APPLICATION OF GLOBAL POSITIONING SYSTEM

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1.1 APPLICATION OF GLOBAL POSITIONING SYSTEM

There are so many devices made with the implementation of Global Positioning System. Google Earth is the most famous application that uses the signals received by the GPS receivers. It enables public also to access the maps which tell the users about the locations all around the world.3DEM is freely available software that will create 3D terrain scenes and flyby animations and export GIS terrain data files using any of the following freely available terrain data as a source. People use Global Positioning System for several uses. A research published states that the percentage of uses for each several requirements is as follows.

- ✓ Car navigation 37%
- ✓ Hand held 26%
- ✓ Tracking 10%
- ✓ GIS 8%
- ✓ Survey 7%
- ✓ Manufacturing 7%
- ✓ Vessel Voyage 2%
- ✓ Military Related 1%

United States and European countries show a rapid growth in using GPS for the car navigations and the number of GPS equipped mobile phone usage. Those facts prove that the Global Positioning System helps many people in many other ways.

Most people who have used a GPS probably can’t imagine any limit to its applications. Even if its shortcomings are grievous (it can’t be used indoors, nor very well in a forest, or where there are many tall buildings or cliffs), solutions have been developed to these problems. Usually these solutions involve broadcasting radio signals or pseudo-GPS signals that are highly accurate. The configuration of these systems is very complicated and requires large institutional investments. Most are made by governments. For instance, the European Union is developing a high-accuracy network (along the lines of the U.S. WAAS) for navigation purposes. Even if a GPS receiver lacks the ability to use these extra networks, GPS can still be used in a number of applications, some of which are described here.

1.1.1 GPS-supported ground surveys:

Ground surveys are generally carried out for cadastral purposes of larger areas in terrain, where visibility requirements of the boundaries prohibit the use of photogrammetric techniques. They may also be preferable in countries where photo-adjudication is not accepted due to accuracy concerns. In Europe, cadastral data are already existent. Therefore, a survey cost comparison with photogrammetric methods is not useful there. However, in a number of development projects, ground survey costs per parcel, including the land registration or land titling aspects, have been established.

In Albania, a new cadastral has been established by European funding at a cost of $5 per parcel. The procedure used was aerial photography–aerial triangulation–digital elevation model–digital orthophotos generation followed by public photo adjudication process. In Georgia, a large German technical cooperation project was carried out by GPS-supported electronic tacheometers at a cost of $10 per parcel.

A survey crew is able to measure about fifty parcels per day. In doing so, it has been proved useful to support the ground surveys with aerial photos or orthophotos. For this purpose, ‘digital plane tables’ in the form of large-screen PDAs may be used which record the measured GPS or electronic tacheometer measurements on the screen. These data are superimposed with prepared (ortho) photographic data on the screen, which helps to identify points to be measured terrestrially. A ‘digital plane table’ costs about $10 000.

An urban area of 250 km2 has about 80 000 parcels. The cost of surveying these terrestrially would therefore be $800 000, which is about the same as the photogrammetric line mapping cost at the scale 1:1000, but about four times as much as the photogrammetric mapping cost at the scale 1:2000. This corresponds to a terrestrial survey cost of $3200/km2.

1.1.2 Mapping and geographic information systems (GIS):

Most mapping grade GPS receivers use the carrier wave data from only the L1 frequency, but have a precise crystal oscillator which reduces errors related to receiver clock jitter. This allows positioning errors on the order of one meter or less in real-time, with a differential GNSS (Global Navigation Satellite System) signal received using a separate radio receiver. By storing the carrier phase measurements and differentially post-processing the data, positioning errors on the order of 10 centimeters are possible with these receivers.

1.1.3 Geophysics and geology:

High precision measurements of crustal strain can be made with differential GNSS by finding the relative displacement between GNSS sensors. Multiple stations situated around an actively deforming area (such as a volcano or fault zone) can be used to find strain and ground movement. These measurements can then be used to interpret the cause of the deformation, such as a dike or sill beneath the surface of an active volcano.

1.1.4 Archeology:

As archaeologists excavate a site, they generally make a three-dimensional map of the site, detailing where each artifact is found. GPS capable of precise tracking of carrier phases for all or most of available signals in order to bring the accuracy of relative positioning down to cm-level values required by these applications.

1.1.5 GPS Tracking”

In fact, it is this use which represents the simplest form of GPS tracking. The user is able, using a portable GPS device, to keep a track of where they have been, in order to be able to either retrace their steps, or follow the same path again in the future. When combined with other technologies such as GPS phones, this also gives the possibility for other users of GPS to follow in the footsteps of the initial user; which can be a useful application of GPS tracking for field activities.

Where GPS tracking comes into its own, however, is when it is combined with other broadcast technologies such as radio. GPS watches, for example, can be fitted with a GPS receiver which is capable of calculating its position, whilst also broadcasting that using a miniature radio transmitter. The signal is relayed to a central command centre equipped with GPS software systems which can track the position of the wearer, and either store it as a path, or relay that information to a third party. That third party could be an anxious parent, or the police. In fact there are a variety of GPS phones and wristbands which are sold in conjunction with a service which enables third parties to find out where their charges are at any time of the day or night.

1.1.6 GPS Vehicle Tracking:

This is particularly useful when using GPS units attached to vehicles which have distinctive identification such as chassis numbers. The same principle applies as for a GPS tracking device designed to be worn by a human, except that the GPS is integrated within the vehicular electronics. This serves two purposes. On the one hand, it provides the driver with an integrated GPS system, without the necessity to purchase a car navigation system, or a PDA-based GPS system, whilst also offering the possibility to relay that information via a radio or mobile phone transmitter. In fact, these systems have already been tried in the field, primarily as a vehicle locator in the event that the vehicle to which the GPS vehicle tracking system is attached is stolen. The police, once informed, can find out from the control centre where the vehicle is, and proceed to track it physically. A useful consequence of being able to use GPS vehicle tracking to locate a vehicle is that the manufacturer can also use the information to alert the driver as to when they near a service centre. If, along with the GPS coordinates, the system relays telemetry information such as the status of the engine, time since the last service, or even information not relating to defects, the receiver of this information can make a decision as to what kind of alert to pass on to the driver. More and more people have used GPS-based systems in cars; many more have benefited from the use of GPS in cars, buses, trains, and trucks. The GPS receiver may be hidden in the dashboard, but may be critical for the taxi company to find out which taxi is closest to you when you call for a pickup. A GPS receiver can help a trucking company better organize deliveries to minimize the fuel used. A bus may have a GPS installed to help the bus company indicate to passengers how long they need to wait for the next one. Navigation systems are used for more than vehicles on land. They are also widely used for nautical and aeronautical navigation. They have become for many sailors irreplaceable because they work regardless of the weather and can easily be combined with computerized chart information. Almost all planes use, or will use, GPS. Together with high-precision positional trans-mission, planes can use GPS-based systems to land in any weather with centimeter precision.

1.1.7 Coordinated Tracking

This also opens up the possibility to allow for coordinated vehicle tracking, in which GPS tracking is used to share location information between several vehicles, all pursuing the same end goal. It is an approach that has been used successfully in conjunction with GPS fish-finder units which help fisherman to locate, track and catch schools of fish. These units are more sophisticated than the average GPS unit, having other features such as depth gauges, tide time information and so forth. The basic GPS functionality is the same however, and units can either share that information with each other, or a central point. The central point can also be one of the fishing vessels, and it has on-board computer systems capable of reconciling all the locator information along with a map, thus allowing the different vessels to coordinate their actions.

This also has military applications, of course, where units can share, in real time, information about their location, even when line-of-sight is no longer possible. In the past, this was done by relaying often inaccurate map co-ordinate estimations; now the locations can be called in with high absolute accuracy.

1.1.8 Consumer GPS Tracking:

Despite its' hi-tech military and commercial fishing applications, as well as use in aviation GPS, the principal application of GPS tracking will be in providing an enabling technology to augment existing systems. These systems will include cell phones and vehicles, usually in conjunction with a central point of service designed to keep track of the location.

1.1.9 Use of GPS to determine well location:

There is typically a lot of good geologic and hydrologic information contained on the well log and drilling report forms. In order for this data to be used for mapping purpose and some regulatory programs, the exact location of well has to be known. GPS have made it possible.

1.1.10 Weather Prediction Improvements:

Measurement of atmospheric bending of GNSS satellite signals by specialized GNSS receivers in orbital satellites can be used to determine atmospheric condition such as air density, temperature, moisture and electron density. Such information from a set of six micro-satellites, launched in April 2006, called the Constellation of Observing System for Meteorology, Ionosphere and Climate COSMIC has been proven to improve the accuracy of weather prediction models.

1.1.11 Photographic Geocoding:

Combining GNSS position data with photographs taken with a (typically digital) camera, allows one to view the photographs on a map or to lookup the locations where they were taken in a gazetteer. It's possible to automatically annotate the photographs with the location they depict by integrating a GNSS device into the camera so that co-ordinates are embedded into photographs as Exif (Exchangeable image file format) metadata. Alternatively, the timestamps of pictures can be correlated with a GNSS track log.

1.1.12 Marketing:

Some market research companies have combined GIS systems and survey based research to help companies to decide where to open new branches, and to target their advertising according to the usage patterns of roads and the socio-demographic attributes of residential zones.

1.1.13 Social Networking

Cellular phones equipped with GPS technology, offering the ability to pinpoint friends on custom created maps, along with alerts that inform the user when the party is within a programmed range.

1.1.14 Altitude Information

GPS has transformed how altitude at any spot is measured. GPS uses an ellipsoid coordinate system for both its horizontal and vertical datums. An ellipsoid—or flattened sphere—is used to represent the geometric model of the earth.

1.1.15 Application to Water Resources

In an effort to protect water resources, GPS is being used to collect the coordinates for well heads as part of the Well Head Protection Program. GPS has also been used to produce coordinates for potable surface water intakes, and reservoir boundaries. To more effectively manage regulatory permits across the various environmental permitting programs, GPS is being used to collect coordinates for facilities that have permits. These include facilities that discharge to surface water, ground water, air, store hazardous waste onsite and/or have underground storage tanks. Environmental monitoring programs are using GPS to generate coordinates for monitoring stations. Water monitoring programs have been determining coordinates of sampling stations for existing water quality monitoring networks. Should a major oil spill occur in their waters, coordinates for the spill location and aerial extent of the plume could be collected. In short order, an effective booming strategy could be developed to protect environmentally sensitive areas in the region of the spill. In the event of a major natural disaster, GPS can be used to assist in the damage assessment and inventory.

- ❖ **GPS Techniques for Water Stage Measurement and River Slope Calculation Wetland Area**

Study of river basin many times involves difficulties of making use of hydrological data such as river stage height due to inaccessibility and political boundaries. The slope of river is very important hydrological data especially from point of view of hydrologic and hydrodynamic models calibration. These specific hydrologic applications need calculation of local changes of water level and slope. Traditionally slope is calculated using data available from water gauge which are always insufficient and the distance between two successive gauge stations varies from few to several kilometre's. For hydrodynamic model calibration the water stage determined based on water level measured should be within few hundred meters. In natural river valley such detailed measurements are difficult to perform by use of classical geodetic leveling technique; in case of marginal river wetland it is even impossible, because of harsh measuring condition such as:

- Disturbance of natural vegetation.
- Many oxbow and wetland areas.
- Unstable organic ground.
- Very few network coordination points.

The GPS technique seems to be optimal tool for altitude measurement in wetlands. The average vertical measurement error for DGPS is about 3m which is sufficient for river slope calculation. GPS become not only accurate but also very fast measurement technique. Moreover GPS technique allows performing high accuracy measurement of all three co-ordinates including altitude, easy and fast way. The DGPS definitely can be used for hydrologic application in various water-bodies.

❖ **Use of GPS receivers as a soil moisture network for water cycle studies**

Soil moisture is fundamental to land surface hydrology, affecting flooding, groundwater recharge, and evapotranspiration [Viterbo and Betts, 1999]. It also influences weather and climate via its influence on turbulent andradiative fluxes between the land surface and atmosphere [Entekhabi and Rodriguez-Iturbe, 1994]. The global distribution and temporal variations of soil moisture are sought both for analyses and modeling purposes. Soil moisture is measured in situ at many locations, both as part of individual studies or as part of monitoring networks.

Measurements of soil moisture, both its global distribution and temporal variations, are required to study the water and carbon cycles. Signals routinely recorded by Global Positioning System (GPS) receivers for precise positioning applications can also be related to surface soil moisture variations. Various studies depicted significant correlation between the result obtain from GPS network and soil moisture fluctuation measured in the top 5 cm of soil with conventional sensors.

1.1.16 Application to Agriculture

Global positioning systems (GPS) are widely available in the agricultural community. Farm uses include:

- Mapping yields (GPS + combine yield monitor)
- Variable rate planting (GPS + variable rate planting system)
- Variable rate lime and fertilizer application (GPS + variable rate controller)
- Field mapping for records and insurance purposes (GPS + mapping software)
- Parallel swathing (GPS + navigation tool).

The Global Positioning System (GPS) provides opportunities for agricultural producers to manage their land and crop production more precisely. Common names for general GPS applications in farming and ranching include precision agriculture, site-specific farming and prescription farming. GPS applications in farming include guidance of equipment such as sprayers, fertilizer applicators and tillage implements to reduce excess overlap and skips. They can also be used to precisely locate soil-sampling sites, map weed, disease and insect infestations in fields and apply variable rate crop inputs, and, in conjunction with yield monitors, record crop yields in fields.

GPS and associated navigation system are used in many types of agricultural operations. These systems are useful particularly in applying pesticides, lime, and fertilizers and in tracking wide planters/drills or large grain-harvesting platforms. GPS navigation tools can replace foam for sprayers and planter/drill-disk markers for making parallel swaths across a field. Navigation systems help operators reduce skips and overlaps, especially when using methods that rely on visual estimation of swath distance and/or counting rows. This technology reduces the chance of misapplication of agrochemicals and has the potential to safeguard water quality. Also, GPS navigation can be used to keep implements in the same traffic pattern year-to-year (controlled traffic), thus minimizing adverse effects of implement traffic.

❖ Yield Monitoring Systems

Yield monitoring systems typically utilize a mass flow sensor for continuous measuring of the harvested weight of the crop. The sensor is normally located at the top of the clean grain elevator. As the grain is conveyed into the grain tank, it strikes the sensor and the amount of force applied to the sensor represents the recorded yield. While this is happening, the grain is being tested for moisture to adjust the yield value accordingly. At the same time, a sensor is detecting header position to determine whether or not yield data should be recorded. Header width is normally entered manually into the monitor and a GPS, radar or a wheel rotation sensor is used to determine travel speed. The data is displayed on a monitor located in the combine cab and stored on a computer card for transfer to an office computer for analysis. Yield monitors require regular calibration to account for varying conditions, crops and test weights. Yield monitoring systems cost approximately $3,000 to $4,000, not including the cost of the GPS unit.

❖ Field Mapping with GPS and GIS

GPS technology is used to locate and map regions of fields such as high weed, disease and pest infestations. Rocks, potholes, power lines, tree rows, broken drain tile, poorly drained regions and other landmarks can also be recorded for future reference. GPS is used to locate and map soil-sampling locations, allowing growers to develop contour maps showing fertility variations throughout fields. The various datasets are added as map layers in geographic information system (GIS) computer programs. GIS programs are used to analyze and correlate information between GIS layers.

❖ Precision Crop Input Applications

GPS technology is used to vary crop inputs throughout a field based on GIS maps or real-time sensing of crop conditions. Variable rate technology requires a GPS receiver, a computer controller, and a regulated drive mechanism mounted on the applicator. Crop input equipment such as planters or chemical applicators can be equipped to vary one or several products simultaneously. Variable rate technology is used to vary fertilizer, seed, herbicide, fungicide and insecticide rates and for adjusting irrigation applications.

❖ Precision Farming

Location coordinate information is needed in precision agriculture to map in-field variability, and to serve as a control input for variable rate application. Differential global positioning system (DGPS) measurement techniques compare with other independent data sources for sample point location and combine yield mapping operations. Sample point location can be determined to within 1m (3ft) 2dRMS using CIA code processing techniques and data from a high-performance GPS receiver. Higher accuracies can be obtained with carrier phase kinematic positioning methods, but this required more time. Data from a DGPS CIA code receiver are accurate enough to provide combine position information in yield mapping. However, distance data from another source, such as a ground-speed radar or shaft speed sensor, needed to provide sufficient accuracy in the travel distance measurements used to calculate yield on an area basis.

Precision farming, sometimes called site-specific agriculture, is a strategic task for agriculture: indeed it has the potential to reduce costs through more efficient and effective applications of crop inputs; it can also reduce environmental impacts by allowing farmers to apply inputs only where they are needed at the appropriate rate. Precision farming requires the use of new technologies, such as GPS, environmental sensors, satellites or aerial images and GIS to asses and understands variations. The various research deals with potentialities and limits of GPS for navigation in agricultural applications. GPS needs for farming applications are:

- Low cost in order to allow farmers to buy GPS technologies;
- High precision in order to reduce the use of pesticides and fertilizers by means of an exact track.

At first, static and kinematic tests needed to be performed, simulating the typical behavior of an agricultural vehicle and using different kinds of GPS receivers and navigation software. The experimental results are presented: particularly, advantages and disadvantages of the popular Kalman filtering on trajectories are discussed. Starting from the analyses of the previous results, and taking into account the typical user requirements, a preliminary design for a new prototype has been done; particularly, both needed instrumentations and their costs and a proposal of a new navigation algorithm will be presented.

Precision farming is a method of crop management by which areas of land within a field may be managed with different levels of input depending upon the yield potential of the crop in that particular area of land. The benefits of so doing are two fold:

- The cost of producing the crop in that area can be reduced.
- The risk of environmental pollution from agrochemicals applied at levels greater than those required by the crop can be reduced.

Precision farming is an integrated agricultural management system incorporating several technologies. The technological tools often include the global positioning system GPS, geographical information system GIS, remote sensing, yield monitor and variable rate technology. The paper talks about the use of GPS to support agricultural vehicle guidance. Equipment for this purpose consists on a yield monitor installed: the system supports human guide by means of a display mapping with a GIS the exact direction produced by GPS receiver put on vehicle top: the driver follows it to cover in an optimal path the full field. GPS receivers for this application require, not only a high accuracy to ensure the reduction of input products, but even an easy and immediate way of use for farmers; without forgetting low costs.

Obviously, the technology to achieve high precision still exists but it is too expensive and difficult to use for not skilled people. Survey modality usually adopted in agricultural applications is real time kinematic positioning, DGPS RTK, which enable to have a good accuracy by means of corrections received. In this experimentation the aim is to obtain a sub-metric accuracy using low cost receivers, which can provide only point positioning. These receivers have been developed for maritime navigation purposes; our aim is their optimization in order to apply them for land navigation in particular for farming activities. Some tests using these receivers were carried out, but results were not satisfying and probably the reason has to be assigned to the implementation of a Kalman filtering inside the receiver software. This is the starting point for a new project, at the moment still in progress, which aim to develop a new algorithm based on Kalman filter. Its purpose is to improve low cost receiver outputs in order to optimize trajectories and to reach needed accuracy in vehicle positioning during agricultural activities.

1.1.17 Others

- **Hiking:** More and more hikers turn to GPS to help them find out more exactly where they are and to help them to plan a route before they go. GPS may not be reliable in canyons or along steep cliffs, but in most situations and weather it provides accurate positional information. Some map makers have started to change their map designs to make it easier for hikers to use. Some tourist areas offer GPS for people to help them follow a certain tour.

- **Aids for the Visually Impaired:** Combined with acoustic or tactile signaling devices, GPS can be used to help visually impaired people find their way in new settings and navigate places that rapidly change—for example, a state fair or a college campus, as was done by Professor RegGolledge and others at the University of California at Santa Barbara

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