METHODFINDER

Practitioner's Guide:

Updating Maps Using Global Positioning Systems (GPS)

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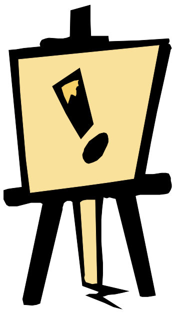
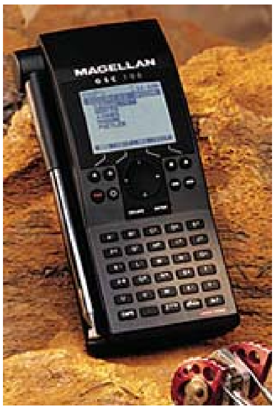
Updating Maps Using Global Positioning Systems (GPS)

Brief Description



The Global Positioning System (GPS) system is a network of satellites orbiting the earth that continuously transmit coded information. The coded information transmitted makes it possible to precisely identify locations on earth by measuring the distances from the satellites through triangulation. The system was originally designed for and used by the U.S. Department of Defense. Since the early 1980's the technology has been made available for civilian use. Initially, the quality of information available for civilian use was reduced. This was done by scrambling the signal of the satellites ("Selective Availability") and therefore reducing the accuracy of civilian handheld GPS to about 100 m. In May 2000 the then President of the USA decided to discontinue the technology of "Selective Availability" and the accuracy of handheld GPS has been increased to 10 m. More expensive systems, higher and sophisticated processing procedures can increase the accuracy up to a few centimeters. This has opened up a market for a multitude of new GPS-applications.



A handheld GPS can measure and log positions on Earth by triangulating the position of satellites

21 activated satellites are continuously sending unique signals while surrounding the Earth

Updating Maps Using Global Positioning Systems (GPS)

Proposed Main Users

Urban & regional planners, surveyors, GIS specialists.

Purpose of the Method

The Global Positioning System (GPS) is a technical tool that can be used for updating and/or defining map feature-coordinates using Geographical Information Systems (GIS). GPS can be used to locate map features that cannot be easily digitized from aerial photographs or satellite images (e.g. water wells, pipelines, administrative boundaries, etc.). GPS can also be used in order to develop new map layers and to rectify satellite image. This is done by collecting coordinates from distinct landmarks that directly refer to a certain pixel in the aerial photograph / satellite image (e.g. road crossings, building edges, towers, junctions, rock formations). With increasing accuracy of the GPS it is increasingly being used by physical and regional planners, particularly when creating or updating map features in order to produce maps scaled in a range from 1:10,000 to 1:100,000.

Updating Maps Using Global Positioning Systems (GPS)

Advantages

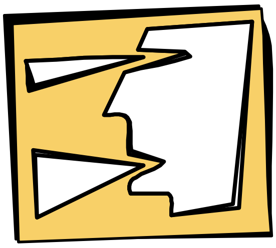
- Quick way of accurately updating maps.
- Ease with which locations for features in maps can be determined with a high degree of accuracy.
- Existing maps can be quickly updated to add new features such as road networks, schools, water supply systems, etc.
- GPS surveys can be undertaken in areas that are vulnerable to regular cloud cover, a fact that often limits the use of satellite images.

Limitations

- For GPS to be useful it requires a high degree of accuracy (including the post-processing of GPS data).
- High-resolution GPS surveys require sophisticated and expensive technologies as well as highly trained staff. Geodetic surveys require a high degree of accuracy if they are to prove useful.
- Distortion of satellite signals can also reduce the area that can be surveyed (e.g. forests, dense urban areas, and tunnels, hill formations)
- The collection of map data is time-consuming, especially if the survey is to cover a wide area or if the level of detail of the survey objects is very high.
- Additional information (attribute data) has to be collected during the survey
- Classification procedures have to be similar for all surveys (e.g. density of trees determined to classify a forest area)

Updating Maps Using Global Positioning Systems (GPS)

Principles and General Procedures



The following steps have to be performed in order to carry out a GPS-survey:

1. Acquisition of a GPS with sufficient accuracy

Since the technology is developing rather fast, it is not possible to recommend a specific GPS model. It is worth comparing costs and the technical specifications in order to identify the most suitable GPS model needed for the task.

2. Setting the properties for the GPS (projection, map datum, coordinate units)

In order to work with the same projection, map datum and coordinate units all relevant GPS data should be directly logged in the desired coordinate system (if the GPS supports this function). This avoids numerous sources of error throughout the entire GPS survey since it is no longer necessary to transfer coordinates at a later stage.

3. Defining map features and corresponding attribute information as well as the level of classification to be surveyed

Before using a GPS the user has to be know how coordinates are logged in the field and how these can then be used for mapping purposes. The following questions help to guide the user during this process:

- **Which map layers** should be displayed / updated in the map? For example wells as point data, road network as lines or land cover as polygons.
- Is a GPS survey the appropriate method to acquire map data of these map layers? For example, a GPS does not work in a dense forest or steep rocky areas.
- Which subtypes of each map layer can be classified and which **objective criteria** lead to this classification (e.g. road types)?

Principles and General Procedures

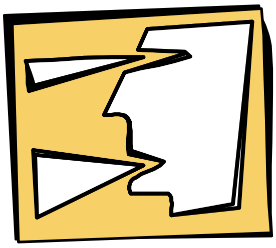
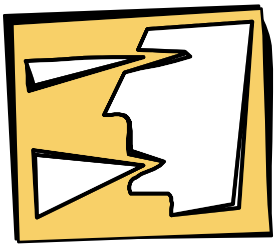


Table 1: Example of classification criteria

Class-ID:	Description	Criteria	Suitability
10	Highway	• At least 4 lanes • Paved	During dry and wet season, All cars & lorries
20	Maintained main road	• 2 lanes • Paved	During dry and wet season All cars & lorries
21	Partially maintained main road	• 2 lanes • Paved • More than 20 % and less than 50 % of the road surface is degraded	During dry season Partially during wet season Cars, lorries & 4 wheel drives (wet season)
22	Not maintained main road	• 2 lanes • Paved • More than 50% of the road surface is degraded	During dry season 4-wheel drive
30	Maintained side road	• 1-2 lanes • Gravel	Dry and wet season, Cars, lorries, 4-wheel drive
31	Degraded side road	• 1-2 lanes • Partially gravel • Degraded (pot holes)	Dry season: lorries Partially wet season (4-wheel drive)
40	Earth road	• 1 lane • Compacted soil • No maintenance	Dry season: cars
50	Walking path	• Less than 1 lane width • Compacted soil	No vehicles, pedestrians, donkeys, bicycle in dry season

Classification criteria can vary with regard to the level of detail of what should be depicted in a map. The higher the number of classes, the more time is required to find the right classification for a certain map feature. If a high number of classes exist, many criteria have to be defined in order to distinguish exactly between the neighboring classes. The optimum classification lies between "too generalized" and "too time-consuming". Table 1 shows how classifications can be reduced to: 10: for Highways; 20-22: for Main roads, 30-31: for secondary roads, etc.

Principles and General Procedures



4. Collecting data with the GPS in the field

During the survey, GPS coordinates can be logged in the field, while additional information has to be noted down synchronously. In general, the GPS stores in the memory a unique number according to one logged waypoint and its coordinates.

However, the GPS does not know:

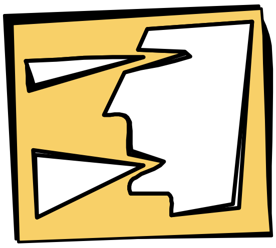
- which map feature has been logged,
- if some coordinates should be combined to a line or polygon,
- which additional information can be observed in the field.

Therefore, forms should be prepared in order to collect all relevant additional information during the survey. However, the style of a GPS survey sheet depends largely on the required information. Basically, additional information is required to group single coordinates in lines or polygons.

Table 2: Example of a GPS survey sheet

GPS-ID	Object ID	1=Point/ 2=Line/ 3=Polygon	Class	Attribute Data / comment
0001	1	1 (Point)	Well	
0002	2	2 (Line Point 1)	Maintained paved road	Min width per lane: 3,5 m
0003	2	(Line Point 2)	“	
0004	2	(Line Point 3)		
0005	2	(Line Point 4)		
0006	2	(Line Point 5)		
0007	3	2 (Line Point 1)	Side road	Gravel coverage: 60 %
0008	3	(Line Point 2)		
0009	3	(Line Point 3)		
0010	4	3 (Poly. Point 1)	Lake	Water quality: Poor
0011	4	(Poly. Point 2)		
0012	4	(Poly. Point 3)		
0013	4	(Poly. Point 4)		Lake border app. 10 m North of this point
0014	4	(Poly. Point 5)		
0015	4	(Poly. Point 6)		
0016	4	(Poly. Point 7)		
0017	4	Represents the last point to close the polygon (equal Poly. Point 1)		
0018	5	1	Church	

Principles and General Procedures



5. Documenting the quality of digitized data and problems that occurred during the survey (e.g. distortion, inaccessibility of areas)

As shown with point 0013 in table 2, it can be useful to measure points, which do not directly have the position of a desired map feature.

6. Transfer of raw GPS data into the computer

Almost all GPS have additional cables or Infrared adapters to transfer the logged raw data onto the computer. The software is generally delivered with the GPS. Many useful tools can also be found and downloaded from the internet.

7. Convert the GPS data to the required coordinate system / projection system (Optional)

If the GPS coordinate system has not been set up properly before the GPS survey, or the GPS only allows the user to store coordinates in a certain system, it can be useful to transfer the coordinate system after the raw data has been imported onto the computer. Many GPS software packages allow the user to recalculate the coordinates into other projection and/or coordinate unit systems.

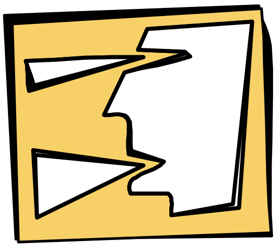
8. Storing the GPS data into a suitable file format (DXF, AutoCAD, ARC/Info Coverage, etc.)

In order to import the GPS coordinates into a GIS, the data has to be stored in pre-determined file format. The required file format depends on the import functions of the GIS software packages. The manuals and help files of the GIS software packages usually include compatibility information and they also show which file formats can be used for importing data.

9. Post-processing of map data in order to increase the accuracy of the collected waypoints

Depending on the GPS being used, there are many ways to increase the accuracy of logged GPS coordinates. For example, data gathered from a second stationary GPS at a nearby location where the exact coordinates are known can be used to correct the logged data gathered by the handheld GPS used in the field. Another way of reducing the level of errors is to move logged points to known positions using satellite images or geo-referenced topographic maps.

Principles and General Procedures



10. Digitizing map features using the collected waypoint data and the documentation about the surveyed map features

Lines and polygons can now be digitized onto GIS map layers on the basis of imported waypoint data and the additionally logged information (see table 2).

11. Entering classified attribute data to the GIS map features (attributes for the network, road level, diameters of pipelines…etc.).

After establishing or updating map layers, additional information can be directly entered as attribute data according to the digitized objects.

12. Cross-checking and updating of survey data with existing map data or satellite images

In view of the fact that satellite images or even older maps that only have a partial coverage of the area being surveyed often have a higher level of accuracy compared to many existing maps, the newly acquired GIS map data can be corrected using these sources of information in the GIS.

13. Documenting all technical procedures in order to refine the technique of map data acquisition with GPS

In order to improve technical procedures and in order to assess the quality of the acquired data, it is important to document all technical procedures used to develop the new maps. This is especially important with regard to the approach used for exchanging data with other organizations or institutions. It is essential to carefully document exactly how the data was collected and classified. There are many different sources of error that can occur during a mapping process using GPS and GIS. This in turn can lead to poor or undesirable results as data is inaccurately presented in the maps. It is very important that the user is made aware of the quality and more importantly the accuracy of the data.

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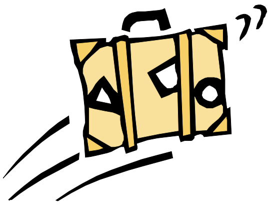
References and Sources Used



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