Augmenting GPS is not limited to sensor integration. As shown below, GPS can be augmented with computer-based tools, such as GIS, for efficient data collection and analysis.

Keywords: Global Navigation Satellite System (GNSS), Geographic Information Systems (GIS), Inertial Navigation System (INS), Assisted GPS (AGPS), Laser Range Finders (LRF)

I INTRODUCTION

GPS or Global Positioning System is a constellation of 27 satellites orbiting the earth at about 12000 miles. These satellites are continuously transmitting a signal and anyone with a GPS receiver on earth can receive these transmissions at no charge. By measuring the travel time of signals transmitted from each satellite, a GPS receiver can calculate its distance from the satellite. Satellite positions are used by receivers as precise reference points to determine the location of the GPS receiver. If a receiver can receive signals from at least 4 satellites, it can determine latitude, longitude, altitude and time. If it can receive signals from 3 satellites, it can determine latitude, longitude and time. The satellites are in orbits such that at any time anywhere on the planet one should be able to receive signals from at least 4 satellites. The basic GPS service provides commercial users with an accuracy of 100 meters, 95% of the time anywhere on the earth. Since May of 2000, this has improved to about 10 to 15 meters due to the removal of selective availability.

II GPS INTEGRATION WITH GIS

Geographic Information System (GIS) is a powerful tool for capturing, storing, editing, updating, retrieving, analyzing, modeling, and displaying data that are spatially referenced to the earth.

GIS consists of three subsystems: – An input system that allows for the collection of data to be used and analysed for some purpose – Computer hardware and software systems that store the data, allow for data management and analysis, and can be used to display data manipulations on a computer monitor – An output system that generates hard copy maps, images, and other types of output.

ISSN [Online]: 2583-2654

2.1 Types of GIS Data

Two basic types of data are normally entered into a GIS

• **Geocode :** The first type of data consists of real world phenomena and features that have some kind of spatial dimension. Usually, these data elements are depicted mathematically in the GIS as either points, lines, or polygons that are referenced geographically (or geocoded) to some type of coordinate system. This type data is entered into the GIS by devices like scanners, digitizers, GPS, air photos, and satellite imagery.

• **Attribute :** Attributes are pieces of data that are connected or related to the points, lines, or polygons mapped in the GIS. This attribute data can be analysed to determine patterns of importance. Attribute data is entered directly into a database where it is associated with element data

GIS integrates data from various sources and helps to visualize patterns and trends that spreadsheets alone won't portray. GIS allows to see patterns, linkages and trends that put the big picture in context. GIS allows us to manage places such as watersheds, neighbourhoods, communities, and ecosystems.

2.2 Functions of GIS

a) GIS accepts geographic input in the form of scanned in and digitized map images

b) It rescales or manipulates geographic data for different purposes

c) It includes a database manager, usually a Relational database management system (RDBMS).

d) It includes query and analysis programs so that you can retrieve answers to simple questions such

e) as the distance between two points on a map or more complicated questions that require analysis, such as determining the traffic pattern at a given intersection.

f) It provides answers visually, usually as maps or graphs.

2.3 Limitations of GIS

GIS is well suited to modelling hospitals and census districts in the manner described above, but is not well suited to representing the catchment areas for the hospitals where these are poorly defined and overlap heavily with surrounding catchments.

Secondly, the data themselves can also cause problems. Much historical data will be taken from historical maps which may not be accurate, and the representation of features from these maps in the GIS at best will only be as accurate as the original source. In reality they are likely to be worse, as new errors are added when the data are captured (or transcribed, to use the historical term).

Thirdly, the academic origins of GIS were located within technological advances in the earth sciences. Its role in academic geography has yet to be fully established, and history trails some way behind this.

The final set of limitations on GIS is practical. GIS software, hardware, data and Personal are costly. As a result, entering into GIS is often more costly than originally anticipated and should be done with care.

2.4 Integrating GIS with GPS

GPS has long been a tool for GIS data collection. It allows us to capture locations of City facilities and

ISSN [Online]: 2583-2654

assets in a digital format in the field an to easily download to GIS as a data layer. Besides the benefit of GPS as a navigation aid, GPS is an important component of a GIS database maintenance system.

2.5 Latest Methods of Integration

Latest Method to integrate GPS/GIS uses : • Active X Controls • GPS Receiver Controls • GIS Controls • Wrapper (Software)

2.5.1 Active X Controls : A few GPS manufacturers have begun developing ActiveX controls to simplify the integration of their GPS hardware with the special needs of the user. Active X controls, which creates the critical components that can be assembled later by other software developers who do not necessarily have to understand all of the details. These controls offer many advantages over traditional interfaces. These controls provide robust interfacing with the host GPS receiver allowing the configuration of several settings and the formatting of data outputs Active X Control Standards. Interfacing standards includes elevation masks, controls for RTCM inputs from beacons and satellites, and bi-directional communication with the receiver. GPS ActiveX control even allows the user to generate and save GPS data for later postprocessing, which is a significant savings in software development.

2.5.2 GPS Receiver Controls : The primary software component is the controller for the GPS receiver. This control manages the GPS receiver's settings, so they can be optimized for how GPS positions are to be collected shared with the GIS application. This control should also monitor the status of the GPS constellation and set special filters and masks to exclude noisy and suspect GPS data, including satellite elevation masks, signal-to-noise ratios, and dilutions of precision (DOP) – especially Positional DOP. Since most GIS/GPS applications require real-time differential corrections, the GPS receiver control should also manage real-time correction sources to achieve submeter accuracies.

2.5.3 GIS Controls : To bind the output of the GPS locations to the GIS requires another set of controls. These controls will both update the map with the current location (an "event" in programming terminology) and save the GPS information to a GIS file. Depending on the GIS application being used in the field, the GPS data may have to be buffered before it is written to the GIS database, to improve GIS data processing efficiencies. This control would also determine what GPS data are written to the GIS file, such as DOP, GPS date, GPS time, differential correction status, etc. The same control would also manage how GPS data are displayed in the GIS.

2.5.4 Wrapper (Software) : All of these controls and the linkages to other programs, such as the GIS and database, need to be managed by a "wrapper" of software developed by the programmer. This wrapper is typically created with "visual" programming tools such as Visual Basic or Visual C. The wrapper also provides the interface presented to the end users, such as buttons, dialogs, and data displays. This portion of the GIS/GPS data use interface is critical to the success of the user, as a friendly and intuitive interface and makes a user dramatically more productive than a poorly designed interface.

ISSN [Online]: 2583-2654

III GPS INTEGRATION WITH INS

Inertial navigation is a self-contained navigation technique in which measurements provided by accelerometers and gyroscopes are used to track the position and orientation of an object relative to a known starting point, orientation and velocity. Inertial measurement units (IMUs) typically contain three orthogonal rate-gyroscopes and three orthogonal accelerometers, measuring angular velocity and linear acceleration respectively. By processing signals from these devices it is possible to track the position and orientation of a device.

3.1 Principle of Operation

The INS is initially provided with its position and velocity from another source (a human operator, a GPS satellite receiver, etc.), and thereafter computes its own updated position and velocity by integrating information received from the motion sensors. The advantage of an INS is that it requires no external references in order to determine its position, orientation, or velocity once it has been initialized. An INS can detect a change in its geographic position (a move east or north, for example), a change in its velocity (speed and direction of movement), and a change in its orientation (rotation about an axis). It does this by measuring the linear acceleration and angular velocity applied to the system. Since it requires no external reference (after initialization), it is immune to jamming and deception.

3.2 INS Applications

Inertial navigation is used in a wide range of applications including the navigation of aircraft, tactical and strategic missiles, spacecraft, submarines and ships. Recent advances in the construction of MicroElectroMechanical Systems (MEMS) have made it possible to manufacture small and light inertial navigation systems.

3.3 Errors in INS

Inertial navigation is usually used to supplement other navigation systems, providing a higher degree of accuracy than is possible with the use of any single system. For example, if, in terrestrial use, the inertially tracked velocity is intermittently updated to zero by stopping, the position will remain precise for a much longer time, a so-called zero velocity update.

3.4 GPS / INS Integration

Estimation theory in general, and Kalman filtering in particular, provide a theoretical framework for combining information from various sensors. One of the most common alternative sensors is a satellite navigation radio, such as GPS which can be used for all kinds of vehicles with direct sky visibility. By properly combining the information from an INS and other systems (Ex: GPS), the errors in position and velocity are stable. Furthermore, INS can be used as a short-term fall back while GPS signals are unavailable.

3.5 GPS / INS Summary : GPS/INS is the use of GPS satellite signals to correct or calibrate a solution from an Inertial Navigation System(INS). Inertial navigation systems usually can provide an accurate solution only for a short period of time. The INS accelerometers produce an unknown bias signal that appears as a genuine specific force. This is integrated twice and produces an error in position. Additionally, the INS software must use an estimate of the angular position of the accelerometers when conducting this integration. Typically, the angular position is tracked through

ISSN [Online]: 2583-2654

an integration of the angular rate from the gyro sensors. These also produce unknown biases that affect the integration to get the position of the unit. The GPS gives an absolute drift-free position value that can be used to reset the INS solution or can be blended with it by use of a mathematical algorithm, such as a Kalman Filter. The angular orientation of the unit can be inferred from the series of position updates from the GPS. The change in the error in position relative to the GPS can be used to estimate the unknown angle error.

IV GPS INTEGRATED WITH CELL PHONE (ASSISTED GPS)

Assisted GPS (A-GPS) is a system that is often able to significantly improve the start up performance, or Time-to-First-Fix (TFF), of GPS. A-GPS is extensively used with GPS-capable cellular phones. AGS development was accelerated by the U.S. FCC's 911 requirement to make cell phone location data available to emergency call dispatchers.

4.1 Basic Concepts

Standalone GPS provides first position in several minutes. A standalone GPS needs orbital information of the satellites to calculate the current position. The data rate of the satellite signal is only 50 bit/s, so downloading orbital information like ephemerides and the almanac directly from satellites typically takes a long time, and if the satellite signals are lost during the acquisition of this information, it is discarded and the standalone system has to start from scratch. In A-GPS, the network operator deploys an A-GPS server. These AGPS servers download the orbital information from the satellite and store it in the database. An A-GPS capable device can connect to these servers and download this information using mobile network radio bearers such as GSM, CDMA, WCDMA, LTE or even using other wireless radio bearers such as Wi-Fi. Usually the data rate of these bearers is high, hence downloading orbital information takes less time.

4.2 Need for AGPS

Standalone/self-ruling GPS units depend solely on information from satellites. A-GPS augments that by using cell tower data to enhance quality and precision when in poor satellite signal conditions. In exceptionally poor signal conditions, for example in urban areas, satellite signals may exhibit multipath propagation where signals skip off structures, or are weakened by meteorological conditions or tree canopy. Some standalone GPS navigators, when used in poor conditions, will be unable to fix a position because of satellite signal fracture and must wait for better satellite reception. A GPS unit may require as long as 12.5 minutes (the time needed to download the GPS almanac and ephemerides) to resolve the problem and be able to provide a correct location.

4.3 AGPS – Modes of Operation

Assistance falls into two categories

4.3.1. Mobile Station Based (MSB) : Information used to acquire satellites more quickly. – It can supply orbital data or almanac for the GPS satellites to the GPS receiver, enabling the GPS receiver to lock to the satellites more rapidly in some cases. – The network can provide precise time.

4.3.2. Mobile Station Assisted (MSA) : Calculation of position by the server using information from the GPS receiver. – The device captures a snapshot of the GPS signal, with

ISSN [Online]: 2583-2654

approximate time, for the server to later process into a position. – The assistance server has a good satellite signal, and plentiful computation power, so it can compare fragmentary signals relayed to it. – Accurate, surveyed coordinates for the cell site towers allow better knowledge of local ionospheric conditions and other conditions affecting the GPS signal than the GPS receiver alone, enabling more precise calculation of position. As an additional benefit, in mobile station assisted implementations, the amount of processing and software required for a GPS receiver can be reduced by offloading most of the work onto the assistance server.

4.4 GPS Tracking Devices

GPS tracking devices are built on a reliable and high-performance system that utilizes A-GPS, GPS and cellular technology to acquire location data and present it to you, the user. The device itself acquires locations from A-GPS and GPS satellites and transmits that data to the servers via the cellular GSM network. The data is encrypted and sent to Pocket Finder servers. Then it is accessed by a user via the website or mobile devices.

V GPS / LRF INTEGRATION

In areas with heavy tree canopy**,** GPS receivers will normally lose lock to the GPS satellites. In addition, real-time differential GPS corrections may not be received as well. To overcome these problems, integrated GPS/handheld laser units, or laser range finders (LRFs), were developed. The way the integrated system operates is to set up the GPS antenna in a nearby open area, which allows the GPS system to operate normally without losing lock to the GPS satellites. With the help of a digital compass, a reflectorless handheld laser, colocated with the GPS receiver, can be used to determine the distance and azimuth to the inaccessible points. This operation is commonly known as the offset function. Software residing in the handheld computer helps in collecting both the offset data and the GPS data. At a later time, all the available information is processed using PC software to determine the coordinates of the inaccessible points. Collecting and processing the data may also be done in real time, while in the field, provided that the real-time DGPS corrections can be received. Once the processing is done, the user can export the output to the required GIS or CAD software. This eliminates the need to place the GPS antenna directly on the features to be mapped.

GPS/laser integration is an attractive tool, especially for the forestry industry. Tree offsets, heights, and diameters can be measured easily with the laser unit. From a single location, a stationary user in a relatively open area can offset any number of points or features. In this case, the user location will be determined precisely by averaging all the GPS data collected while taking the offset measurements. Other applications of the GPS/laser integration include mapping points under bridges, mapping points on a busy roadway, mapping highway signs, and mapping shore lines, to name a few. GPS/laser integration can be used to map point features, line features, or area features.

VI GPS / PSEUDOLITE INTEGRATION

One of the fastest growing applications of GPS is open-pit mining. The use of GPS in open-pit mining can remarkably reduce the cost of various mining operations. The availability of real-time GPS positioning at centimetre-level accuracy has attracted the attention of the mining industry. This is mainly because accurate real-time positioning is a key component that leads to automating the heavy and expensive mining machines. As such, smart mining systems can be developed that not only increase mining safety but also reduce costly labor.

Unfortunately, similar to the earlier cases, the satellite signal will be partially blocked as the pit

ISSN [Online]: 2583-2654

deepens. As such, in deep open-pit mining, GPS alone cannot be used reliably for mining positioning. One promising system that can augment GPS to ensure high-accuracy positioning at all times is the pseudolite (short for pseudo satellite) system. A pseudolite is a ground-based electronic device that transmits a GPS-like signal (code, carrier frequency, and data message), which can be acquired by a GPS receiver. Unlike GPS, which uses atomic clocks onboard the satellites, pseudolites typically use low-cost crystal clocks to generate the signal.

VII CONCLUSION

The main objective of this paper was to discuss the various of GPS integration methods. In GPS/GIS integration discussed about the various types of GIS data and functions of GIS. Discussed latest four methods to integrate GPS/GIS namely Active X Controls, GPS Receiver Controls, GIS Controls, Wrapper (Software). GPS/INS is the use of GPS satellite signals to correct or calibrate a solution from an Inertial Navigation System (INS). Assisted GPS (A-GPS) is a system that is often able to significantly improve the start up performance, or Time-to-First-Fix (TFF), of GPS. A-GPS is extensively used with GPS-capable cellular phones. GPS/laser integration is an attractive tool, especially for the forestry industry. Tree offsets, heights, and diameters can be measured easily with the laser unit. From a single location, a stationary user in a relatively open area can offset any number of points or features. GPS/Pseudolite integration is used in once of the fastest growing application of open-pit mining to increase the centimetre level accuracy.

REFERENCES

[1] Harrington, Andrew, GPS/GIS Integration: GPS Can Play a Major Role in GIS Data Maintenance? GeoWorld, Daneilson, Todd (ed.), Vol.12 No.10, Arlington Heights: Adams Business Media.

[2] Harrington, Andrew, GPS/GIS Integration: Consider the Differences Among GPS Integration Technologies? GeoWorld, Daneilson, Todd (ed.), Vol.13 No.2, Arlington Heights: Adams Business Media.

[3] Ehab M. Shaheen, Sherif A. Elgamel, Mohammed K. Bek, Understanding GPS Tracking /Acquisition Processes with Interference.

[4] P Srinivas, A Kumar, Overview of architecture for GPS-INS integration.

[5] Yang, Y., Tightly Coupled MEMS INS-GPS Integration with INS Aided Receiver Tracking Loops, PhD Thesis, Department of Geomatics Engineering, University of Calgary, Canada, UCGE Report No. 20270.

N. Nuli Namassivaya was born in August 1967 at Eluru, Andhra Pradesh. He obtained B.E. from Gulbarga University in 1988 and M.Tech. from Jawaharlal Nehru Technological University in 1994 with Automation and Control Systems with University Topper. Presently he is working as Associate Professor in MVSR Engineering College, Hyderabad. He published 48 papers at International & National Journals & Conferences to his credit and out of 6 papers won Best Paper awards. He got 1 patent on Performance and Cost GNSS. He has more than 3 decades of teaching experience. He is a Fellow member of IETE and a Life Member of CSI, IE(I), ISOI, BES and ISTE. He served in various capacities in the above mentioned Professional organizations. He obtained Rashtriya Gaurav Award by India International Friendship Society, New Delhi on 11 March, 2005 & Best Citizens of India award in recognition of exceptional caliber and outstanding performance in chosen area of activity by Best Citizen of India, New Delhi during Jan., 2006. His Biographical note is included in Asia/Pacific Who's Who in Jul., 2016. He also awarded Bharat Ratna Rajiv Gandhi Gold Medal award by Global Economic Progress & Research Association on 21 Mar., 2020 and Engineering Seva Ratna Award by ECI Foundation in association with IE(I), Telangana State Centre on 5 Dec., 2021.