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Geographical Information Systems: Implementations in Real World and Future Challenges

Konstantinos Karamitsios*

CTO at MyCompany Projects O.E., Paleon Patron Germanou 33, Thessaloniki 54622, Greece

Email: kk@mycompany.com.gr

Abstract

Geographical Information Systems (G.I.S.) has become a very promising sector nowadays. The non-stop breakthroughs of the information technology in combination with the continuous amelioration of the science of geology have transformed the need of accurate data and clean visualization into an indispensable tool. The implementation of new technological techniques in the field of G.I.S. is a very interesting subject that anyone would like to keep an eye on. In this paper we present what G.I.S. is and how is it used in real world. After a short description of what G.I.S. do, we search for current G.I.S applications that are in use and also examine the prospects of the future challenges of this field. Our research is focused on various fields of the computer science and how they are or can be implemented on geographical information system applications.

Keywords: geoscience; geographical information systems; GIS; WSN; Semantic Web.

1. Introduction

A geographic information system is also referred to as GIS. Some of its specific functions include collecting, storing, editing, analyzing, managing and presenting data, whether in geographical or spatial form. GIS is an acronym that is also used to represent geographic information science, GIScience. This is the study of geographic information systems. It is an arm of geoinformatics, which is the umbrella academic discipline. The advanced form of GIS is spatial data infrastructure, which is basically a concept which practically has no limits. The definition of GIS has a broad reach. Its applications are diverse. It is highly applicable to a variety of purposes. These include telecommunications, engineering, transport and logistics, insurance and planning [1].

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* Corresponding author.

This vast coverage is the reason why services that make use of visualization and analysis cannot do without GIS and location intelligence applications.

2. Geographical Information Systems and Geoinformatics Applications

Using GIS may rely on certain requirements. This could be in line with the jurisdiction or area, for instance, a city. It may also depend on what purpose it is required for, and application. There are certain times when a GIS implementation may be specifically designed for one particular organization. When this happens, only the jurisdiction, organization and application for which the GIS were developed can make use of it. It may become incompatible with a GIS that has been specifically designed for other areas, business, organization or application.

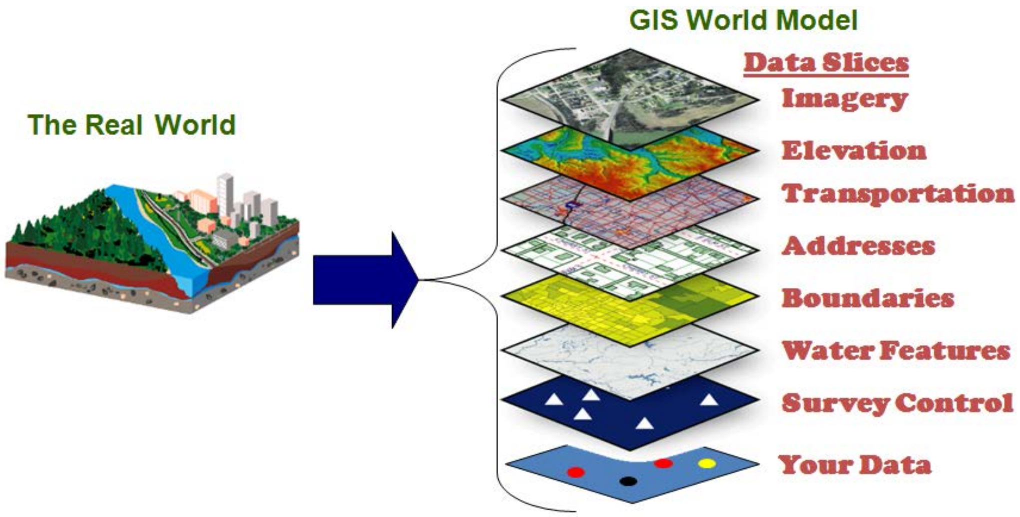

Figure1: G.I.S. Layers Model [2]

Location-based organizations using GIS enjoy frequently updated geographical data. This is automatically done and there is absolutely no need for them to take a trip down to the field just to get the updating manually done. Of course there is the possibility of combining GIS technology with other effective enterprise solutions. A good example is SAP. This kind of combination is perfect for making highly efficient decision support system for enterprises.

GIS technology has limited advantages to offer a large variety of fields. Over the years, both hardware and software components of GIS have witnessed significant improvements. This is not all. The costs of the components have been reduced, all thanks to the popularity and high demand for GIS technology. These components have been majorly embraced by government agencies, public and private organizations, crime mapping, science, and national defense. GIS technology has also been embraced by other fields such as real estate, climatology, sustainable development, natural resources, public health and landscape. The list does not exclude transportation and logistics, archaeology, architecture, regional and community planning, transportation and logistics. Besides, GIS is offering location-based services. This enables mobile devices that are equipped with GPS to display their location by indicating fixed objects which are very close by. This could range from a nearby gas station to a restaurant. Such locations can also be displayed by indicating mobile objects such as children, friends or police car. The positions of these fixed or mobile objects could be sent back to a central server which would either display or process them..

2.1 Open Geospatial Consortium standards

The Open Geospatial Consortium also known as OGC is a foreign based industry consortium of over 384 universities, companies, individuals and government agencies taking part in a consensus process in other to create a geoprocessing specification that is available to the public [3]. Protocols and open interfaces characterized by OpenGIS Specifications sustains interoperable solutions that "geo-enable" wireless and location-based services, the Web, mainstream IT, as well as enable those who develop technology, create services and compound spatial information that is useful and accessible via any type of application. OGC protocols consist of Web Feature Service, and Web Map Service.

2.2 Web mapping

Unlike in the past, there has been an increase in the number of mapping applications one can have access to on the web. With these websites, anyone can have all the geographical data they need. Bing Maps and Google maps are very good examples.

Users that now want to create apps tailor made for their unique needs can now do so with great ease. Google map in collaboration with OpenLayers have designed API with which users can use in customizing their apps [4]. The tools provided by Google map comes with features like satellite imaging technology, searches, maps of streets, routing and geocoding. Web mapping has made crowd sourcing projects like OpenStreetMap possible, thanks to the combined effort put together in creating free world maps that can be edited

2.3 The dimension of time

With GIS, geographers can easily extract geographical information like atmospheric conditions, condition of the earth's surface, and condition down below. With GIS, geographers can easily find out the changes experienced by the earth on daily basis even for years. These changes can be seen in form of animation. Changes like drought and vegetation have been displayed by GIS in form of animations. These animations help researchers ascertain the health condition of the earth. To calculate climatic differences like fall in rainfall or decline in vegetation between different regions, scientist will have to make use of two variables [5].

The ease of collecting digital data from across the globe has enabled the efficient running of analysis with GIS. To produce graphics used in representing vegetation, GIS relies on satellite sensor technologies like Advanced Very High Resolution Radiometer (AVHRR). This technology works by extracting the energy of the Earth across different spectrum and bands within 1 square Kilometer. AVHRR is capable of capturing images two times a day from the earth. The two major sensors used as sensors for capturing data from the earth are AVHRR and MODIS (Moderate Resolution Imaging Spectroradiometer). In the future, it is likely more advanced sensors will be developed.

With the help of GIS, decision makers have been able to come up with plans used in developing support systems

3. Geospatial Sensor Networks

This is a smart and dynamic web based sensor technology that runs on interconnected sensors, used in carrying out in depth analysis and monitoring of the earth, via interconnected network of sensors. As technology continue to advance, smart sensors are getting cheaper by the day. This set of sensors comes with high resolutions capability, cordless communication system, superfast computing, artificial intelligence etc. It is for this reason that the sensors are used worldwide in capturing geographic data, as well as the distribution of such data [6].

Geospatial sensors are characterized by the following characteristics: High resolution, smart, ease of operation and scalable.

There are three different layers contained in the sensor

- Information layer
- Sensor layer
- Communication layer

Researchers at York University are on a mission to come up with geospatial sensing device that runs on the internet. To better understand all challenges that would confront the use of sensor wed in the future, scientist and developers decided to create an environment compatible with sensor web; known as Geospatial Sensor Web Information Fusion Testbed (GeoSWIFT). GeoSWIFT also contains three discticnt layers; Information, sensor and communication layer. The most important component of GeoSWIFT is a sensing service which functions as a global sensor and can be queried by web users. GeoSWIFT is basically made up of a viewer and a server. These two components serve the following purposes; combines distinct sensing source with spatial data which could either be in vector or raster form, after which it then supplies a clear access to needed information. GeoSWIFT is a solid proof that web based sensors work. With this technology, researchers can easily fish out areas that need more work in spatial web based sensors.

4. Future Challenges

4.1 Real-Time GIS

A lot of time is put in the making of a map. Justification can only be made if a map created can remain useful over a long period of time. What this means is that conventional maps only contain sparse geographic details of the earth like mountains, water bodies, streets and roads. But as technology continue to improve, mapping has as well improved greatly over the last 20 years thanks to GPS and advanced computing system. What this means is that maps can now be created at the click of a button[7]. Now we Neogeography; the making of a personalized map with features unique to the creator of the map. This map can be used to ascertain the traffic on a road because of sensors and GPS navigating system embedded in it. Such a map can also be used by air control personnel to gauge air traffic; a manger whose job is to contain emergency situations can see real-time conditions and how to respond to disaster; a public health specialist can also use the map in evaluating real-time state should a disease break out.

It has become clear that GIS isn't a technology only meant for running analysis on data that is static, but can works well for dynamic real-time process used in making informed decisions. GIS will certainly be used in the future for advanced real-time scenarios. Technologies that will enable researchers manage dynamic conditions; will be in great need in the future. With data on ground, researchers can then come up with firm decisions, even in the face of uncertainties logically.

4.2 Multiple Views of the World

During its early stage of development, GIS was heavily criticized by social scientist who argued that it was impossible for the entire continent to be represented scientifically, as postulated by the developers of GIS. They also believed that geographic truth is absolute and not relative and personal. Most times, GIS gives us a single view point which is mostly that of government, instead of several viewpoints which include individuals and groups. Of late, there have been multiple cases of Google maps portraying disputed boundaries coupled with place-names, especially in foreign countries. This incident was reported in Maclean, a weekly magazine that discusses current affairs issues and published in Canada. Himalayas for instance is portrayed by google.com in a different way as Google India (google.in) and Google China (google.cn) does. The law in both countries demands that all maps must portray the countries national policy. While google.in displays Kashmir as a region in India, google.com shows it as being under dispute between Pakistan and India [8].

Maps are meant to portray the beliefs of its creator, and this violates the scientific approach used in the developing of GIS. For GIS, the name of a particular region isn't absolute, but related to the individual of group that gave a region its name. For instance, an English man will call the water body separating France from England the English Channel, while a French man would call it La Manche. How does GIS plan to manage this conflicting views, is a question on the lips of many.

4.3 Geospatial Semantic Web

As internet technology continues to advance, Resource Description Framework (RDF) is continually being used to increase Geospatial data in form of datasets that is available online. This technology works on the principle of linked open data, which aids the connection and publishing of data on the web. Linked Open Data is used collaboratively with SPARQL protocol and RDF Query language in the modeling of data, studying implicit relationship like geospatial relationship, which ordinarily can't be queried. As an example, there are certain datasets used in describing features like parks and monuments. Trouble arises when one attempts to link each dataset with another when they haven't been declared yet [9].

Open Geospatial consortium (OGC) is now gradually adopting GeoSPARQL as a standard. The goal for adopting this as a standard is to find solutions to geospatial representation. GeoSPARQL gives researchers similar representation of geospatial data through the use of RDF, added with its capability of filtering relationships that exist in geospatial entities. The first step we will take is to introduce certain concepts of geospatial representation, to make it easy to understand GeoSPARQL. What we aim at achieving at Semantic web is to make accessibility of materials easy, by creating logical and actionable connections are made between concepts, thus enabling a user understand concepts which might sound alien. Geospatial Semantic web does not just stop at concept and content, but goes beyond that in providing man and machine absolute access to a broad spectrum of knowledge.

5. Conclusion

New technological sectors just as sensor networks, internet of things and semantic web are a very promising companionship of geographical information systems. The union of them could drive the geoscience into new paths and introduce new concepts of geographical measurements. GIS in simpler words refer to an information system that is capable of capturing, storing, editing, analyzing, sharing, and displaying geographic information. The GIS applications equally come in handy for users when they are ready to present the result of these operations. On the other hand, Geographic information science, GIScience, deals with geographic concepts, applications, as well as systems. All these concepts are very promising and best is yet to come.

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