Geographic Information Systems: A Primer

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Abstract— Geographic information system (GIS) is a tool for working with geographic information. It is a computer-based system for mapping and analyzing spatial data. GIS helps individuals and organizations make better decisions. The GIS technology can be used to analyze spatial data and provide insight into our problems and suggest ways to address them. This paper provides a primer to GIS, including what GIS does and how it is used to produce maps and other useful information.

Keywords— GIS, geographic information system, geographic information science

I. INTRODUCTION

Information that used to be in databases is now unleashed in a new way using geography. Maps are now everywhere – on the Internet, on your phone, and in your car. They show patterns and reveal connections which may not be possible with text. They are reliable means of communicating geographic knowledge [1]. They provide useful information to the map users. They preserve history and inform the future. A major disadvantage of traditional paper maps is that they are restricted to two-dimensional representation.

Geographic information system refers to any information system that edits, analyzes, stores, and displays geographic information on a map. It is a computer-based system that captures geographic data for the purpose of analysis and viewing. Although GIS has been around since the early 1960s, the term "geographic information system" was coined by Roger Tomlinson in 1968 who created the first GIS and is referred to as the father of GIS [2].

GIS technology is an efficient tool for working with geographic data. It helps in making correct decisions about locations. The location can be specified in many ways, such as position (X, Y, and Z), latitude and longitude, address, ZIP code or country. The GIS is closely related to the global positioning systems (GPS), which have made it possible to determine the position of an object on earth's surface. GIS users often use GPS to gather geographic data.

II. HOW GIS WORKS

A typical GIS-based project involves collecting data, entering it in GIS, analyzing it, and producing maps. The components of GIS setup are:

- *Hardware:* This includes the computers on which GIS operates and web servers. These computers may be stand-alone or connected together as a network with output devices such as printers, scanners, and digitizers. The computer system must have enough memory to store large amounts of data.
- *Software*: GIS software supports both spatial and attribute data, which may come from several sources. One way of obtaining spatial data is by digitizing or scanning existing paper maps. Software tools must include data manipulation, file management, database management, and graphical user interface. Common software used in GIS includes ArcGIS, GRASS, MapInfo, and ENVI.
- *Data*: GIS must store information or data in some way. Its ability to process spatial data is important. The data may be spatial (vector or raster) or attribute/tabular. Spatial data are positional data that refers to where things are and are usually specified geometrically. The type of data storage device selected depends on application. Data processing is key to GIS. Data entered into a GIS is often processed to remove errors. Figure 1 shows the relationship between data capture, maintenance, and presentation [3].
- *People*: This consists of GIS well-trained professionals, GIS managers, database administrators, and users. People are the most important component of GIS. GIS professionals build and maintain GIS databases, and use
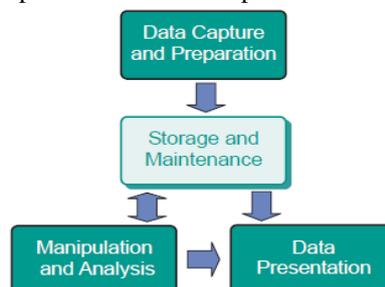

Figure 1 Relationship between data capture, maintenance, and presentation [3].

GIS software to analyze data. Researchers and practitioners apply GIS to fit their specific collaborative processes.

III. GIS APPLICATIONS

The GIS supports a wide range of applications. Its use has grown rapidly in recent years. GIS is applied in engineering, telecommunications, science, education, business, management, government, insurance, criminology, epidemiology, land surveying, real estate, transportation, logistics, and archaeology. To be concrete, we will consider some of these applications [1].

- *Education*: Students will learn more efficiently by integrating multimedia and GIS. In this case, the computer takes the role of the teacher. It is important that K-12 students learn how to use the GIS technology.
- *Telecommunication*: The wireless industry uses GIS for data integration of its customers in the US [4]. GIS helps telecommunications professionals to compete, overcome challenges, and gain a competitive edge.
- *Business*: Marketers, retailers, and managers harness the power of geography to better understand their data, overcome challenges, respond to market needs, and delivered profitability. GIS assists in managing business assets and increasing productivity.
- *Health Care*: Heath care services and hospitals depend on GIS to provide timely and accurate information for high-quality services. GIS benefits nurses, physicians, health professions, and social workers. Health care workers use GIS to build information about patients and their clinical status [5].
- *Government*: Governments at all levels use GIS to fulfill their missions, enhance services, increase efficiency, support initiatives, engage citizens in democratic processes, and deliver accountability.
- *Public Safety*: GIS helps public safety personnel to handle location-based information. It enables them to respond to 911 emergency calls in a timely manner. GIS is also valuable to law enforcement officers.
- *Military Operations*: Most military operations and decisions involve geography. The military and defense organizations use GIS in their command, communication, control, surveillance, and intelligence.

Recently, there has been easily accessible mapping software such as MapQuest and Microsoft Virtual Earth which give the user access to huge amounts of geographic information. Google Maps enables people to add traffic information to road maps.

IV. ADVANTAGES AND DISADVANGES

GIS allows users to analyze spatial relationships which may not be readily apparent. It can be used to depict change and provide useful snapshots of data in time. The main disadvantage of GIS is the cost involved and technological expertise required. GIS technology is not affordable in some developing countries. Although the cost of hardware and software is decreasing substantially, the training and expertise required to run GIS constitute a drawback [6]. Research is still needed to find a way of representing three-dimensional structures. The challenge of GIS lies ahead as new ways of conducting business emerge.

V. CONCLUSIONS

Many disciplines have benefited from GIS technology. Although GIS as a discipline is continuously evolving, GIS as a technology is mature. The technology is simple enough that an elementary school student can learn to use it. Advances in computer hardware and software will lead to a growing GIS adopting multimedia to represent information. GIS will become an integral part of many disciplines and cut across all areas of modern information society. Education and training of GIS professionals must meet the current needs of the knowledge-based society [7].

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