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Spatial Data Capture in GIS: A Review

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Abstract
Geographic information system (GIS) is a computer-aided system that is capable of capturing a large number of spatial data. GIS enables the sharing of a series of real-time data in a secure environment. In this paper, I critique the various perspectives from which geographic information system is defined. The methods used to capture spatial data will be examined. Then I distinguish between automation and geoprocessing and give examples of the latter. Finally, I will touch on aspects of data quality and highlight the importance of metadata and geospatial data in GIS.

Keywords: map projection, data quality, geoprocessing, geodatabase, metadata, data collection, vector data, raster data, gis, remote sensing

Introduction

When Roger Tomlinson coined the term geographic information system (GIS) or the government of Canada he never would have imagined the intensity of debate or the impact the three letter acronym would have (Wright *et al*., 1997) [33]. Defined GIS as an organized activity by which people measure and represent geographic phenomena then transform these representations into other forms while interacting with social structures. Shin and Campbell (2011) [29] stated that GIS is used to organize, analyze, visualize, and share all kinds of data and information from different historical periods and at various scales of analysis. In this paper, I critique the various perspectives from which geographic information system is defined. The methods used to capture spatial data will be examined. According to Eldrendali a successful GIS mostly depends on the correct use of map projections, so this issue is investigated. I also think of conceptual models and data models as the pillars of GIS. Then I distinguish between automation and geoprocessing and give examples of the latter. Finally, I will touch on aspects of data quality and highlight the importance of metadata and geospatial data in GIS. The motivation to do this research came from class discussions, and as a Forestry student I felt compelled to do more in-depth research. This course provides an overview of what is expected, so that this research deepens the understanding and establishes a solid foundation of the basic principles and concepts of GIS.

What is a geographic information system?

GIS stands for geographic information systems and Arnold defined it as a set of manual or computer techniques used to store and manipulate geographic reference data. According to Wright *et al* (1997) [33] geospatial information science deals with geospatial concepts, elements used to describe, analyze, model, reason, and make decisions, for features distributed over the surface of the Earth. Wright *et al* (1997) [33] also point out that science is often used as a synonym for research, so GIS is a science that involves research into a set of basic problems, mostly of these are the oldest methods since its development. GIS is a tool that refers to the use of any kind of software, tools, equipment such as computerization and consultants to investigate a problem (Wright, 1997) [33]. Most importantly, this tool is separate and independent from the main issue, which has little to do with the accuracy of the research. There are two GIS data sources maps and images. A map is a physical or conceptual representation of features that occur on or near the earth's surface (GIS, 2001) [18].

An analog map is a map that does not retain its image and can be viewed directly (GIS, 2001) [18]. Radiography is a technique for imaging the Earth's surface, atmospheric or liquid state (Shane and Campbell, 2011) [29]. A camera that acts as a sensor is installed on balloons, airplanes, rockets, satellites and other space vehicles (Shin and Campbell, 2011) [29]. Two general data collection methods are primary data collection and secondary data collection. Both vector and raster models have their own basic data collection methods. According to Longelli *et al*. The most important form of primary raster data collection is remote sensing, a technique used to obtain information about the physical, chemical and biological properties of objects without affecting the body. Information is obtained from measuring the amount of electromagnetic radiation reflected, transmitted and scattered from objects. Sensors that operate in the electromagnetic spectrum are used to obtain measurements. Aerial photographs are collected using compact or digital cameras and then raster scanned onto film (Longley *et al*., 2005) [24]. Most aerial photographs are collected on an 'ad hoc' basis using cameras mounted in airplanes flying at low altitudes (3000-9000m) (Longley *et al*., 2005) [24]. Primary vector data capture is a major source of geographic data and the two main branches are ground surveying and GPS. Stated that ground surveying is based on the principle that is 3D location of any point can be determined by measuring angles and distances from other known points. If the coordinate system of the point is known or unknown, all subsequent points can be collected in the coordinate system or from a relative or local one. The Navigation Satellite Timing, And Ranging Global Positioning Systems or NAVSTAR GPS, is a satellite based radio navigation systems that is capable of providing extremely accurate worldwide, 24-hour, 3 dimension (latitude, longitude, and elevation) locational data (Lange and Gilbert, 2005) [23]. They can record the scene with great accuracy. LiDAR, a new technology that uses laser rangefinder scanning to produce precise topographic maps, is the primary means of conducting aerial scans for light detection and aerial detection (Longley *et al*., 2005) [24]. Collecting geographic data from secondary sources involves creating raster and vector files and databases from maps, photographs and other paper documents. To store raster data, scanners use scanning to convert copied media into digital images, while scanner devices can record the amount of reflected light from a local data source and transform duplicate media (Longley *et al*., 2005) [24]. Digitization, stereophotogrammetry and COGO data acquisition are the most commonly used techniques for vector data capture (Longley *et al*., 2005) [24]. Digitization are methods of converting raster data to vector data. The easiest way to create vectors from raster layers is to manually digitize the vector objects from the computer screen using a mouse or digital cursor. Photogrammetry is the science and technology of measuring photographs, aerial photographs (Longley *et al*., 2005) [24]. Measurements are extracted from overlapping image pairs using detectors. Sometimes this is the only practical way to capture geographic data. COGO, also known as coordinate geometry, refers to a data collection method that uses geometric shapes and distances to define each part of an object. COGO data is a very accurate measurement (Longley *et al*., 2010) [25]. Map projection is a systematic representation of locations from a curved surface on a tabular map. It is basically a mathematical formula used to translate longitude and latitude on the Earth's surface into x and y coordinates on a plane (Shin and Campbell, 2011) [29]. Stated that these map projections used in GIS are based on expanded surfaces on which latitude and longitude are indicated. An expandable surface is a surface that can be laid flat without distortion. The three most important surfaces that can be developed are cone, cylinder and plate. Points on the ground are marked on zoomable screens. This surface is folded to form a flat map (Bolstad 2002 cited in Eldrandaly, 2006) [16]. This flattening process is not perfect and causes distortions and changes in spatial properties such as distance, location, shape and direction. There are two types of symbols: flat and conical. In planar projection, a circular plane is placed on a flat surface. Also known as azimuth or zenith bearing. This type of ridge can affect land and marine surfaces (Kennedy, 2000) [20]. The Arctic and Antarctic are the most common contact points for GIS databases (Kennedy, 2000) [20]. The contact point can also be at the equator or anywhere on the surface of the earth. The polar conditions in the diagram above are the simplest. Parallels of latitude are circles that are perpendicular to the pole, and meridians are straight lines that intersect the pole at right angles (Kennedy, 2000) [20]. In general, the shape of the plan is that the longitudinal lines rotate at the point of contact and radiate outward from the column like the spokes of a wheel (Kennedy, 2000) [20]. Spread, shape and movement are circular around the contact point. Because of these planar projections, circular sites are better suited than square sites (Kennedy, 2000) [20]. In conical projection, latitude and longitude are interpolated (Kennedy, 2000) [20].

Fig 1: Polar

A simple projection along the latitude is parallel to the globe. This is called the standard parallel line (Kennedy, 2000) [20]. The meridians lie on the surface of the cone and meet at the apex or apex of the cone. The parallel latitudes are marked on the ringing cones (Kennedy, 2000) [20]. The cone is truncated at each pole to produce a final cone projection with straight lines of intersection for meridians and concentric arcs for parallels (Kennedy, 2000) [20]. The top of the cone is usually cut to produce a more accurate projection, this is due to distorting increasing away from the standard parallel (Kennedy, 2000) [20]. The two conceptual models of reality that gave rise to the two data models are discrete objects/data where features are seen as objects or entities and continuous spatial variation. According to learn GIS (n.d.) discrete data is data that represents features which exist independently with clear and definable boundaries. The three geometrical primitives: points, lines, or polygons is defined using one or more x,y coordinate pairs called vertices, and are thus described as discrete objects because of their precisely defined locations and boundaries. Continuous variation or data is the opposite of discrete data, data which does not have clear and definable boundaries but instead makes a blanket of data across a landscape, defined with a scale of values (learn GIS, n.d.). Data such as temperature, precipitation, elevation, slope and aspect are all examples of continuous data and is more suited for raster data. While both data types can have data with either discrete or continuous properties, most often, vector data is described as discrete while raster is described as continuous (learn GIS,n.d)There are two basic data models: vector and raster. In the vector data model, real-world entities are represented using one of three geometrical primitives: points, lines, polygons. Each primitive is defined by one or more x, y coordinate pairs called vertices. Points are zero-dimensional vectors defined by two or more coordinate pair, and lines are one-dimensional vectors defined by two or more coordinate pairs. Polygons or area are two dimensional objects defined by three or more coordinate pairs. Raster data is modeled as a matrix grid of cells or pixels of equal size to provide spatial data. Each cell has an associated value that represents how the object functions at that location. Even where the variable does not have to be given a value, it is usually null. The advantage of raster data is that the data is relatively easy to generate and easy to analyze (Davis, 2001) [11]. Each cell has a unique code that is easy to recognize (Davis, 2001) [11]. Because of its simplicity, raster data can be processed by all machines, even old and slow ones (Davis, 2011) [11]. The level of technology and costs can be kept low. However, Stated that one of the main disadvantages of rasters is that they are often large files. Each cell must be coded, even if it contains no data, meaning the value is zero (Davis, 2001) [11]. Because of this, there is a high demand for computer storage, especially for high-resolution formats (Davis, 2001) [11]. Each cell is expanded in raster format, so the output images have a low resolution and are less attractive. On the other hand, due to the precision of the symbols, the vector data for lines and polygons better represent the reality and the appearance of the output images (Shin and Campbell, 2011) [29]. The storage capacity is lower because the data structure is smaller and the file size is smaller. Also topology, spatial analysis is easy, e.g. Proximity and network analysis. In contrast, due to the unique nature of vector data, continuous data is poorly stored in vector format (Kumar, 2018) [22]. Because of the complex nature of the data structure there are limited shortcuts for storing data like in raster, the location for ever vortex must be stored in the model. Topology is important but any feature edit requires updates on topology and this ioften result in intensive processing, especially when dealing with large datasets. Bajjali (2017) [2] defined geoprocessing as the tool and processes used to generate derived data sets from other data using a set of tools. Wang and Selwood (2005) [30] mentioned that a typical geoprocessing takes an input dataset performs an operation on that dataset generating new information return as an output dataset. Automation is the ability to perform repetitive tasks and is one of the shining points of computers (Dixon and Udameri, 2016) [14]. Automation involves choosing the right geoprocessing tools to work with the dataset. Automation can be useful when the user has the same task and controls a series of devices for multiple domains. Two common geoprocessing tools are clamp and buffer. Defense based on spatial relationship to proximity. Hehai 1997 stated in Dong *et al* (2003) [15] that the main idea of the defense is to create a boundary and a distance to its boundary and define the impact and scope of services to the environment and around. The area within the specified distance is called the buffer zone (Dixon and Odamary, 2016) [14]. Shin and Campbell (2011) [29] used the example of a resource manager requiring no sites within 1,000 feet of breeding habitat for the Delhi flower fly near the western United States. Points of flow can be marked on an arc map. Then select the block tool in the arc box, import the pose as an input layer, and convert the distance unit to feet.

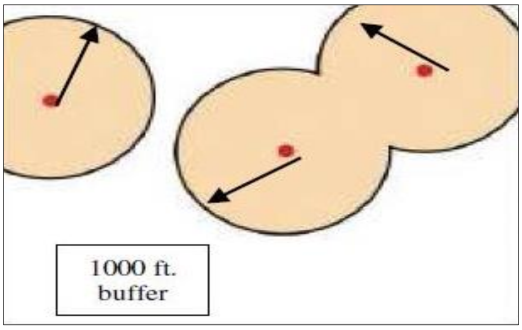

Fig 1

The arc map creates a 1,000-foot buffer zone around all areas of the species' habitat (see figure below). Defined a slice as the GIS process of extracting a subset of spatial data from a larger data set by selecting data that is inside (or outside) a specified 1000-foot boundary. Spatial analysts sometimes work in large geographic areas, but prefer to work with a specific area within that larger area. For example, a population researcher is looking for population information from the Bog Walk community in St Catherine. A jacket tool can take a swamp walk from the St. After clipping, all features of the preserved part of the input layer are included in the output (Shin and Campbell, 2011) [29]. Monomir cited in Wong and Wu (1996) [32] believed that users of spatial data should pay attention to the quality of the data because it affects the reliability of the decision or the success of the policies. Pointed out that the interpretation of spatial data quality issues has already resulted in wasted money from many poor policies, accidents and deaths. In the same way, Goodchild (1993) [19] asserts that data errors and inaccuracies cause significant problems, including incorrect outcomes and consequences of decisions based on bad data. Data quality is important when GIS is used to make decisions that may adversely affect data subjectivity (Caprioli *et al.*, 2003) [5]. Therefore, the quality of the data must be high because it often results in successful guidelines, decisions and initiatives. The quality of attribute data can be determined by using the boundaries in the geodatabases, which helps to reduce data entry errors by removing invalid entries. Goodchild 1991, cited in Kitchin and Tate (2013) [21], defined justice as the relationship between measurement and reality. In other words, accuracy is about how close a measurement or observation is to measuring the true value (Humboldt State University, 2019). Accuracy refers to the accuracy of the information in the report of the measurement (Goodchild 1991 according to Kitchin and Tate, 2013) [21]. Tiwari *et al* (2017) [31] stated that precision, also known as repeatability or reproducibility, is the extent to which repeated measurements under different conditions show similar results. The target or true location is the center or blue eye. The truth is that it takes many attempts to stay in the same place. This can be seen in the two graphs on the left because the pins are in the same positions. Accuracy is the effort to get closer to the true center or point. The third chart from the left is correct, although the distribution is small, the bet is close to the center, the true value, or its location, Multi-point, stacked or multi-line layers. Believed that the authors in their research focus on analytical methods in GIS, and rarely talk about the design used to organize the data itself. Developed a model of a geospatial database structure in Arc GIS online that organizes mining data. Baldridge (2012) [3] stated that ESRI is pushing the idea of a landscape because it is less restrictive for data organization than many file formats. Cioba *et al*. (2011) [8] pointed out that one of the benefits of a geodatabase is the inclusion of boundaries for features. An attribute range limits the values that can be specified for an attribute, and excludes incorrect or unusual values. Believed that these topological validation rules created by geospatial databases reduce data entry errors and ensure data quality and consistency. ESRI introduced the file geodatabase with the latest version of Arc GIS 9.2. One of its special advantages is the storage space, one terabyte per dataset and each file allows for many datasets. Geodatabase is important as it has great storage potential and able to manage big data and also document relevant metadata making the data easy to catalog, query and identify. Wong and Wu (1996) [32] defined metadata as data describing data or data above data. One type of information that is usually included in metadata is data quality and according to the Spatial Data Transfer standards it should consist of five portions covering lineage, positional accuracy, attribute accuracy, logical consistency and completeness (Wong and Wu, 1996) [32]. Metadata is important to any information product document (IPD) as these aspects in spatial data quality is crucial to enable the correct use of spatial data, help potential users decide if particular spatial database is appropriate for specific purpose, and to warn users to what extent they should trust the data mentioned that a problem often encountered in the creation and use of archaeological GIS data is the lack of or misidentification of the data source. Attribute fields are used to record the data collection methods of the field. Metadata in the form of attribute fields ensures that data in a geographic database is identified with its source. One of the most important functions of metadata is to identify data and to help potential users identify relevant, important, and relevant information about a data set. Metadata provides identifying or descriptive elements of the information contained in a data set and makes it easy for future users to find the data (Coloundre *et al*., 1998).

Conclusion

There is no universal definition of the term GIS. Many explanations have been given by the pioneers. GIS is considered interdisciplinary as its applications and applications go beyond geography. GIS is a tool, method, science and service from different perspectives. GIS as a science involves the study of a complex set of problems in a variety of disciplines. GIS as a tool is where hardware or software tools are used to advance a problem, most importantly, separate and independent from the problem itself. GIS data can be obtained from many sources, and both include paper maps and aerial photographs. The two general admission methods are primary and secondary. Primary data comes from direct measurements, while secondary data comes from existing data. Basic raster methods use sensors/cameras to obtain measurements. For remote sensing, sensors in the electromagnetic spectrum and aerial images, as usual, put their sensors on airplanes, balloons, and rockets. Basic vector data uses satellites through GPS technology, LiDAR technology and tools such as total stations through land mapping to obtain measurements. The first secondary data for a raster is a scan. Digitization, stereo photogrammetry, and geometric data recording are the most commonly used techniques for vector data capture. The land is windy and the surface cannot be developed. The transformation of coordinates/points from a curved surface to a 2D or flat map surface is called mapping. The two conceptual models of reality are distinct and continuous. Private bodies such as lakes and ponds have definable boundaries, but plains themselves have no boundaries. The two main data models are vector and raster. The vector data model represents features of the earth in the form of points, lines and polygons. Raster data is displayed in rows and columns of cells or a grid structure. Vector data is reproduced better than raster data, due to the accuracy of the points. Raster data files take up more storage space than vector data. Raster is a simpler data structure than vector. The topology is in vector though not in raster data. Geoprocessing functions use a tool to perform an operation on an input to create a new dataset. Filters are used for proximity filtering and distance is used for spatial filtering. Clip is a tool that extracts a specific region from a larger region and creates a new dataset with the selected region. Data quality is one of the most important aspects of GIS that affect the success of policies and decisions. Accuracy is a range of repeated measurements under unchanging conditions that will show similar results. Accuracy is how close the measurement is to the true value. Geospatial databases can be found as containers in a GIS. It is important because it helps in organizing and storing data. Topological validation is used in regions in geospatial databases to ensure data quality. Metadata is data about data. Data is crucial for those who will need it in the future.

Key Terms and Definitions

Augmented Reality: Augmented Reality (AR) into GIS assures the link between the perception of user and the relationship with the real world. The real world is represented with 2D and 3D virtual information. The computer augments the actual landscape with additional information that can be supported by inserting fields based on GIS applications.

Crowdsourcing: Crowdsourcing is an act of performing a GIS task by a user on a voluntary basis for a set of users. This type of action is based on a bottom-up approach. It is associated with the creation of data through a group dynamic. The crowdsourced data collection is carried out using portable devices (GPS, PC, mobile phones) and the data is synchronized in the central database, accessible and shareable, based on services and maps on the web.

GIS in the Cloud: GIS in the cloud or cloud GIS bases on the integrated web systems. The data generates maps to support the analysis and optimization of real time operations. The cloud integration helps the organization of complex workflows and maintaining extensive geodatabases.

GIS: GIS is a system that permits to visualize, analyze, display and understand the relationships between spatial phenomena. Nowadays, GIS is capable to transform large numbers of data, analyze and transform momentarily alternate data and generate charts, graphs, summary and descriptive statistics. Among the main key elements to a noble GIS it is noted: computer hardware and software, operational context (people and organizations) and internet service.

Real-Time: Real-time is a term often used to describe the time of execution of a task. This tool helps the users to obtain a frequently monitoring and more efficiently. GIS technology enables the sharing of a series of real-time data. Among the main features is visualization, analysis and understanding of phenomena in reduced timescale.

Pace-Time: Space-time is suggested in Hägerstrand time-geographic framework. Presents and analyses the individual activities in time and space dimensions. In GIS environment results in the spatial representation of the dimension x and y and temporal dimensions of time in hours, minutes or seconds. The space-time patch is used for the implementation of the daily trajectory of the individual in time and space.

Web-Based GIS: Web-based GIS is based on a type of distributed information. This set of technological services is part of a communication structure between the GIS server and the client. Their relationship is expressed through

URLs (created by the server) and HTTP (for the customer). Spatial data access, advanced mapping and spatial analysis are the most common type of analysis options in Web-based GIS.

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