Artificial Intelligence in GIS: A Roadmap to remote sensing and GPS

Srilekha Pamarthi [1], Sai Sindhu Dandamudi[2]

[1] Software Engineer, Infotech Enterprises Limited

[2] Software Engineer, Infotech Enterprises Limited

Madhapur, Hyderabad

Abstract:

The article is aimed at providing the framework for providing the user the desired map which is generally a spatial representation shown as a processed data framework which is nothing but point to point mapping or generally called as pixel to pixel mapping. Here we have also embedded artificial intelligence because the agent uses various artificial intelligent techniques for providing access to, and support for the manipulation of, spatial information. The agent is designed as an open architecture that can accommodate a large number of mobile users and services possibly distributed across a wide geographical area. Today's users are mobile and are equipped with small powerful devices. Using wireless communication, these devices are/will be capable of exchanging digital data and voice from almost any location. In this paper, we present the agent architecture which is aimed at replacing the monolithic approach to geographic information systems with a new dynamic, lean, and customizable system supporting spatially-oriented applications. We present this vision, describe the design of the agent that we architected and discuss a sample application.

Keywords: *Agent, GPS, Remote sensing, Spatial data, Artificial Intelligence*.

About the Author:

MS. Srilekha Pamarthi graduated from CVR College of Engineering, Hyderabad in Bachelor of Technology specialized in Electronics and Communication Engineering and is presently working as software engineer in Telecom department in Infotech Hyderabad .Has got one year real time experience in JAVA and Content Engineering.

Email: Srilekha.pamarthi@infotech-enterprises.com

Contact No: +91 – 8977014798

About the Co-Author:

MS. Sai Sindhu Dandamudi graduated from Princeton College of Engineering, Hyderabad in Bachelor of Technology specialized in Computer Science Engineering and is presently working as software engineer in Telecom department in Infotech Hyderabad .Has got one year real time experience in JAVA and Content Engineering.

Email:Sindhu.dandamudi@infotech-enterprises.com

Contact No: +91 – 7702859747

Introduction

The concept of agent is becoming increasingly important not only in research but also in commercial applications. Research on agents emerged initially form Distributed Artificial Intelligence, a branch of Artificial Intelligence that deals with the solution of complex problems by networks of autonomous, cooperating computational processes called agents. Based on the concept of agent we define Spatial Agents as agents that make spatial concepts computable. By implementing spatial agents we hope to solve the following problems: Locating and retrieving Spatial Information in large networks (and specifically the Internet), Facilitate the handling of a GIS user interface, Implementing improved spatial tasks and Creating interfaces between GIS and specific software packages. This paper deals with the concept of designing the agent which responds to the user requested data and displays it efficiently to the user with various algorithms used in it and providing the user requested map that he deserves to view which is a spatial representation. It also deals with the concepts of Remote Sensing and GPS where it fetches the co-ordinates of the user and the destination. It discusses with GPS satellites where it snaps the image from user to the destination with distance as diameter and sweeps a sphere around the user using concept of digital geo referencing. This article also discusses with pattern recognition and natural language processing in Artificial Intelligence where agent normalizes the map, responds and interact with the user to reach his destiny. So let us start with remote sensing and GPS.

Description:

I. GPS , Remote Sensing and Spatial data:

Remote Sensing (RS) refers to the science of identification of earth surface features and estimation of their geo-biophysical properties using electromagnetic radiation as a medium of interaction. Spectral, spatial, temporal and polarization signatures are major characteristics of the sensor/target, which facilitate target discrimination. Earth surface data as seen by the sensors in different wavelengths (reflected, scattered and/or emitted) is radiometrically and geometrically corrected before extraction of spectral information. Remote sensing makes it possible to collect data on dangerous or inaccessible areas. Aircraft and satellites are the common platforms for remote sensing of the earth and its natural resources.

There are two main types of remote sensing: passive remote sensing and active remote sensing. Passive sensors detect natural radiation that is emitted or reflected by the object or surrounding area being observed. Active sensors emit energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. Radar and LiDAR are examples of active remote sensing where the time delay between emission and return is measured, establishing the location, height, speeds and direction of an object.

The Global Positioning System is a satellite-based radio navigation system provided by the US Department of Defense. It permits users with suitable receivers to establish their position, speed and time on land, sea or in the air, at any time of the day or night and in any weather condition. The System is accurate to within 30 meters, which is equal to or better than any other radio navigation system available today.

A GPS receiver can obtain a position fix anywhere in the world. GPS receivers use the principle of "RANGING". The receiver measures the distance from a location on earth to the positions of several satellites to determine the latitude and longitude of the position on earth.

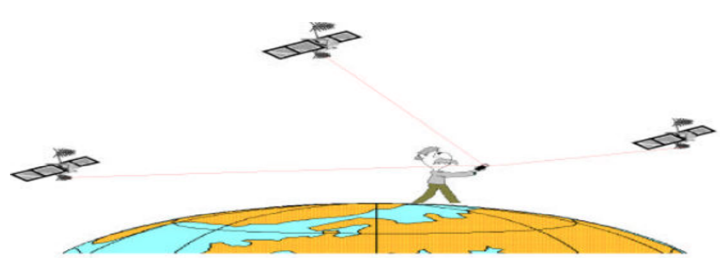


Fig: 1: GPS Navigation

Suppose when the user turn on the GPS receiver it picks up the signal of 1 satellite. The receiver tells the location of that satellite and the distance between the user and it. But this single measurement is not a big help. At best, it concludes that user is within a rather large circle whose circumference is determined by distance from the user to the satellite. When the GPS receiver picks the signals of another satellite helps to narrow down the location so that destination will be within the intersection of two large circles. As the number of satellites increases the user finds the precise point of the destination and the elevation.

The GPS remote sensing is the major part which senses the location and destination of the user the data that a GPS satellite passes is the longitudes and latitudes of the user location and the destination but the very important thing is that our agent requires the spatial data of the surrounding map till the destination of the user that spatial data has to be given as input from the GPS satellite. As the satellite records the spatial geographical data, our agent requests the data from the satellite serving this GPS and remote sensing with an area equal to the circle constructed with distance equal to the source and the destination as diameter around the user and the user as the center of the circle in order to load the map dynamically instead of static maps which we use now a days. By this the map or the route which is really present on that area that the user had requested will be given to the agent for further processing.

II. Concept of Digital Image Georeferencing in our Agent:

After getting the spatial data and the user required co-ordinates the spatial data has to be processed with the agent specified co-ordinates which our agent uses these co-ordinates for further processing which is called as convention. The map and the user location and destination are to be named or the co-ordinates are to be agent specified for this process we use digital image georeferencing. What is Georeferencing?

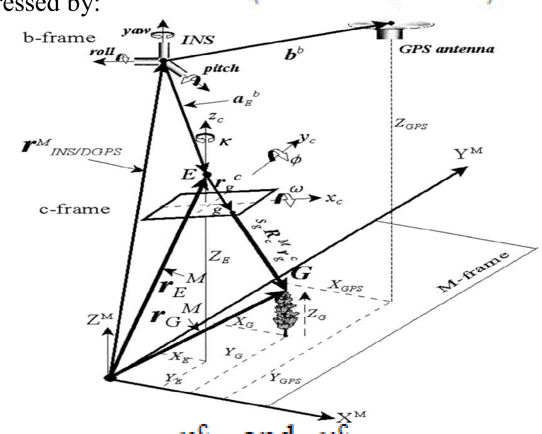
Georeferencing is the process of aligning a raster data set to known map coordinates and assigning a coordinate system. Georeferencing creates additional information within the file itself and/or in supplementary files that accompany the image file that tells GIS software how to properly place and draw it. Georeferencing means that coordinates from a known system are assigned to an aerial photo or scanned paper map. Thus, the photo pixels get a geographic location. The procedure is carried out so that the raster datasets can be used with other spatial data. If the raster data only consists of a scanned map or photo, attributive data needs to be assigned to the picture. A photo or scanned map is often manually digitized into vector format features.

Direct georeferencing of digital images can be described by first introducing the collinearity concept rearranged for object coordinates as:

$$r_G^M = r_E^M(t) + s_g \mathbf{R}_c^M r_g^c(t)$$

Where r_G^M is the georeferenced 3D vector of coordinates of an arbitrary object point G in the mapping frame (M-frame) is the 3D vector of the coordinates of the exposure station E, of any imaging sensor, at the instant of exposure, in the M-frame; $r_E^M(t)$ is the scalar factor per point per image for each imaging sensor; is a matrix rotating each imaging sensor camera frame (c-frame) into the M-frame utilizing the three photogrammetric rotation angles ω, φ and κ; and s_g is the 3D vector of coordinates of the image point g in the (c-frame), expressed by:

$$r_g^c(t) = \left(x_g^c - x_{pp}^c ; \frac{y_g^c - y_{pp}^c}{k} ; -f \right)$$



Where x_g^c and y_g^c are image coordinates of point g and x_{pp}^c and y_{pp}^c are offset points; *k* is a scale factor accounting for the nonsquareness of the CCD pixels; f is the calibrated focal length of the lens in use.

III. Extraction of roads from spatial data:

Digital road information is required for a variety of applications ranging from provision of basic topographic infrastructure over transportation planning, traffic and fleet management and optimization, car navigation systems, location -based services, tourism, to web-based emergency response applications and virtual environments. Unsupervised extraction of roads from satellite imagery eliminates the need for human operators to perform the time consuming and expensive process of mapping roads from aerial photographs. We have spatial data with the digital image georefrenced by our agent now as the user obviously requires the road map so the roads ahs to be normalized from the map with the help of image processing technique called PATTERN RECOGNITION.

The classification of surveys and different techniques on automatic and semi-automatic road extraction methods and related works is very difficult, given the variety of existing proposals in the literature. However, we can select the principal factors in order to achieve it. These factors are the following: the preset objective, the extraction technique applied, and the type of sensor utilized. These methods seek to obtain the detection and definition of the road network starting from original images, GIS data and context information. Normally segmentation and vectorization geometric techniques are used, as well as processes, models and patterns characteristics of the low, mid and high level of knowledge.

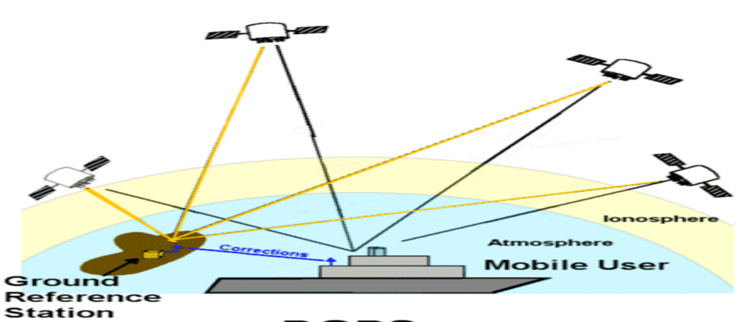
IV. GIS Pattern Recognition :

While remote sensing has made enormous progress over recent years and a variety of sensors now deliver medium and high resolution data on an operational basis, a vast majority of applications still rely on basic image processing concepts developed in the early 70s: classification of single pixels in a multi-dimensional feature space. Although the techniques are well developed and sophisticated variations include soft classifiers, sub-pixel classifiers and spectral un-mixing techniques, it is argued that they do not make use of spatial concepts. Looking at high-resolution images it is very likely that a neighboring pixel belongs to the same land cover class as the pixel under consideration. With the advent of high-resolution satellite imagery, the increasing use of airborne digital data and radar data the need for context-based algorithms and object-oriented image processing is increasing. Recently available commercial products reflect this demand.

Before pattern recognition, air photo interpretation and photo reading from aerial reconnaissance were used to define objects in order and its significance. In GIS Pattern recognition, the camera serves as the most common sensor systems. The digital images are taken remotely from this sensor acts as the object where features are established from which we try to extract significant patterns. Pattern is defined as an arrangement of descriptors (length, diameter, shape numbers, regions).

The remote sensing image classification has mainly two ways. One is the visual interpretation, the other is computer automatic classification. The visual interpretation is a process of utilizing biology geosciences rules and the check analysis method to carry on generalized analysis and logical deduction according to the operating person's experience and knowledge, the sample's image characteristic and the spatial characteristic (shape, size, shadow, texture, graph, position and layout), together with many kinds of non-remote sensing information. The computer automatic classification uses the pattern recognition technology and the artificial intelligence technology to carry on the analysis and the deduction, understand the remote sensing image, and complete the interpretation of the remote sensing image finally, according to the land object's characteristic in the remote sensing image and the goal land object's interpretation experience and image formation rules in the expert knowledge library, based on the computer system.

V. Navigation with DGPS:



DGPS Geometry

Fig: 2: DGPS Geometry

GPS is a satellite-based global navigation system created and operated by the United States Department of Defense (DOD) in 1970s. One of today's most demanding applications of GPS technology is to track the remote vehicles, or AVL (Automatic Vehicle Location). Based on the equation "Distance = Rate x Time", the GPS receiver determines the vehicle position by calculating the "Time" it takes for the spread-spectrum signals to be transmitted from each satellite to the earth. The speed at which the spread-spectrum waves travel is the "Rate".

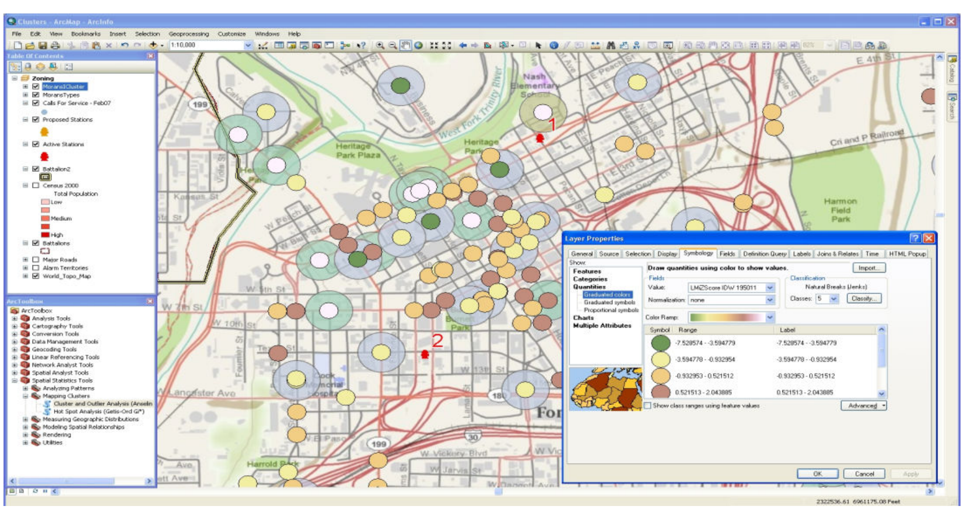
Since position accuracy depends on the receiver's ability to accurately calculate the time it takes for each satellite signal to travel to earth, there are primarily five factors that can cause the receiver's calculation error. The combination of these errors can limit GPS accuracy up to 100 meters 95% of the time and up to 300 meters 5% of the time.
The factors are:

i. Ionosphere and troposphere delays on the radio signal
ii. Signal multi-path
iii. Receiver clock biases
iv. Orbital errors, also known as ephemeris errors of the satellite's exact location
v. The intentional degradation of the satellite signal by the DOD. It is known as "Selective Availability (SA)" and is intended to prevent adversaries from exploiting highly accurate GPS signals and using them against the United States or its allies.

Each of the above mentioned problems has a solution. To get around the errors associated with GPS, a technique called Differential GPS (DGPS) can be employed. The basic premise behind DGPS is error correlation. Most of the errors due to GPS are highly correlated between receivers within close proximity of each other. DGPS can reduce or cancel error sources such as satellite clock bias, atmosphere delays, orbit bias. According to the different modes of operation, DGPS can be divided into three classes: position-based DGPS, pseudo range DGPS and carrier phase. The principles are basically the same but corrected sophistication and precision levels of each technique are quite different. Differential GPS involves the co-operation of two receivers, one's that stationary and another that's roving around making position measurements. The stationary receiver is the key. It ties all the satellite measurements into a solid local reference.

GPS receivers use timing signals from at least four satellites to establish a position. Each of those timing signals is going to have some error or delay depending on what sort of perils have befallen it on its trip down to us. Since each of the timing signals that go into a position calculation has some error, that calculation is going to be a compounding of those errors. Differential GPS can eliminate all errors that are common to both the reference receiver and the roving receiver. These include everything except multipath errors (because they occur right around the receiver) and any receiver errors (because they're unique to the receiver).

VI. Arc GIS : A User End Display:



ArcGIS is a suite consisting of a group of GIS software products produced by ESRI. ArcGIS is a system for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. ArcGIS is used for displaying the pixellized map with navigation of the user.

VII. Integration of NLP in Arc GIS :

Natural language appears to be an optimal substitute for formal query languages in allowing users to access databases (DBs) according to their own familiar concepts and requirements, but, the explicit and structured way in which information is stored in DBs is in sharp contrast with the inherent vagueness and implicitness of natural language semantics and, more generally, with the way users conceptualize the goal-oriented information they search has inhibited the substitution. The results presented in this paper show that developments in NLP make the use of natural language as a substitute is close to fruition.

Systems based on “semantic grammars” were quite popular in the past decades, but, recently, they have been replaced by systems using one or more layers of some intermediate representation language. The user’s query, for example “How can I get to X, by car, in less than two hours”, is translated into a set of clauses, “I want to get to X” ^ “I travel by car” ^ “Journey time smaller or equal (<=) than two hours”, expressing high level logical-semantic representations. The use of an intermediate level of semantic representation raises the issue of its format and structure. Such representations have the advantages of reducing the amount of potential structural semantic ambiguities, enhancing the robustness of the overall process of logical form construction and providing a mapping onto semantic structures. The NLP solution, described in this paper, relies on the ASQL technology, property of Ula s.r.l based in

Trento, Italy. In our approach, natural language queries are mapped onto a level of logical-semantic representation, generated from a level of linguistic representation (LR) of the query. LF is linked to the domain ontology, which acts as a formal interpretive model of LF predicative constants and expresses the conceptual restrictions constraining the compositional process of building logical forms out of the syntactically analyzed natural language.

Logical forms are eventually automatically mapped into SQL queries by other specific components of ASQL overall architecture, namely an LF post-processor and parser, a Fuzzy Engine dealing with treatment of lexical vagueness, an SQL translation Engine and, where necessary, a Dialogue Manager.

Conclusion:

We have just given the theoretical overview of the system we have proposed and are working on the practical results to extend the concept to other GIS platforms also.

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