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GIS, remote sensing and GPS: Their activity, integration and fieldwork

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Abstract
The sciences, Progress, technologies, practices and application of remote sensing (RS), Global Positioning System (GPS) and of Geographic Information Systems (GIS) arose separately, developed in parallel, balance, intersect, and are now inextricably linked. Almost all the features in most GIS are collected by means of GPS data, satellite imagery or aerial photogrammetry (digital photogrammetry), and GIS is the application where this imagery is most generally visualized. “All the foundation elements of GIS come from RS and GPS: cultural features, highway, roads, buildings, environment, water features, topography, terrain, forestry, soils, slopes, geology, and many others”.
The fast extension, rapid development, fieldwork, and integration of spatial technologies such as RS, the GPS and GIS have created many new tools for professional development, but have also broadened the "digital divide" leaving many with little understanding and conception of the technology and potential applications.
In this paper presents examples of extension-related applications of GIS-GPS-RS technologies and discusses how to go about learning more and determining if these technologies would be useful and their activity, Integration and Fieldwork. Also In this paper the necessity of integrating, activity and fieldwork of GPS, RS, and GIS is discussed following their definition. The current status of integration is reviewed under four proposed models: linear, interactive, hierarchical, and complex.

Keywords: GIS, remote sensing, GPS

Introduction
GIS and RS and include the two major components of geographic information science (GISci), an overarching field of endeavor that also encompasses global positioning systems (GPS) technology, geodesy, geomatics and traditional cartography (Goodchild 1992, Estes and Star 1993, Hepner *et al*. 2005). Now, GIS software almost always includes tools for display and analysis of images, and image processing software commonly contains options for analyzing ‘ancillary’ geospatial data (Faust 1998).
However RS and GIS expand quasi-asunder, the cooperation between them has become increasingly obvious (Aronoff 2005). Also James W. Merchant and Sunil Narumalani (in chapter 18 - 2009 and 2014) comprehensively reviewed current subject in the integration of RS and GIS with an emphasis on how GIS technology should cope with increased ability in remote sensing data attainment.
We focus on integration, activity and Fieldwork of RS, GPS and GIS. Our definition of integration includes the use of each technology to benefit the other, as well as the application of both technologies, in concert, for modeling and decision-support. Through these definitions, the necessity of their integration is justified. Next, all possible methods by which the three disciplines have been integrated are summarized and presented graphically. Four models of integration (linear, interactive, hierarchical, and complex) are proposed and evaluated.

Definition and activity
Before any discussion on the activity, integration and Fieldwork of GIS, Remote Sensing and GPS can begin, they must be defined precisely first.
GPS, which stands for Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world [9].

The GPS is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil, and commercial users around the world [10, 5].

GIS, Geographic information system or Geospatial information system enables you to envision the geographic aspects of a body of data. Basically, it lets you query or analyze a database and receive the results in the form of some kind of map. Since many kinds of data have important geographic aspects, a GIS can have many uses: weather forecasting, sales analysis, population forecasting, and land use planning, to name a few. A GIS lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends. GIS benefits organizations of all sizes and in almost every industry [6]. There is a growing interest in and awareness of the economic and strategic value of GIS. GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. What goes beyond a GIS is a spatial data infrastructure, a concept that has no such restrictive boundaries [11, 5].

RS, Remote sensing technologies are used to gather information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. Most remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation, which is processed into a digital image that can be overlaid with other spatial data [7]. Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Remote sensing is a sub-field of geography. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation) [13, 5].

Remote sensing Collecting and interpreting information about the environment and the surface of the earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote-sensing methods include aerial photography, radar, and satellite imaging [6, 4].

Requirement of Integration

Despite its various definitions, GIS distinguishes itself from the other two technologies in that it enables data from diverse sources to be integrated, analyzed, and even modeled owing to its powerful analytical functionality. These functions, however, cannot be fully realized if the GIS database is incomplete, inaccurate, or obsolete. By their nature, the data contained in a GIS database are either spatial (e.g., administrative boundaries and boundaries of land-cover parcels) or thematic (e.g., types of land cover). Traditionally, spatial data and some thematic data associated with them are digitized from existing topographic or land-use maps. Nevertheless, these maps are secondary in nature. They may not show all desired features because of map generalization. Second, topographic or land-use maps may be obsolete due to rapid changes on the ground. These limitations can be overcome with the use of RS and/or GPS.

Aerial photographs and satellite images are original and are able to offer more current areal-based data than do topographic and thematic maps, while GPS is an efficient method of collecting data in a timely fashion [1, 4].

One element common to all definitions of remote sensing presented in the preceding section is its data acquisition functionality. Original aerial photographs and satellite images, digital or analog, are geographically referenced to their own coordinate systems. Point-based data at selected landmarks, commonly known as ground control points (GCPs), may be used to geo-reference remotely sensed images. GPS data, even if areal in nature, can by no means replace aerial photographs or satellite images because of their inability in obtaining truly 2D areal data [1].

The above discussion illustrates that RS, GIS, and GPS are intrinsically complementary to one another in their primary functions. Each of the technologies has its limitations. If applied individually, it may be troublesome or impossible for each technology to function properly in certain applications. The importance of GPS in contemporary GIS and remote sensing analyses can hardly be overstated (see Gao 2002) [3].

Models of Integration

The diverse methods for the integration of remote sensing, GPS, and GIs, as has been described in the literature, can be conceptualized and summarized by four models: linear, interactive, hierarchical, and complex. They are elaborated on below [1].

Linear Model

Data flow linearly from GPS to RS and ultimately to a GIS in the linear model (Figure 1). In this model the unique strength of each component is utilized to the maximum. That is, GPS is used to obtain geometric control for aerial photographs and satellite imagery. Rectified photographs and images are then integrated into a GIS database. The linear structure of the model implies that the three components are not equally important. All of the spatial analysis and modeling are carried out in the GIs. In this sense, GPS data serve to bridge the gap between remote sensing data and other data in the GIS database. They are used to standardize satellite images and aerial photographs to a geo-referencing system used by other GIS data [1].

In this model, the integration of GPS data with RS occurs in three temporal modes-simultaneous, independent, and post-processing-all of which take place prior to integration with a GIs.

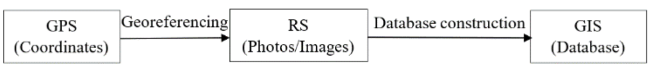

Fig 1: The liner model of integration

Interactive Model

The interactive model bears a striking resemblance to the linear one in structure (Figure 2). Upon closer scrutiny, data flow mutually between GPS and RS, and between RS and GIS. The maturity implies that the ultimate task of integration may be carried out in a raster GIS or in a digital image analysis system such as ERDAS Imagine@T.hus, remote sensing can no longer be perceived as a mere feeder of data to a GIS. Although it is possible for data to flow from a GIS to remote sensing in this model, left-to-right integration is much more common than is data flow in the opposite direction, as the arrow width in Figure 2 implies [1].

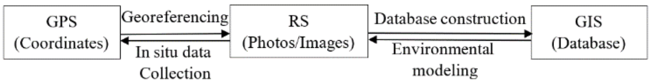

Fig 2: The interactive model of integration

Hierarchical Model

There are two tiers of integration in the hierarchical model (Figure 3). The first tier of integration (overlay) occurs between GPS data and RS imagery. In addition to the aforementioned rectification of remotely sensed images using GPS derived coordinates, the rectified images are also used to characterize in situ samples according to their locations determined with a GPS receiver. Overlay of in situ samples with a digital photograph or satellite imagery helps to establish the association between the variable under study and its image properties (Usery *et al*., 1995; Gao and O'Leary, 1997). Statistical relationship between the two variables may be established using a spatial analysis package such as S-Plus [1].

Fig 3: The hierarchical model of integration

Complex Model

Containing all possible associations between any two components, the complex model represents the ultimate or total integration of GPS, RS, and GIS (Figure 4). In addition to all links contained in the previous three models, there is an extra interaction between GPS and GIS. In this case, GPS data may be directly exported to a GIS database to update it or to construct new databases (Bor, 1994). These data can be point, linear, or even areal. Their geometric properties must be transformed to those of the data already stored in the GIS database before the integration. This integration has found applications in precision farming in which a GPS receiver is used to measure coordinates associated with precision-farming variables while a GIS is used for data integration, storage, and analysis (Swindell, 1995; Lachapelle eta]., 1996). Examples include work in precision farming, mobile mapping, emergency response, and wildlife management (see Gao 2002, Sampson and Delgiudice 2006, Hong *et al.* 2006). The integration of a GIS with GPS is similar to that between remote sensing and GPS [1].

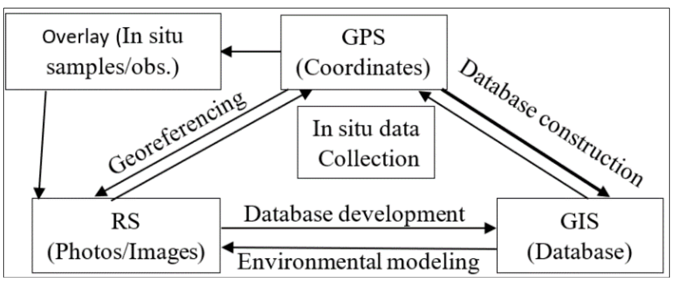

Fig 4: The complex model of integration

Fieldwork

The widespread and largest use of computers has led to the development of new technologies, collectively known as geographical information sciences (GIs), for mapping and monitoring features on the surface of the Earth. Foremost for reconnaissance and fieldwork among these technologies are: GIS, which can take digital datasets and produce maps showing features of interest in matter of seconds; the GPS, which allows positions to be determined to ±10 m anywhere on the Earth's surface; and methods of observing features from a distance, such as photography or infra-red scanning, known as RS. These GIS techniques complement the surveys and sampling that are at the heart of scientific exploration (Figure 5): they greatly enhance the types of fieldwork that can be carried out, reduce the amount of time needed for many tasks and improve the quality of results [2].

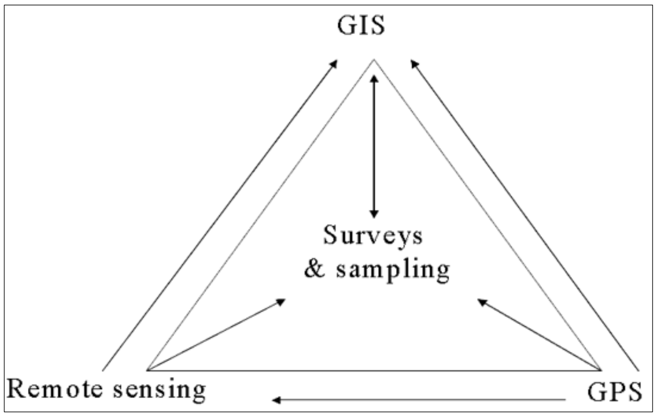

Fig 5: Geographical information sciences and expedition fieldwork.

A fundamental objective of most exploration is to observe and record information about the part of the world being studied, for instance by field surveys, photography, or questionnaires. The development of ever-cheaper and more powerful computers, GIS software and GPS kit, along with low-cost satellite pictures of the Earth, has greatly improved the potential of expeditionary fieldwork to record, analyses and present data that may help us to improve conditions on this beleaguered planet [2, 8].

Remote sensing provides us with a means of recording the distribution of features on the surface of the Earth and changes in those features over time: it is often the only source of new data about a region that will be available to you, prior to you going there to collect field data. Your GPS will tell you where you are in your study region and allows you to input your sample locations into a GIS. A GIS is a means of combining existing data and new data from fieldwork or the interpretation of remotely sensed images. GIS-generated maps greatly reduce the original amounts of data and can be designed to focus on specific themes of interest to your research [2, 12].

There are many ways in which geographical information sciences can help with fieldwork projects, these are just a few of the possible applications.

Existing Applications

The value of integrating and Fieldwork GIS, GPS, and RS lies in those applications that require comprehensive and georeferenced data current up to seconds or instantly. These applications include *Resources management and Environmental monitoring*, *Emergency response*, *mobile mapping*, *Logistics*, *Research*, *Monitoring*, *Conservation applications*, *Technology transfer*, *Education*, and etc.

Resources Management and Environmental Monitoring
Multi-use management complexities of natural resources. Integration empowers them to quantitatively model the resources and objectively analyze their multiple demands in nearly real time. Remote sensing is critical to acquiring data for the efficient management of natural resources such as forests [1].
Resulting in the reduction in the loss of nutrients from agricultural fields (Ifft *et al*., 1995).
Ground photographs is visualization of scenic resources (Clay and Marsh, 1997) [12].

Emergency Response
Emergency situations such as fires, accidents, and crime scenes require automatic vehicle navigation to the concerned spot.
Other capabilities, such as improved flood prediction and global mobile communications during relief, are almost within reach. Decisions related to floodplain management require a high-resolution digital elevation model (DEM) and floodplain-related GIs data layers. A high-resolution DEM may be generated using digitally scanned photos in conjunction with highly accurate ground control from a GPS survey (Sugumaran *et al*., 2000) [1].

Mapping and Mobile Mapping
Mapping of linear features (e.g., roads, pipelines, power lines, river networks, coastlines, etc.) [Cooper *et al*.1995] and to some extent, areal features, is achievable with GPS alone by logging data along the features of their perimeters. Aerial photographs can be used to accurately locate trees and to create appropriate maps that highlight individual trees and other landmarks (Kane and Ryan, 1998). Highway and railway maintenance, softcopy photogrammetry, and utility mapping [Novak, 1993] [1].

Logistics: Planning routes and navigation;
Research: Mapping vegetation, wildlife, urbanization, soils and geological features;

Monitoring: Data logging of fire extents, forest loss, river channel changes;

Conservation applications: Assessing biodiversity, park zonation, impact assessment;

Technology transfer: Training local technical staff, donating hardware and shareware;

Education: Maps for displays, involving school children with fieldwork [2].

Results and Discussion
The wide variety of approaches by which "GIS, Remote Sensing and GPS: their activity, Integration and Fieldwork" is summarized in four models: linear, interactive, hierarchical, and complex. The linear model is the classic example of integration and fieldwork in which the unique strength of each discipline is utilized. Representing the ultimate integration and fieldwork, the complex model contains all possible interactions between any two components. This model may degenerate into one of the other three if some interaction is missing from the integration.
In mapping natural resources, land-based resources such as farmland, vegetation, and forests have been studied extensively. Among environmental problems, the coastal zone has received the most attention. By comparison, hydrology, especially watershed and storm water management, an area that can benefit considerably from the integrated approach, has received insufficient attention. Nor has landscape ecology Thus, the full potential of integrating GPS with remote sensing and GIS has not yet been realized. Predictably, more research on the applications of integration to these areas will be carried out in the future.
The value of integrating and fieldwork GPS with remote sensing and GIS is the greatest in applications that require comprehensive, georeferenced, real-time or almost real-time data. These applications include mobile mapping, disaster mitigation, and emergency response. The future prospects for integrating GPS with remote sensing and GIS are in the development of enhanced location-aware multi-media PDA systems and distributed DMGIS. Many new applications will become possible if the obstacles to integration and mobile communications are successfully tackled.

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