GIS/GPS

Geographic information systems (GIS) use computers to acquire, store, process, and analyze geographic information, which is defined as information about features and phenomena at specified locations on or near the Earth's surface. The Global Positioning System (GPS) is one of a growing number of satellite systems that emit precisely timed signals, allowing users on or above the Earth's surface to determine position with great accuracy. Both GIS and GPS have fuelled a major growth in mapping and in services that support various kinds of decision-making, including wayfinding, management of distributed resources, and modeling of the human and physical processes that affect and modify the Earth. Social networks have emerged that use GIS and GPS to create large amounts of geographic information under the rubric of neogeography; and many social-networking sites now include information about the real-time geographic positions of members of the network.

GIS

The earliest forms of GIS were developed in response to several apparently disparate requirements. First, measurement of properties such as area or length from paper maps had always been notoriously tedious, slow, and inaccurate when performed by hand, whereas computerization offered speed and precision. Second, manual editing during the map-making process could clearly benefit from computerization, just as editing of text has done. Third, researchers studying transportation were drawn to the advantages of computerization to handle the diverse types of geographic information needed in planning. Finally, statistical agencies in many countries were quick to adopt computerization because of its advantages in handling and aggregating large volumes of geographically referenced data. By the late 1970s the scale economies of addressing all of these applications with a single technology had become clear, and a GIS software industry began to develop.

The Internet had a dramatic effect on GIS, beginning with the release of the first browsers in 1992. At first applications emphasized top-down dissemination of data, and many governments invested in digital libraries of GIS data. Metadata standards were promulgated and widely adopted, supporting search and discovery of data meeting user-defined needs. One of the first of these was the Alexandria Digital Library at the University of California, Santa Barbara, developed beginning in 1993 as an on-line mechanism for accessing the extensive holdings of the university's map library. Today many such repositories of geographic information exist, and some have reached petabyte scale. Today the concept has evolved into the geoportal, a single point of entry to the holdings of many participating digital libraries. The US Government's Geospatial One-Stop is typical of this genre.

While data download by sophisticated users dominated early applications of the Internet, by 2000 it was clear that server-side applications would reach a much broader user base. In this mode data remain at the server, and are processed by a remote user using the server's software. Such services offer a limited functionality compared to client-side GIS, but address common applications. An early example is Mapquest, a service based on a database of streets and roads that allows users to find addresses and display them in map form, and to obtain driving directions between two such addresses. These functions are now available in a variety of forms, and accessible through a range of mobile devices. In 2005 Google Earth and Google Maps gave many users their first experiences of the power of GIS to manage and display geographic information, and to execute simple functions. Moreover the publication of the application programming interfaces (APIs) of these services allowed users to develop their own advanced applications.

GPS

Early devices for determining position on the Earth's surface -- the astrolabe, sextant, and clock -- were crude, unreliable, and difficult to use. Electronic aids to navigation date from the mid 20^{th} century, but the first truly global, easy-to-use systems had to await the development of orbiting satellites. GPS was designed in the 1970s as a system primarily targeted at military applications, allowing ground, air, and sea forces to determine position quickly and accurately. It relies on a constellation of orbiting satellites (24 in the basic constellation), each carrying a synchronized atomic clock and emitting precisely timed signals. A GPS receiver detects the signals of the subset of satellites that is sufficiently high above the horizon, and computes position in three dimensions. In the original design the accuracy obtainable by civilian users was significantly degraded, but an Executive Order in the late 1990s following the first Gulf War removed this "selective availability". Today a simple hand-held receiver achieves accuracies of 10m or better in the horizontal; differential GPS acquires dynamic correction data from a network of ground stations, allowing accuracies of 1m or better; and specialized systems are capable of accuracies of 1cm or better.

A parallel Russian system, GLONASS, has been in operation for many years, and some GPS receivers are enabled for both it and GPS signals. A European system, Galileo, is under development, and several other systems are in various stages of planning.

In practice the applications of GPS are limited by the availability of satellite signals, which are severely impacted indoors, under heavy tree cover, and in the urban canyons of major cities. In effect both GPS and GIS are technologies of the outdoors, where the average modern human spends only a small fraction of his or her time, and extending both to the indoors is a major research area.

GPS receivers can be embedded in a range of devices, and many 3G mobile phones include one. The applications that accompany GPS-enabled devices can be used to record the locations at which photographs were taken by a digital camera; to record an individual's track; to compute the rate of energy use by a runner; to track the vehicles of a fleet; and to upload all of this information to a central database.

GIS, GPS, and social networks

By 2005 it had become clear that these technologies, previously the preserve of experts, could be used effectively by the average citizen. The term “neogeography” describes this breaking down of the traditional distinction between expert and amateur in the creation of geographic information as user-generated Web content. Amateurs begain to create “mash-ups”, using the APIs of Web services to join geographic information and produce new maps or other forms of useful data. For example, the Fundrace service combines the content of a public database of the names and addresses of donors to political parties with the mapping interface of Google Maps, allowing anyone to see which of their neighbors have donated what, and to whom. OpenStreetMap developed as a project to enlist amateurs in the creation of a free, digital map of the world, relying on social networking and GPS to engage large numbers of citizens worldwide. During the Haiti earthquake recovery of January 2010 OpenStreetMap became the means by which hundreds of people worldwide were able to enhance and maintain an accurate map of Port-au-Prince and its surroundings for use by the recovery effort, and to do so within a few days. This combination of social networking and mapping during emergencies has now produced a number of grass-roots organizations of dedicated volunteers, such as CM*Net, the International Network of Crisis Mappers. At a more local scale, social networks have evolved in many areas to handle and disseminate information about emergencies, and to compile and distribute such information in the form of real-time maps. These processes have been especially effective during fire emergencies in the Western US in recent years, and have shown how it is possible for a community, supported by a social network, to act as a densely distributed population of communicating observers that can out-perform the more traditional information systems maintained by government agencies. While these networks typically rely on connection to the Internet, the Ushahidi service, which originated in Kenya, allows citizens to contribute and receive information using phone-based SMS.

A second intersection between GIS/GPS and social networking occurs in the real-time georeferencing of individual locations. The Foursquare service is dedicated to allowing friends to discover each other’s locations in real time, and major social network services such as Facebook have now added this feature, based on GPS tracking of phones. Other geographically enabled social networks include CouchSurfing, which links travelers to potential home accommodation.

In future we can anticipate a time when it will be possible to know where everything is at all times. GPS and RFID (radio-frequency identification) already track the locations of mobile phones, cars passing through tollgates, articles for sale in stores, farm animals, and many other types of object. Networks of neogeographers have already shown how effective mapping can be when carried out as a volunteer, community effort, and are creating maps of phenomena that were never mapped in the past, such as cultural heritage sites. Communities are using Web services to notify local governments of potholes and dysfunctional streetlights, and are providing real-time information about the impacts of earthquakes and forest fires. At the same time these developments raise important questions, about privacy and the confidential nature of much geographic information, about the accuracy of information contributed by amateurs, and about trust.

See also: Computer Networks; Paths/Walks/Cycles; Internet History and Networks

Further Reading

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Michael F. Goodchild
University of California, Santa Barbara