Chapter 11
Coupling GPS and GIS

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ABSTRACT

Since the 1990s, the integration of GPS and GIS has become more and more popular and an industry standard in the GIS community worldwide. The increasing availability and affordability of mobile GIS and GPS, along with greater data accuracy and interoperability, will only ensure steady growth of this practice in the future. This chapter provides a brief background of GPS technology and its use in GIS, and then elaborates on the integration techniques of both technologies within their limitations. It also highlights data processing, transfer, and maintenance issues and future trends of this integration.

INTRODUCTION

The use of the Global Positioning System (GPS) as a method of collecting locational data for Geographic Information Systems (GIS) is increasing in popularity in the GIS community. GIS data is dynamic – it changes over time, and GPS is an effective way to track those changes (Steede-Terry, 2000). According to Environmental Systems Research Institute (ESRI) president Jack Dangermond, GPS is "uniquely suited to integration with GIS. Whether the object of concern is moving or not, whether concern is for a certain place at a certain time, a series of places over time, or a place with no regard to time, GPS can measure it, locate it, track it." (Steede-Terry, 2000).

Although GIS was available in the market in the 1970s, and GPS in the 1980s, it was only in the mid-1990s that people started using GPS coupled to GIS. The GPS technology and its analogs (Global Navigation Satellite System or GLONASS in Russia and the proposed Galileo system in Europe) have proven to be the most cost-effective, fastest, and most accurate methods of providing location information (Longley et. al, 2005; Trimble, 2002; Taylor et. al, 2001). Organizations that maintain GIS databases – be they local governments or oil companies – can

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easily and accurately inventory either stationary or moving things and add those locations to their databases (Imran et. al, 2006; Steede-Terry, 2000). Some common applications of coupling GPS and GIS are surveying, crime mapping, animal tracking, traffic management, emergency management, road construction, and vehicle navigation.

BACKGROUND

Need for GPS Data in GIS

When people try to find out where on earth they are located, they rely on either absolute coordinates with latitude and longitude information or relative coordinates where location information is expressed with the help of another location (Kennedy, 2002). GIS maps can be created or corrected from the features entered in the field using a GPS receiver (Maantay and Ziegler, 2006). Thus people can know their actual positions on earth and then compare their locations in relation to other objects represented in a GIS map (Thurston et. al, 2003; Kennedy, 2002).

GIS uses mainly two types of datasets: (a) primary, which is created by the user; and (b) secondary, which is collected or purchased from somewhere else. In GIS, primary data can be created by drawing any feature based on given dimensions, by digitizing ortho-photos, and by analyzing survey, remote sensing, and GPS data. Using GPS, primary data can be collected accurately and quickly with a common reference system without any drawing or digitizing operation. Once the primary data is created, it can be distributed to others and be used as secondary data. Before using GPS as a primary data collection tool for GIS, the users need to understand the GPS technology and its limitations.

The GPS Technology

The GPS data can be collected from a constellation of active satellites which continuously transmit coded signals to receivers and receive correctional data from monitoring stations. GPS receivers process the signals to compute latitude, longitude, and altitude of an object on earth (Giaglis, 2005; Kennedy, 2002).

A method, known as triangulation, is used to calculate the position of any feature with the known distances from three fixed locations (Letham, 2001). However, a discrepancy between satellite and receiver timing of just 1/100th of a second could make for a misreading of 1,860 miles (Steede-Terry, 2000). Therefore, a signal from a fourth satellite is needed to synchronize the time between the satellites and the receivers (Maantay and Ziegler, 2006; Longley et. al, 2005; Letham, 2001). To address this fact, the satellites have been deployed in a pattern that has each one passing over a monitoring station every twelve hours, with at least four visible in the sky all the times (Steede-Terry, 2000).

The United States Navigation Satellite Timing and Ranging GPS (NAVSTAR-GPS) constellation has 24 satellites with 3 spares orbiting the earth at an altitude of about 12,600 miles (USNO NAVSTAR GPS, 2006; Longley et. al, 2005; Steede-Terry, 2000). The GLONASS consists of 21 satellites in 3 orbital planes, with 3 on-orbit spares (Space and Tech, 2005). The proposed system GALILEO will be based on a constellation of 30 satellites and ground stations (Europa, 2005).

The NAVSTAR-GPS has three basic segments: (1) the space segment, which consists of the satellites; (2) the control segment, which is a network of earth-based tracking stations; and (3) the user segment, which represents the receivers that pick up signals from the satellites, process the signal data, and compute the receiver's location, height, and time (Maantay and Ziegler, 2006; Lange and Gilbert, 2005).