CHAPTER 3

GDAT — A GPS Data Acquisition Tool for Cultural History

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Abstract

This article discusses the design and implementation of a GPS based data acquisition tool for scholars in cultural history at the University of Vienna's Department of Geography and Regional Research. This endeavour is part of an interdisciplinary research network in Vienna that is funded by the Austrian Science Fund. The article gives a short historical overview of techniques of cartographic data acquisition and mapping, and then describes the basic principles of GPS before introducing the concepts behind the GDAT software.

1 Introduction

Throughout recorded history, maps have been the major vehicle for the assembly, storage and display of geographic information. A long time before the development of geographic information systems (GIS), scholars engaged in cartography were dealing with the collection, manipulation and graphic display of geographic information in maps (Kimerling 1996).

Johnson (2002: 7) says that "geography is not only a fundamental factor in the patterning of human activities, but also a powerful and widely understood method of indexing information." By storing coordinates (place names) with the collected datasets, a valuable spatial index can be added to the archives of research groups, thus helping to make the data collections more sustainable.

2 Background

The *Cultural History Information System* (CHIS), a sub-project of the Austrian National Research Network "The Cultural History of the Western Himalaya from the 8^{th} Century", seeks to compile, homogenize, manage, analyze, query, compare, and visualize cultural-history data from different disciplines in a comprehensive and user-friendly way. A prerequisite for this holistic compilation, as well as a connecting element, is the spatial component of the data. The exact localization of objects of cultural history and the subsequent integration into a *Geographic Information System* (GIS) pose a challenge to the CHIS group: in the majority of cases, coordinates of objects are retrieved by locating the associated place names. With this procedure, the coordinates for the objects are only as accurate as the underlying sources for place names. Errors can be caused by ambiguous place notations or the wrong allocation of objects. Furthermore, objects can only be mapped in smaller scale levels giving a regional overview, since the localization takes place on the level of settlements and dismisses more detailed information.

By simultaneously capturing exact coordinates with the aid of *Global Positioning System* (GPS) devices together with the object information such as images and descriptions, the archives can be made more valuable and sustainable and the work of the CHIS group can be greatly facilitated. Mobile consumer electronic devices with built-in GPS receivers such as PDAs, smart phones and recently tablet computers have become increasingly popular and affordable in the past years. Against this background, and with the need of the collection of detailed spatial information in mind, the CHIS sub-project group has decided to design and develop an easy-to-use *GPS Data Acquisition Tool* (GDAT) for mobile devices. The software for project partners and scholars in the fields of cultural history was designed to work on all GPS-enabled windows mobile devices, thus guaranteeing a wide availability of the service.

3 Mapping Places

Maps are graphic representations of space, generalized to such an extent that they give the map users an adequate picture of the characteristics of an area, for specific use contexts in predefined scale levels. Besides topographic reference layers which are necessary for orientation, they can feature all kinds of thematic information. This information must contain an indication of location before it can be depicted as points, lines, areas, or raster cells in maps.

The spatial component that is recorded with cultural-history data is often rather vague and mostly exists in the form of place names on the level of settlements, regions or countries. For mapping, these place descriptions need to be translated into coordinates with the aid of other sources. The spatial extent of map features is encoded in geographical coordinates, that is, in degrees of latitude and longitude, or geodetic coordinates within specified coordinate systems. Once points, lines, polygons and pixel cells of raster images (e.g., satellite imagery) are assigned coordinates in a process called georeferencing, they can be combined in layers with other features or surfaces that are registered to the same locations. Layering can be used for simple visual comparison and is also a prerequisite for advanced spatial analysis in geographic information systems.

4 Surveying

Surveying primarily deals with geometric measurements on the earth's surface, the computation of derived quantities, e.g., coordinates, areas, etc., and the representation of this numerical data in graphical form, such as in plans or maps (Kahmen and Faig 1988).

Ancient cultures like that of the Egyptians used very simple geometrical methods such as pegs and ropes for demarcating land. Throughout history the surveying instruments improved. In the early 18th century within European countries, triangulation was used to build a hierarchy of fixed point networks which allowed surveying point positions with the aid of trigonometry. The first complete surveys of European countries were executed mainly for military purposes. Over time the triangulation networks became more refined, the instruments (such as plane tables, later theodolites and nowadays laser scanning) developed and with them the maps became more accurate.

Soon after the advent of aviation, air-borne remote sensing was a central focus of interest for surveyors. New methods of stereographic analysis enabled a very detailed depiction of terrain and the maps derived from remote sensing imagery became very accurate. Today, space-borne remote sensing facilitates a high frequency of image delivery and thus allows the economical surveying even of vast uninhabited areas. For very detailed

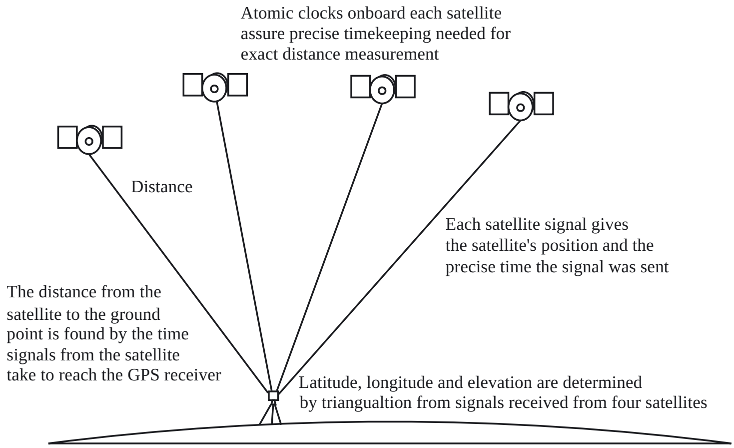

Figure 3.1 Principle of GPS positioning (Kimerling 1996)

mapping tasks, aerial photogrammetry is still preferred, because of the higher resolution that the imagery offers.

Another surveying technique that has become popular over the last decades also depends on satellites orbiting the earth: GPS, the Global Positioning System, is used in combination with mobile devices to record three-dimensional spatial positions for small (e.g., archaeological surveys) or large (collaborative) mapping endeavours (e.g., *Open Street Map*).

5 Basic Principles of GPS

GPS is a satellite-supported system for position finding as well as recording and navigation. The complete and accurate denomination is NAVSTAR-GPS which is an abbreviation for Navigation Satellite Timing and Ranging Global Positioning System. A minimum of twenty-four operational satellites in six orbits at a height of 20,200 kilometers guarantee global availability of the service at all times.

GPS satellites transmit a time signal and their actual position which can be received by all GPS enabled devices. By calculating the duration the signal needs to travel to the receiver, the distance to the satellite can be calculated. By utilizing the distance from three satellites and a forth satellite for eliminating time errors, the actual latitude, longitude and height of the current receiver's position can be calculated.

GPS accuracy is affected by different factors, including the number of satellite signals, the satellite dispersion over the horizon, atmospheric effects and natural as well as artificial barriers to the signal. In most occasions the accuracy is superior to 10 meters, which is sufficient for determining the absolute position of objects in a wider area, but may lead to problems when attempting to capture the relative positions of objects close to each other (e.g., statues in a small courtyard). Accuracy can be increased up to a few centimeters by utilizing differential measurements, which is sufficient even for large scale archaeological surveys.

GPS satellites are permanently orbiting the globe and the signals can be received free of charge. Thus GPS has become a wide-spread and powerful tool that allows even non-expert users to find and record their positions, respectively to track their movements, regardless of weather conditions and their whereabouts.

6 GPS on Consumer Devices

Compared to the technology which is in use nowadays, the first receivers for GPS signals were rather large, featured poorer accuracy and required a long duration until satellite signals were captured and full operation capability was established. These devices could only receive few — typically four to five — channels and had heavy battery consumption. A miniaturization was first noticeable in the group of receivers for outdoor activities. Such equipment became smaller and more battery efficient, strongly reducing the size and weight of the devices. Still, the usage of these devices required expert knowledge.

Nowadays GPS chipsets are very small and efficient. They can be built into every kind of mobile consumer electronic device and offer excellent reception, while little battery power is needed for capturing and computing satellite signals. This low priced and efficient technology is to a great part responsible for the boom in the sector of car navigation devices. Over the last years GPS chipsets also increasingly found their way into everyday consumer electronics like PDAs, smart phones, or tablet computers — devices which are practically omnipresent in modern households.

7 Using GPS and Consumer Electronics for Fieldwork

Most consumer electronic GPS-enabled devices can be used to record X,Y, and Z coordinates of points (waypoints) and line data (tracks) in the field.

Figure 3.2 Start-up screen and interface of GDAT

Some equipment even features the capability to record and/or calculate areas.

Many fieldwork tasks require that some kind of diary or log, within which the object information (e.g., descriptions, related photo numbers) is stored, is maintained parallel to the coordinates. PDAs and smart phones can be a very practical solution for such fieldwork tasks, since they combine the ability to record photos (with the respective coordinates stored alongside the photograph) and to keep an electronic log/diary for the according descriptions. The advantages of this approach are obvious: when the data is already completely stored in digital format, digitization processes for later archiving purposes are superseded.

8 GDAT Concept

The GPS data acquisition tool (GDAT) was developed for scholars from the humanities as an instrument for quick and easy GPS recording. The software works in the Windows Mobile environment, which makes it widely applicable on a variety of smart phones and PDAs with built-in GPS antenna. The acquisition of costly GPS equipment therefore becomes unnecessary for those who possess such devices.

An intuitive and easily manageable interface (cf. Figure 3.2) allows users to quickly employ the system and to acquire data in the field. The system allows the capturing of point data (single objects), line data (e.g., *maṇi* walls, routes of pilgrimage), and area data (large objects like the layouts of temple compounds). Through the utilization on PDAs and smart phones, which come along with full (touch-screen) keyboards, metadata about the captured objects can easily be stored and edited.

9 Data Formats and Application

Standard GPS devices are capable of recording point (waypoints) and line data (tracks). GDAT additionally offers the possibility of capturing area polygons. The common format for data acquired with GPS devices is the GPS exchange format (GPX). The GPX format uses an XML schema for storing waypoint and track data. The main advantage of this format is the high degree of interoperability: GPX data can be handled with most standard GIS software packages as well as with earth browsers like *Google Earth* or *Nasa World Wind*. Hence, recorded data can not only be utilized by GIS-experts but can also be visualized in freely available browsers for verification purposes by everyone.

GDAT stores the captured GPS coordinates and metadata are simultaneously in the interoperable GPX format as well as in KML files, the native format for *Google Earth* data which allows the immediate setting of parameters for a later visualization. The *Keyhole Markup Language* (KML) is also based on XML and became a standard format for all geobrowsers in 2008 (Open Geospatial Consortium 2008)

10 GDAT Workshop

In April 2009 during the conference "Cultural Flows across the Western Himalaya" at the Indian Institute of Advanced Studies (IIAS), Shimla, India, the GDAT software was presented at a hands-on workshop (see Figure 3.3). An international group of 15 scholars from various disciplines of the humanities were utilizing the system to capture objects on the grounds of the IIAS and could assure themselves of the usability of the system. Immediately after the workshop the data was visualized using Google Earth.

The GDAT software proved to be an easy-to-use application for acquiring and visualizing geographic data with mobile devices. One of the main issues remains the availability of hardware devices. Although Windows Mobile based devices such as smart phones are already widely spread, not everyone has access to such hardware. One option that is currently under assessment at the Department of Geography of the University of Vienna

(a) Hands-on workshop at Indian Institute of Advanced Study, Shimla

(b) Captured data in Google Earth

Figure 3.3

is an extension of the service. Making the system available for other environments (e.g., Apple iPhone, Google Android) would strongly increase the availability of the service.

11 From 'Mapping Location' to 'At-Location Mapping'

The latest advancements in technology make it clear that the usage of GPS for data capture in the field is no longer a task for experts only. GPS technology permeates the smart phone market and is increasingly popular with tablet computers like the Apple iPad. This trend has already influenced the way everyday consumers deal with spatial information and will completely change the approaches to capturing data in the field. In well developed areas where constant access to the internet is a matter of course, the acquired data can be transferred to online databases instantaneously. The consecutive visualization in maps can be generated automatically in real-time. Thus map makers and experts from other domains will be able to create maps at their current location. However, in remote regions where a connection to the internet is not ubiquitous (e.g., the Himalayan mountains) it will still be necessary to store acquired data offline and to transfer the data to the servers later, when a suitable internet connection is available.

Abbreviations

CHIS *Cultural History Information System*. See also Chapter 1 in this volume. Department of Geography and Regional Research, University of Vienna. URL: http://www.univie.ac.at/chis/ (retrieved 19/05/2010).

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