Unit 1

GIS section

Topography

Not to be confused with topology or typography.

This article is about the study of Earth's surface shape and features. For discussion of land surfaces themselves, see Terrain. For other uses, see Topography (disambiguation.(

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A topographic map with contour intervals

Topography (from Greek τόπος topos, "place", and γράφω graphō, "write") is a field of planetary science comprising the study of surface shape and features of the Earth and other observable astronomical objects including planets, moons, and asteroids. It is also the description of such surface shapes and features (especially their depiction in maps). The topography of an area can also mean the surface shape and features themselves.

In a broader sense, topography is concerned with local detail in general, including not only relief but also vegetative and artificial features, and even local history and culture. This meaning is less common in America, where topographic maps with elevation contours have made "topography" synonymous with relief. The older sense of topography as the study of place still has currency in Europe.

Topography specifically involves the recording of relief or terrain, the three-dimensional quality of the surface, and the identification of specific landforms. This is also known as geomorphometry. In modern usage, this involves generation of elevation data in electronic form. It is often considered to include the graphic representation of the landform on a map by a variety of techniques, including contour lines, hypsometric tints, and relief shading.[1][2][3[

Etymology

The term topography originated in ancient Greece and continued in ancient Rome, as the detailed description of a place. The word comes from the Greek words τόπος (topos, place) and γραφία (graphia, writing).[4] In classical literature this refers to writing about a place or places, what is now largely called 'local history'. In Britain and in Europe in general, the word topography is still sometimes used in its original sense.[5[

Detailed military surveys in Britain (beginning in the late eighteenth century) were called Ordnance Surveys, and this term was used into the 20th century as generic for topographic surveys and maps.[6] The earliest scientific surveys in France were called the Cassini maps after the family who produced them over four generations.[citation needed] The term "topographic surveys" appears to be American in origin. The earliest detailed surveys in the United States were made by the “Topographical Bureau of the Army,” formed during the War of 1812,.[7] which became the Corps of Topographical Engineers in 1838.[8] After the work of national mapping was assumed by the U.S. Geological Survey in 1878, the term topographical remained as a general term for detailed surveys and mapping programs, and has been adopted by most other nations as standard.

In the 20th century, the term topography started to be used to describe surface description in other fields where mapping in a broader sense is used, particularly in medical fields such as neurology.

Objectives

An objective of topography is to determine the position of any feature or more generally any point in terms of both a horizontal coordinate system such as latitude, longitude, and altitude. Identifying (naming) features and recognizing typical landform patterns are also part of the field.

A topographic study may be made for a variety of reasons: military planning and geological exploration have been primary motivators to start survey programs, but detailed information about terrain and surface features is essential for the planning and construction of any major civil engineering, public works, or reclamation projects.

Techniques of topography

There are a variety of approaches to studying topography. Which method(s) to use depend on the scale and size of the area under study, its accessibility, and the quality of existing surveys.

Direct survey

A surveying point in Germany

Main article: Surveying

Surveying helps determine accurately the terrestrial or three-dimensional space position of points and the distances and angles between them using leveling instruments such as theodolites, dumpy levels and clinometers.

Even though remote sensing has greatly sped up the process of gathering information, and has allowed greater accuracy control over long distances, the direct survey still provides the basic control points and framework for all topographic work, whether manual or GIS-based.

In areas where there has been an extensive direct survey and mapping program (most of Europe and the Continental US, for example), the compiled data forms the basis of basic digital elevation datasets such as USGS DEM data. This data must often be "cleaned" to eliminate discrepancies between surveys, but it still forms a valuable set of information for large-scale analysis.

The original American topographic surveys (or the British "Ordnance" surveys) involved not only recording of relief, but identification of landmark features and vegetative land cover.

Remote sensing

Main article: Remote sensing

Remote sensing is a general term for geodata collection at a distance from the subject area.

Aerial and satellite imagery

Main article: Aerial photography

Main article: Satellite imagery

Besides their role in photogrammetry, aerial and satellite imagery can be used to identify and delineate terrain features and more general land-cover features. Certainly they have become more and more a part of geovisualization, whether maps or GIS systems. False-color and non-visible spectra imaging can also help determine the lie of the land by delineating vegetation and other land-use information more clearly. Images can be in visible colours and in other spectrum

Photogrammetry

Main article: Photogrammetry

Photogrammetry is a measurement technique for which the co-ordinates of the points in 3D of an object are determined by the measurements made in two photographic images (or more) taken starting from different positions, usually from different passes of an aerial photography flight. In this technique, the common points are identified on each image. A line of sight (or ray) can be built from the camera location to the point on the object. It is the intersection of its rays (triangulation) which determines the relative three-dimensional position of the point. Known control points can be used to give these relative positions absolute values. More sophisticated algorithms can exploit other information on the scene known a priori (for example, symmetries in certain cases allowing the rebuilding of three-dimensional co-ordinates starting from one only position of the camera.(

Radar and sonar

Satellite radar mapping is one of the major techniques of generating Digital Elevation Models (see below). Similar techniques are applied in bathymetric surveys using sonar to determine the terrain of the ocean floor. In recent years, LIDAR (Light Detection and Ranging), a remote sensing technique using a laser instead of radio waves, has increasingly been employed for complex mapping needs such as charting canopies and monitoring glaciers.

Forms of topographic data

Terrain is commonly modelled either using vector (triangulated irregular network or TIN) or gridded (Raster image) mathematical models. In the most applications in environmental sciences, land surface is represented and modelled using gridded models. In civil engineering and entertainment businesses, the most representations of land surface employ some variant of TIN models. In geostatistics, land surface is commonly modelled as a combination of the two signals - the smooth (spatially correlated) and the rough (noise) signal.

In practice, surveyors first sample heights in an area, then use these to produce a Digital Land Surface Model (also known as a digital elevation model). The DLSM can then be used to visualize terrain, drape remote sensing images, quantify ecological properties of a surface or extract land surface objects. Note that the contour data or any other sampled elevation datasets are not a DLSM. A DLSM implies that elevation is available continuously at each location in the study area, i.e. that the map represents a complete surface. Digital Land Surface Models should not be confused with Digital Surface Models, which can be surfaces of the canopy, buildings and similar objects. For example, in the case of surface models produces using the LIDAR technology, one can have several surfaces - starting from the top of the canopy to the actual solid earth. The difference between the two surface models can then be used to derive volumetric measures (height of trees etc.(.

Raw survey data

Topographic survey information is historically based upon the notes of surveyors. They may derive naming and cultural information from other local sources (for example, boundary delineation may be derived from local cadastral mapping. While of historical interest, these field notes inherently include errors and contradictions that later stages in map production resolve.

Remote sensing data

As with field notes, remote sensing data (aerial and satellite photography, for example), is raw and uninterpreted. It may contain holes (due to cloud cover for example) or inconsistencies (due to the timing of specific image captures). Most modern topographic mapping includes a large component of remotely sensed data in its compilation process.

Topographic mapping

Main article: Topographic map

A map of Europe using elevation modeling

In its contemporary definition, topographic mapping shows relief. In the United States, USGS topographic maps show relief using contour lines. The USGS calls maps based on topographic surveys, but without contours, "planimetric maps".

These maps show not only the contours, but also any significant streams or other bodies of water, forest cover, built-up areas or individual buildings (depending on scale), and other features and points of interest.

While not officially "topographic" maps, the national surveys of other nations share many of the same features, and so they are often generally called "topographic maps".

Existing topographic survey maps, because of their comprehensive and encyclopedic coverage, form the basis for much derived topographic work. Digital Elevation Models, for example, have often been created not from new remote sensing data but from existing paper topographic maps. Many government and private publishers use the artwork (especially the contour lines) from existing topographic map sheets as the basis for their own specialized or updated topographic maps.[9[

Topographic mapping should not be confused with geologic mapping. The latter is concerned with underlying structures and processes to the surface, rather than with identifiable surface features.

Digital elevation modeling

Main article: Digital elevation model

Relief map: Sierra Nevada Mountains, Spain

۳D rendering of a DEM used for the topography of Mars

The digital elevation model (DEM) is a raster-based digital dataset of the topography (hypsometry and/or bathymetry) of all or part of the Earth (or a telluric planet). The pixels of the dataset are each assigned an elevation value, and a header portion of the dataset defines the area of coverage, the units each pixel covers, and the units of elevation (and the zero-point). DEMs may be derived from existing paper maps and survey data, or they may be generated from new satellite or other remotely-sensed radar or sonar data.

Topological modeling

A geographic information system (GIS) can recognize and analyze the spatial relationships that exist within digitally stored spatial data. These topological relationships allow complex spatial modelling and analysis to be performed. Topological relationships between geometric entities traditionally include adjacency (what adjoins what), containment (what encloses what), and proximity (how close something is to something else.(

reconstitute a sight in synthesized images of the ground,

determine a trajectory of overflight of the ground,

calculate surfaces or volumes,

trace topographic profiles,

Cartography

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"Cartographer" redirects here. For the album by E.S. Posthumus, see Cartographer (album.(

A medieval depiction of the Ecumene (1482, Johannes Schnitzer, engraver), constructed after the coordinates in Ptolemy's Geography and using his second map projection. The translation into Latin and dissemination of Geography in Europe, in the beginning of the 15th century, marked the rebirth of scientific Cartography, after more than a millennium of stagnation

Cartography (from Greek Χάρτης, chartes or charax = sheet of papyrus (paper) and graphein = to write) is the study and practice of making maps. Combining science, aesthetics, and technique, cartography builds on the premise that reality can be modeled in ways that communicate spatial information effectively.

The fundamental problems of traditional cartography are to:[citation needed[

Set the map's agenda and select traits of the object to be mapped. This is the concern of map editing. Traits may be physical, such as roads or land masses, or may be abstract, such as toponyms or political boundaries.

Represent the terrain of the mapped object on flat media. This is the concern of map projections.

Eliminate characteristics of the mapped object that are not relevant to the map's purpose. This is the concern of generalization.

Reduce the complexity of the characteristics that will be mapped. This is also the concern of generalization.

Orchestrate the elements of the map to best convey its message to its audience. This is the concern of map design.

Modern cartography is closely integrated with geographic information science (GIScience) and constitutes many theoretical and practical foundations of geographic information systems.

Contents

History

Main articles: History of cartography and List of cartographers

Copy (1472) of St. Isidore's TO map of the world.

The earliest known map is a matter of some debate, both because the definition of "map" is not sharp and because some artifacts speculated to be maps might actually be something else. A wall painting, which may depict the ancient Anatolian city of Çatalhöyük (previously known as Catal Huyuk or Çatal Hüyük), has been dated to the late 7th millennium BCE.[1][2] Other known maps of the ancient world include the Minoan "House of the Admiral" wall painting from c. 1600 BCE, showing a seaside community in an oblique perspective and an engraved map of the holy Babylonian city of Nippur, from the Kassite period (14th – 12th centuries BCE).[3] The oldest surviving world maps are the Babylonian world maps from the 9th century BCE.[4] One shows Babylon on the Euphrates, surrounded by a circular landmass showing Assyria, Urartu[5] and several cities, in turn surrounded by a "bitter river" (Oceanus), with seven islands arranged around it.[6] Another depicts Babylon as being further north from the center of the world.[4[

The ancient Greeks and Romans created maps, beginning at latest with Anaximander in the 6th century BC.[7] In the 2nd century AD, Ptolemy produced his treatise on cartography, Geographia.[8] This contained Ptolemy's world map - the world then known to Western society (Ecumene). As early as the 8th century, Arab scholars were translating the works of the Greek geographers into Arabic.[9[

In ancient China, geographical literature spans back to the 5th century BC. The oldest extant Chinese maps come from the State of Qin, dated back to the 4th century BC, during the Warring States Period. In the book of the Xin Yi Xiang Fa Yao, published in 1092 by the Chinese scientist Su Song, a star map on the equidistant cylindrical projection.[10][11] Although this method of charting seems to have existed in China even prior to this publication and scientist, the greatest significance of the star maps by Su Song is that they represent the oldest existent star maps in printed form.

Early forms of cartography of India included the locations of the Pole star and other constellations of use.[12] These charts may have been in use by the beginning of the Common Era for purposes of navigation.[12[

Mappa mundi is the general term used to describe Medieval European maps of the world. Approximately 1,100 mappae mundi are known to have survived from the Middle Ages. Of these, some 900 are found illustrating manuscripts and the remainder exist as stand-alone documents.[13[

The Tabula Rogeriana, drawn by Muhammad al-Idrisi for Roger II of Sicily in 1154

The Arab geographer Muhammad al-Idrisi produced his medieval atlas Tabula Rogeriana in 1154. He incorporated the knowledge of Africa, the Indian Ocean and the Far East, gathered by Arab merchants and explorers with the information inherited from the classical geographers to create the most accurate map of the world up until his time. It remained the most accurate world map for the next three centuries.[14[

Europa regina in Sebastian Münster's "Cosmographia", 1570

In the Age of Exploration, from the 15th century to the 17th century, European cartographers both copied earlier maps (some of which had been passed down for centuries) and drew their own based on explorers' observations and new surveying techniques. The invention of the magnetic compass, telescope and sextant enabled increasing accuracy. In 1492, Martin Behaim, a German cartographer, made the oldest extant globe of the Earth.[15[

Johannes Werner refined and promoted the Werner map projection. In 1507, Martin Waldseemüller produced a globular world map and a large 12-panel world wall map (Universalis Cosmographia) bearing the first use of the name "America". Portuguese cartographer Diego Ribero was the author of the first known planisphere with a graduated Equator (1527). Italian cartographer Battista Agnese produced at least 71 manuscript atlases of sea charts.

Due to the sheer physical difficulties inherent in cartography, map-makers frequently lifted material from earlier works without giving credit to the original cartographer. For example, one of the most famous early maps of North America is unofficially known as the "Beaver Map", published in 1715 by Herman Moll. This map is an exact reproduction of a 1698 work by Nicolas de Fer. De Fer in turn had copied images that were first printed in books by Louis Hennepin, published in 1697, and François Du Creux, in 1664. By the 18th century, map-makers started to give credit to the original engraver by printing the phrase "After [the original cartographer]" on the work.[16[

Technological changes

A pre-Mercator nautical chart of 1571, from Portuguese cartographer Fernão Vaz Dourado (c. 1520–c. 1580). It belongs to the so-called plane chart model, where observed latitudes and magnetic directions are plotted directly into the plane, with a constant scale, as if the Earth were a plane (Portuguese National Archives of Torre do Tombo, Lisbon.(

Mapping can be done with GPS and laser rangefinder directly in the field (for example by Field-Map technology). Real-time map construction improves productivity and quality of mapping. Image shows mapping of forest structure (position of trees, dead wood and canopy.(

In cartography, technology has continually changed in order to meet the demands of new generations of mapmakers and map users. The first maps were manually constructed with brushes and parchment; therefore, varied in quality and were limited in distribution. The advent of magnetic devices, such as the compass and much later, magnetic storage devices, allowed for the creation of far more accurate maps and the ability to store and manipulate them digitally.

Advances in mechanical devices such as the printing press, quadrant and vernier, allowed for the mass production of maps and the ability to make accurate reproductions from more accurate data. Optical technology, such as the telescope, sextant and other devices that use telescopes, allowed for accurate surveying of land and the ability of mapmakers and navigators to find their latitude by measuring angles to the North Star at night or the sun at noon.

Advances in photochemical technology, such as the lithographic and photochemical processes, have allowed for the creation of maps that have fine details, do not distort in shape and resist moisture and wear. This also eliminated the need for engraving, which further shortened the time it takes to make and reproduce maps.

Advances in electronic technology in the 20th century ushered in another revolution in cartography. Ready availability of computers and peripherals such as monitors, plotters, printers, scanners (remote and document) and analytic stereo plotters, along with computer programs for visualization, image processing, spatial analysis, and database management, have democratized and greatly expanded the making of maps. The ability to superimpose spatially located variables onto existing maps created new uses for maps and new industries to explore and exploit these potentials. See also: digital raster graphic.

These days most commercial-quality maps are made using software that falls into one of three main types: CAD, GIS and specialized illustration software. Spatial information can be stored in a database, from which it can be extracted on demand. These tools lead to increasingly dynamic, interactive maps that can be manipulated digitally.

With the field rugged computers, GPS and laser rangefinders, it is possible to perform mapping directly in the terrain. Construction of a map in real time, for example by using Field-Map technology, improves productivity and quality of the result.

Map types

General vs thematic cartography

Small section of an orienteering map.

Topographic map of Easter Island.

Relief map Sierra Nevada

In understanding basic maps, the field of cartography can be divided into two general categories: general cartography and thematic cartography. General cartography involves those maps that are constructed for a general audience and thus contain a variety of features. General maps exhibit many reference and location systems and often are produced in a series. For example, the 1:24,000 scale topographic maps of the United States Geological Survey (USGS) are a standard as compared to the 1:50,000 scale Canadian maps. The government of the UK produces the classic 1:50,000 (replacing the older 1 inch to 1 mile) "Ordnance Survey" maps of the entire UK and with a range of correlated larger- and smaller-scale maps of great detail.

Thematic cartography involves maps of specific geographic themes, oriented toward specific audiences. A couple of examples might be a dot map showing corn production in Indiana or a shaded area map of Ohio counties, divided into numerical choropleth classes. As the volume of geographic data has exploded over the last century, thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data.

An orienteering map combines both general and thematic cartography, designed for a very specific user community. The most prominent thematic element is shading, that indicates degrees of difficulty of travel due to vegetation. The vegetation itself is not identified, merely classified by the difficulty ("fight") that it presents.

Topographic vs topological

A topographic map is primarily concerned with the topographic description of a place, including (especially in the 20th and 21st centuries) the use of contour lines showing elevation. Terrain or relief can be shown in a variety of ways (see Cartographic relief depiction.(

A topological map is a very general type of map, the kind you might sketch on a napkin. It often disregards scale and detail in the interest of clarity of communicating specific route or relational information. Beck's London Underground map is an iconic example. Though the most widely used map of "The Tube," it preserves little of reality: it varies scale constantly and abruptly, it straightens curved tracks, and it contorts directions. The only topography on it is the River Thames, letting the reader know whether a station is north or south of the river. That and the topology of station order and interchanges between train lines are all that is left of the geographic space.[17] Yet those are all a typical passenger wishes to know, so the map fulfils its purpose.[18[

Map design

Illustrated map.

Map purpose and informations' selection

Arthur H. Robinson, an American cartographer influential in thematic cartography, stated that a map not properly designed "will be a cartographic failure." He also claimed, when considering all aspects of cartography, that "map design is perhaps the most complex."[19] Robinson codified the mapmaker's understanding that a map must be designed foremost with consideration to the audience and its needs.

From the very beginning of mapmaking, maps "have been made for some particular purpose or set of purposes".[20] The intent of the map should be illustrated in a manner in which the percipient acknowledges its purpose in a timely fashion. The term percipient refers to the person receiving information and was coined by Robinson.[21] The principle of figure-ground refers to this notion of engaging the user by presenting a clear presentation, leaving no confusion concerning the purpose of the map. This will enhance the user's experience and keep his attention. If the user is unable to identify what is being demonstrated in a reasonable fashion, the map may be regarded as useless.

Making a meaningful map is the ultimate goal. Alan MacEachren explains that a well designed map "is convincing because it implies authenticity" (1994, pp. 9). An interesting map will no doubt engage a reader. Information richness or a map that is multivariate shows relationships within the map. Showing several variables allows comparison, which adds to the meaningfulness of the map. This also generates hypothesis and stimulates ideas and perhaps further research. In order to convey the message of the map, the creator must design it in a manner which will aid the reader in the overall understanding of its purpose. The title of a map may provide the "needed link" necessary for communicating that message, but the overall design of the map fosters the manner in which the reader interprets it (Monmonier, 1993, pp. 93.(

In the 21st century it is possible to find a map of virtually anything from the inner workings of the human body to the virtual worlds of cyberspace. Therefore there are now a huge variety of different styles and types of map - for example, one area which has evolved a specific and recognisable variation are those used by public transport organisations to guide passengers, namely urban rail and metro maps, many of which are loosely based on 45 degree angles as originally perfected by Harry Beck and George Dow.

Naming conventions

Most maps use text to label places and for such things as the map title, legend and other information. Although maps are often made in one specific language, place names often differ between languages. So a map made in English may use the name Germany for that country, while a German map would use Deutschland and a French map Allemagne. A word that describes a place using a non-native terminology or language is referred to as an exonym.

In some cases the correct name is not clear. For example, the nation of Burma officially changed its name to Myanmar, but many nations do not recognize the ruling junta and continue to use Burma. Sometimes an official name change is resisted in other languages and the older name may remain in common use. Examples include the use of Saigon for Ho Chi Minh City, Bangkok for Krung Thep and Ivory Coast for Côte d'Ivoire.

Difficulties arise when transliteration or transcription between writing systems is required. Some well-known places have well-established names in other languages and writing systems, such as Russia or Rußland for Россия, but in other cases a system of transliteration or transcription is required. Even in the former case, the exclusive use of an exonym may be unhelpful for the map user. It will not be much use for an English user of a map of Italy to show Livorno only as "Leghorn" when road signs and railway timetables show it as "Livorno". In transliteration, the characters in one script are represented by characters in another. For example, the Cyrillic letter Р is usually written as R in the Latin script, although in many cases it is not as simple as a one-for-one equivalence. Systems exist for transliteration of Arabic, but the results may vary. For example, the Yemeni city of Mocha is written variously in English as Mocha, Al Mukha, al-Mukhā, Mocca and Moka. Transliteration systems are based on relating written symbols to one another, while transcription is the attempt to spell in one language the phonetic sounds of another. Chinese writing is now usually converted to the Latin alphabet through the Pinyin phonetic transcription systems. Other systems were used in the past, such as Wade-Giles, resulting in the city being spelled Beijing on newer English maps and Peking on older ones.

Further difficulties arise when countries, especially former colonies, do not have a strong national geographic naming standard. In such cases, cartographers may have to choose between various phonetic spellings of local names versus older imposed, sometimes resented, colonial names. Some countries have multiple official languages, resulting in multiple official placenames. For example, the capital of Belgium is both Brussel and Bruxelles. In Canada, English and French are official languages and places have names in both languages. British Columbia is also officially named la Colombie-Britannique. English maps rarely show the French names outside of Quebec, which itself is spelled Québec in French.[22[

The study of placenames is called toponymy, while that of the origin and historical usage of placenames as words is etymology.

In order to improve legibility or to aid the illiterate, some maps have been produced using pictograms to represent places. The iconic example of this practice is Lance Wyman's early plans for the Mexico City Metro, on which stations were shown simply as stylized logos. Wyman also prototyped such a map for the Washington Metro, though ultimately the idea was rejected. Other cities experimenting with such maps are Fukuoka, Guadalajara and Monterrey.[23[

Map symbology

A map of the southwest coast of Ireland created in the early 18th century. Notice the north arrow at the bottom of the map. Also, colors are used in the map to distinguish different geographical areas.

The quality of a map's design affects its reader's ability to extract information and to learn from the map. Cartographic symbology has been developed in an effort to portray the world accurately and effectively convey information to the map reader. A legend explains the pictorial language of the map, known as its symbology. The title indicates the region the map portrays; the map image portrays the region and so on. Although every map element serves some purpose, convention only dictates inclusion of some elements, while others are considered optional. A menu of map elements includes the neatline (border), compass rose or north arrow, overview map, bar scale, projection and information about the map sources, accuracy and publication.

When examining a landscape, scale can be intuited from trees, houses and cars. Not so with a map. Even such a simple thing as a north arrow is crucial. It may seem obvious that the top of a map should point north, but this might not be the case.

Map coloring is also very important. How the cartographer displays the data in different hues can greatly affect the understanding or feel of the map. Different intensities of hue portray different objectives the cartographer is attempting to get across to the audience. Today, personal computers can display up to 16 million distinct colors at a time. This fact allows for a multitude of color options for even for the most demanding maps. Moreover, computers can easily hatch patterns in colors to give even more options. This is very beneficial, when symbolizing data in categories such as quintile and equal interval classifications.

Quantitative symbols give a visual measure of the relative size/importance/number that a symbol represents and to symbolize this data on a map, there are two major classes of symbols used for portraying quantitative properties. Proportional symbols change their visual weight according to a quantitative property. These are appropriate for extensive statistics. Choropleth maps portray data collection areas, such as counties or census tracts, with color. Using color this way, the darkness and intensity (or value) of the color is evaluated by the eye as a measure of intensity or concentration.

Map generalization

Main article: Cartographic generalization

A good map has to compromise between portraying the items of interest (or themes) in the right place on the map, and the need to show that item using text or a symbol, which take up space on the map and might displace some other item of information. The cartographer is thus constantly making judgements about what to include, what to leave out and what to show in a slightly incorrect place. This issue assumes more importance as the scale of the map gets smaller (i.e. the map shows a larger area) because the information shown on the map takes up more space on the ground. A good example from the late 1980s was the Ordnance Survey's first digital maps, where the absolute positions of major roads were sometimes a scale distance of hundreds of metres away from ground truth, when shown on digital maps at scales of 1:250,000 and 1:625,000, because of the overriding need to annotate the features.

Map projections

The Earth being spherical, any flat representation generates distortions such that shapes and areas cannot both be conserved simultaneously, and distances can never all be preserved.[24] The mapmaker must choose a suitable map projection according to the space to be mapped and the purpose of the map

Photozincography

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Photozincography, sometimes referred to as Heliozincography but essentially the same process, known commercially as zinco, is the photographic process developed by Sir Henry James FRS (1803–1877) in the mid-nineteenth century.

This method enabled the accurate reproduction of images, manuscript text and outline engravings, which proved invaluable when originally used to create maps during the Ordnance Survey of Great Britain during the 1850s, carried out by the government's Topographical Department, headed by Colonel Sir Henry James[1[

Contents

Basis

The foundation of this method is the insolubility of bichromate of potash upon exposure to light, allowing the printing of images on to zinc from photographic negatives.

Method

At this time, high-contrast negatives were made using the wet plate collodion method (a solution of nitrocellulose in ether or acetone on glass). Once the negative had been made, a sheet of thin tracing paper was coated in a mixture of saturated potassium bichromate solution and gum water, and dried. This was then placed under the photographic negative and exposed to light for 2–3 minutes. The bichromate/gum mixture remained soluble on the parts of the tracing paper that were shielded from light by the opaque areas of the negative, allowing it to be removed, leaving an insoluble ‘positive’ image. This bichromate positive was then placed on a sheet of zinc covered in lithographic ink, and put through a printing press three or four times. After removal of the paper, the zinc plate was washed in a tray of hot water (containing a small amount of gum), using a camel-hair brush to remove all the soluble bichromate combined with ink. What remained on the zinc plate was a perfect representation in ink of the original composition, by virtue of the ink binding to the insoluble potassium bichromate.

The main advantage and innovation of this process over lithography was the use of zinc plates rather than stone ones. Zinc plates were lighter and easier to transport, could produce more prints, and were far less brittle than the stone plates originally used.[2] The use of zinc plates was also the origin of the name photozincography, which Sir Henry James claims to have invented.

History

Zinco or photozincography developed at the Ordnance Survey out of a need to reduce large-scale maps more effectively. The original method using a pantograph, was overly complicated, time consuming and, due to the number of moving parts, inaccurate. While there was some concern that photography would distort the image, Sir Henry set out to explore the possibility of using photography, setting up a photography department at the Ordnance Survey in 1855 and also securing funds to build the "glasshouse", a photography building with an all glass roof to allow as much natural light in as possible for photography.[3] The development and discovery of photozincography or zinco came about four years later, being first mentioned in Sir Henry's report to Parliament in 1859.

While the Ordnance Survey's Directory General Henry James (Ordnance Survey) claimed to have invented the process, a similar system of document copying had been developed in Australia. John Walter Osborne (1828–1902) developed a similar process for use in Australia and for the same reasons as Sir Henry, to avoid using the tracing system of the pantagraph.[4] While developed at the same time Sir Henry’s process, however as Sir Henry explained to a representative of Mr. Osborne in the quote below, he publicized it first.

I therefore handed this gentleman a copy of my Report, and desired him to read the account given of our process at page 6 of that Report, and to examine the copy of the Deed bound up with it, and not to show me the description of Mr. Osborne's process if it was differed from ours. After reading it, he said at once it was the same process, and I then told him it was useless for him to attempt to take out a patent as my printed Report had everywhere been circulated[5[

Sir Henry, despite being the person who oversaw and set up the photography department, was not the actual inventor. The head of the photography department at Southampton, Captain A. de. Scott, did much of the ground work and basic development on photozincography. Sir Henry did acknowledge the work of Captain A. de. Scott in the development and use of the system in the introduction to the photozincographied Domesday Book.[6] Despite this it was Sir Henry who gained most of the public attention through his pamphlet on photozincography. He was knighted in 1861 for services to science.[7[

The use of photozincography at the Ordnance Survey was a great success, with Sir Henry claiming it saved over £2000 a year, from the invention of photo-zincography; the cost of producing a map of a rural district was reduced from 4 to 1 and maps of towns were reduced from 9 to 1.[8] It was also claimed that up to 2000 or 3000 impressions could be taken from a single plate. Despite this, the process was not perfect: it did not reproduce a full colour picture, and until 1875 boys were employed to colour in the maps produced by this method. The process, while better than the pantagraph, still required a large amount of labour to prepare the zinc plates for pressing. However, photozincography began to be used fairly rapidly in Europe. Sir Henry was even honoured by the Queen of Spain.[9] Though originally developed to reproduce maps, the process was eventually to be used on a whole series of manuscripts, to preserve them and make them more available to the public. This included a reproduction of the Domesday Book in 1861–64 and several volumes of historical manuscripts. Whilst the process of photo-zincography was invented mostly for use the Ordnance Survey, The Photographic News stated that the process could also be used in the Patent office and would save vast amounts of time and money. [8] The use of photozincography began to decline in the 1880s as better methods of reproductions were made available and in the 1900s the glasshouse was pulled down to make way for new printing presses.

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Canada Geographic Information System

The Canada Geographic Information System (CGIS) was developed in the 1960s and 1970s to assist in regulatory procedures of land-use management and resource monitoring. At that time, Canada was beginning to realize problems associated with its seemingly endless boundaries, in combination with natural resource availability. The government therefore decided to launch a national program to assist in management and inventory of its resources. The simple automated computer processes designed to store and process large amounts of data enabled Canada to begin a national land-use management program and become a foremost promoter of geographic information systems (GIS.(

CGIS was designed to withstand great amounts of collected data by managing, modeling, and analyzing this data very quickly and accurately. As Canada presented such large datasets, it was necessary to be able to focus on certain regions or provinces in order to more effectively manage and maintain land-use. CGIS enabled its users to effectively collect national data and, if necessary, break it down into provincial datasets. Early applications of GIS with Canadian datasets benefited land-use management and environmental impact monitoring programs.

Development

In 1960, Roger Tomlinson was working at an aerial survey company in Ottawa, Spartan Air Services. The company was focused on producing large-scale photogrammetric and geophysical maps. In the early 1960s, Tomlinson and the company were asked to produce a map for site-location analysis in an east African nation. Tomlinson immediately recognized that the new automated computer technologies might be applicable and even necessary to complete such a detail-oriented task more effectively and efficiently than humans. Eventually, Spartan met with IBM offices in Ottawa to begin developing a relationship to bridge the previous gap between geographic data and computer services. Tomlinson brought his geographic knowledge to the table as IBM brought computer programming and data management.

The Canadian government and Tomlinson began working towards the development of a national program after a 1962 meeting between Tomlinson and Lee Pratt, head of the Canada Land Inventory (CLI). Pratt was charged with creation of maps covering the entire region of Canada's commercially productive areas by showing agriculture, forestry, wildlife, and recreation, all with the same classification schemes. Not only was the development of such maps a formidable task, but Pratt understood that computer automation may assist in the analytical processes as well. Tomlinson was the first to produce a technical feasibility study on whether computer mapping programs would be viable solution for the land-use inventory and management programs, such as CLI. He is also given credit for coining the term geographic information system and is recognized as the "Modern Father of GIS".

CGIS continued to be developed and operated by the Canadian government until the late 1980s, at which point the widespread emergence of commercial GIS systems slowly rendered it obsolete. In the early 1990s, a group of volunteers successfully extracted all of the data from the old computer tapes, and the data made available on GeoGratis.

Topology

From Wikipedia, the free encyclopedia

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Not to be confused with topography.

This article is about the branch of mathematics. For other uses, see Topology (disambiguation.(

Möbius strips, which have only one surface and one edge, are a kind of object studied in topology.

Topology (from the Greek τόπος, “place”, and λόγος, “study”) is a major area of mathematics concerned with the most basic properties of space, such as connectedness. More precisely, topology studies properties that are preserved under continuous deformations, including stretching and bending, but not tearing or gluing. The exact mathematical definition is given below. Topology developed as a field of study out of geometry and set theory, through analysis of such concepts as space, dimension, and transformation.

Ideas that are now classified as topological were expressed as early as 1736. Toward the end of the 19th century, a distinct discipline developed, which was referred to in Latin as the geometria situs (“geometry of place”) or analysis situs (Greek-Latin for “picking apart of place”). This later acquired the modern name of topology. By the middle of the 20th century, topology had become an important area of study within mathematics.

Topology has many subfields. Point-set topology establishes the foundational aspects of topology and investigates concepts inherent to topological spaces (basic examples include compactness and connectedness). Algebraic topology tries to measure degrees of connectivity using algebraic constructs such as homology and homotopy groups. Geometric topology primarily studies manifolds and their embeddings (placements) in other manifolds. A particularly active area in geometric topology is low dimensional topology, which studies manifold of 4 or fewer dimensions. This includes knot theory, the study of mathematical knots.

A three-dimensional depiction of a thickened trefoil knot, the simplest non-trivial knot

See also: topology glossary for definitions of some of the terms used in topology and topological space for a more technical treatment of the subject.

Contents

History

The Seven Bridges of Königsberg is a famous problem solved by Euler.

Topology began with the investigation of certain questions in geometry. Leonhard Euler's 1736 paper on the Seven Bridges of Königsberg[1] is regarded as one of the first academic treatises in modern topology.

The term "Topologie" was introduced in German in 1847 by Johann Benedict Listing in Vorstudien zur Topologie,[2] who had used the word for ten years in correspondence before its first appearance in print. "Topology," its English form, was first used in 1883 in Listing's obituary in the journal Nature[3] to distinguish "qualitative geometry from the ordinary geometry in which quantitative relations chiefly are treated". The term topologist in the sense of a specialist in topology was used in 1905 in the magazine Spectator.[citation needed] However, none of these uses corresponds exactly to the modern definition of topology.

Modern topology depends strongly on the ideas of set theory, developed by Georg Cantor in the later part of the 19th century. Cantor, in addition to establishing the basic ideas of set theory, considered point sets in Euclidean space as part of his study of Fourier series.

Henri Poincaré published Analysis Situs in 1895,[4] introducing the concepts of homotopy and homology, which are now considered part of algebraic topology.

Maurice Fréchet, unifying the work on function spaces of Cantor, Volterra, Arzelà, Hadamard, Ascoli, and others, introduced the metric space in 1906.[5] A metric space is now considered a special case of a general topological space. In 1914, Felix Hausdorff coined the term "topological space" and gave the definition for what is now called a Hausdorff space.[6] In current usage, a topological space is a slight generalization of Hausdorff spaces, given in 1922 by Kazimierz Kuratowski.[citation needed[

For further developments, see point-set topology and algebraic topology.

Elementary introduction

Topology, as a branch of mathematics, can be formally defined as "the study of qualitative properties of certain objects (called topological spaces) that are invariant under a certain kind of transformation (called a continuous map), especially those properties that are invariant under a certain kind of equivalence (called homeomorphism)." To put it more simply, topology is the study of continuity and connectivity.

The term topology is also used to refer to a structure imposed upon a set X, a structure that essentially 'characterizes' the set X as a topological space by taking proper care of properties such as convergence, connectedness and continuity, upon transformation.

Topological spaces show up naturally in almost every branch of mathematics. This has made topology one of the great unifying ideas of mathematics.

The motivating insight behind topology is that some geometric problems depend not on the exact shape of the objects involved, but rather on the way they are put together. For example, the square and the circle have many properties in common: they are both one dimensional objects (from a topological point of view) and both separate the plane into two parts, the part inside and the part outside.

One of the first papers in topology was the demonstration, by Leonhard Euler, that it was impossible to find a route through the town of Königsberg (now Kaliningrad) that would cross each of its seven bridges exactly once. This result did not depend on the lengths of the bridges, nor on their distance from one another, but only on connectivity properties: which bridges are connected to which islands or riverbanks. This problem, the Seven Bridges of Königsberg, is now a famous problem in introductory mathematics, and led to the branch of mathematics known as graph theory.

A continuous deformation (a type of homeomorphism) of a mug into a doughnut (torus) and back.

Similarly, the hairy ball theorem of algebraic topology says that "one cannot comb the hair flat on a hairy ball without creating a cowlick." This fact is immediately convincing to most people, even though they might not recognize the more formal statement of the theorem, that there is no nonvanishing continuous tangent vector field on the sphere. As with the Bridges of Königsberg, the result does not depend on the exact shape of the sphere; it applies to pear shapes and in fact any kind of smooth blob, as long as it has no holes.

To deal with these problems that do not rely on the exact shape of the objects, one must be clear about just what properties these problems do rely on. From this need arises the notion of homeomorphism. The impossibility of crossing each bridge just once applies to any arrangement of bridges homeomorphic to those in Königsberg, and the hairy ball theorem applies to any space homeomorphic to a sphere.

Intuitively two spaces are homeomorphic if one can be deformed into the other without cutting or gluing. A traditional joke is that a topologist can't distinguish a coffee mug from a doughnut, since a sufficiently pliable doughnut could be reshaped to the form of a coffee cup by creating a dimple and progressively enlarging it, while shrinking the hole into a handle. A precise definition of homeomorphic, involving a continuous function with a continuous inverse, is necessarily more technical.

Homeomorphism can be considered the most basic topological equivalence. Another is homotopy equivalence. This is harder to describe without getting technical, but the essential notion is that two objects are homotopy equivalent if they both result from "squishing" some larger object.

Equivalence classes of the English alphabet:

Homeomorphism	Homotopy equivalence
Alphabet homeo.png	Alphabet homotopy.png

An introductory exercise is to classify the uppercase letters of the English alphabet according to homeomorphism and homotopy equivalence. The result depends partially on the font used. The figures use a sans-serif font named Myriad. Notice that homotopy equivalence is a rougher relationship than homeomorphism; a homotopy equivalence class can contain several of the homeomorphism classes. The simple case of homotopy equivalence described above can be used here to show two letters are homotopy equivalent. For example, O fits inside P and the tail of the P can be squished to the "hole" part.

Thus, the homeomorphism classes are: one hole two tails, two holes no tail, no holes, one hole no tail, no holes three tails, a bar with four tails (the "bar" on the K is almost too short to see), one hole one tail, and no holes four tails.

The homotopy classes are larger, because the tails can be squished down to a point. The homotopy classes are: one hole, two holes, and no holes.

To be sure we have classified the letters correctly, we not only need to show that two letters in the same class are equivalent, but that two letters in different classes are not equivalent. In the case of homeomorphism, this can be done by suitably selecting points and showing their removal disconnects the letters differently. For example, X and Y are not homeomorphic because removing the center point of the X leaves four pieces; whatever point in Y corresponds to this point, its removal can leave at most three pieces. The case of homotopy equivalence is harder and requires a more elaborate argument showing an algebraic invariant, such as the fundamental group, is different on the supposedly differing classes.

Letter topology has some practical relevance in stencil typography. The font Braggadocio, for instance, has stencils that are made of one connected piece of material.

Mathematical definition

Main article: Topological space

Let X be a set and let τ be a family of subsets of X. Then τ is called a topology on X if:

Both the empty set and X are elements of τ

Any union of elements of τ is an element of τ

Any intersection of finitely many elements of τ is an element of τ

If τ is a topology on X, then the pair (X, τ) is called a topological space. The notation Xτ may be used to denote a set X endowed with the particular topology τ.

The members of τ are called open sets in X. A subset of X is said to be closed if its complement is in τ (i.e., its complement is open). A subset of X may be open, closed, both (clopen set), or neither. The empty set and X itself are always clopen.

A function or map from one topological space to another is called continuous if the inverse image of any open set is open. If the function maps the real numbers to the real numbers (both spaces with the Standard Topology), then this definition of continuous is equivalent to the definition of continuous in calculus. If a continuous function is one-to-one and onto, and if the inverse of the function is also continuous, then the function is called a homeomorphism and the domain of the function is said to be homeomorphic to the range. Another way of saying this is that the function has a natural extension to the topology. If two spaces are homeomorphic, they have identical topological properties, and are considered topologically the same. The cube and the sphere are homeomorphic, as are the coffee cup and the doughnut. But the circle is not homeomorphic to the doughnut

Geospatial analysis

From Wikipedia, the free encyclopedia

) Redirected from Geospatial(

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Geospatial analysis is an approach to applying statistical analysis and other informational techniques to data which has a geographical or geospatial aspect. Such analysis would typically employ software capable of geospatial representation and processing, and apply analytical methods to terrestrial or geographic datasets, including the use of geographic information systems and geomatics.[1][2][3[

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Geographical information system usage

Geographical information systems (GIS) use geospatial analysis in a variety of contexts. Use of the word geospatial in place of Geographical Analysis is incorrect.

Basic applications

Geospatial analysis, using GIS, was developed for problems in the environmental and life sciences, in particular ecology, geology and epidemiology. It has extended to almost all industries including defense, intelligence, utilities, Natural Resources (i.e. Oil and Gas, Forestry etc.), social sciences, medicine and Public Safety (i.e. emergency management and criminology). Spatial statistics typically result primarily from observation rather than experimentation.

Basic operations

In the case of vector-based GIS this typically means operations such as map overlay (combining two or more maps or map layers according to predefined rules), simple buffering (identifying regions of a map within a specified distance of one or more features, such as towns, roads or rivers) and similar basic operations. This reflects (and is reflected in) the use of the term spatial analysis within the Open Geospatial Consortium (OGC) “simple feature specifications”. For raster-based GIS, widely used in the environmental sciences and remote sensing, this typically means a range of actions applied to the grid cells of one or more maps (or images) often involving filtering and/or algebraic operations (map algebra). These techniques involve processing one or more raster layers according to simple rules resulting in a new map layer, for example replacing each cell value with some combination of its neighbours’ values, or computing the sum or difference of specific attribute values for each grid cell in two matching raster datasets. Descriptive statistics, such as cell counts, means, variances, maxima, minima, cumulative values, frequencies and a number of other measures and distance computations are also often included in this generic term spatial analysis. Spatial analysis includes a large variety of statistical techniques (descriptive, exploratory, and explanatory statistics) that apply to data that vary spatially and which can vary over time.

Advanced operations

Geospatial analysis goes beyond 2D mapping operations and spatial statistics. It includes:

Surface analysis —in particular analysing the properties of physical surfaces, such as gradient, aspect and visibility, and analysing surface-like data “fields;”

Network analysis — examining the properties of natural and man-made networks in order to understand the behaviour of flows within and around such networks; and locational analysis. GIS-based network analysis may be used to address a wide range of practical problems such as route selection and facility location (core topics in the field of operations research, and problems involving flows such as those found in hydrology and transportation research. In many instances location problems relate to networks and as such are addressed with tools designed for this purpose, but in others existing networks may have little or no relevance or may be impractical to incorporate within the modeling process. Problems that are not specifically network constrained, such as new road or pipeline routing, regional warehouse location, mobile phone mast positioning or the selection of rural community health care sites, may be effectively analysed (at least initially) without reference to existing physical networks. Locational analysis "in the plane" is also applicable where suitable network datasets are not available, or are too large or expensive to be utilised, or where the location algorithm is very complex or involves the examination or simulation of a very large number of alternative configurations.

Geovisualization — the creation and manipulation of images, maps, diagrams, charts, 3D views and their associated tabular datasets. GIS packages increasingly provide a range of such tools, providing static or rotating views, draping images over 2.5D surface representations, providing animations and fly-throughs, dynamic linking and brushing and spatio-temporal visualisations. This latter class of tools is the least developed, reflecting in part the limited range of suitable compatible datasets and the limited set of analytical methods available, although this picture is changing rapidly. All these facilities augment the core tools utilised in spatial analysis throughout the analytical process (exploration of data, identification of patterns and relationships, construction of models, and communication of results(

Web mapping

From Wikipedia, the free encyclopedia

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This article has multiple issues. Please help improve it or discuss these issues on the talk page.

This article includes a list of references, but its sources remain unclear because it has insufficient inline citations. (February 2011(

This article is written like a personal reflection or essay rather than an encyclopedic description of the subject. (February 2011(

This article may contain original research. (February 2011(

Web mapping is the process of designing, implementing, generating and delivering maps on the World Wide Web and its product. While web mapping primarily deals with technological issues, web cartography additionally studies theoretic aspects: the use of web maps, the evaluation and optimization of techniques and workflows, the usability of web maps, social aspects, and more. Web GIS is similar to web mapping but with an emphasis on analysis, processing of project specific geodata and exploratory aspects.[1] Often the terms web GIS and web mapping are used synonymously, even if they don't mean exactly the same. In fact, the border between web maps and web GIS is blurry. Web maps are often a presentation media in web GIS and web maps are increasingly gaining analytical capabilities.

A special case of web maps are mobile maps, displayed on mobile computing devices, such as mobile phones, smart phones, PDAs and GPS. If the maps on these devices are displayed by a mobile web browser or web user agent, they can be regarded as mobile web maps. If the mobile web maps also display context and location sensitive information, such as points of interest, the term Location-based services is frequently used."[2[

"The use of the web as a dissemination medium for maps can be regarded as a major advancement in cartography and opens many new opportunities, such as realtime maps, cheaper dissemination, more frequent and cheaper updates of data and software, personalized map content, distributed data sources and sharing of geographic information. It also implicates many challenges due to technical restrictions (low display resolution and limited bandwidth, in particular with mobile computing devices, many of which are physically small, and use slow wireless Internet connections), copyright[3] and security issues, reliability issues and technical complexity. While the first web maps were primarily static, today's web maps can be fully interactive and integrate multiple media. This means that both web mapping and web cartography also have to deal with interactivity, usability and multimedia issues."[4[

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Development and implementation

The advent of web mapping can be regarded as a major new trend in cartography. Previously, cartography was restricted to a few companies, institutes and mapping agencies, requiring expensive and complex hardware and software as well as skilled cartographers and geomatics engineers. With the rise of web mapping, a range of data and technology was born - from free data generated by OpenStreetMap to proprietary datasets owned by Navteq, Google, and others. A range of free software to generate maps has also been generated, alongside proprietary tools like ArcGIS. As a result, the barrier to entry for creating maps on the web has shifted from that of the paper atlas and other traditional cartography.

Types of web maps

A first classification of web maps has been made by Kraak.[5] He distinguished static and dynamic web maps and further distinguished interactive and view only web maps. However, today in the light of an increased number of different web map types, this classification needs some revision. Today, there are additional possibilities regarding distributed data sources, collaborative maps, personalized maps, etc.

Analytic web maps

These web maps offer GIS analysis, either with geodata provided, or with geodata uploaded by the map user. As already mentioned, the borderline between analytic web maps and web GIS is blurry. Often, parts of the analysis are carried out by a serverside GIS and the client displays the result of the analysis. As web clients gain more and more capabilities, this task sharing may gradually shift.

Animated web maps

Animated Maps show changes in the map over time by animating one of the graphical or temporal variables. Various data and multimedia formats and technologies allow the display of animated web maps: SVG, Adobe Flash, Java, QuickTime, etc., also with varying degrees of interaction. Examples for animated web maps are weather maps, maps displaying dynamic natural or other phenomena (such as water currents, wind patterns, traffic flow, trade flow, communication patterns,social studies projects, and for college life, etc.(.

Collaborative web maps

Main article: Collaborative mapping

Collaborative maps are still new, immature and complex to implement, but show a lot of potential. The method parallels the Wikipedia project where various people collaborate to create and improve maps on the web. Technically, an application allowing simultaneous editing across the web would have to ensure that geometric features being edited by one person are locked, so they can't be edited by other persons at the same time. Also, a minimal quality check would have to be made, before data goes public. Some collaborative map projects:

Google Map Maker

OpenStreetMap

WikiMapia

meta:Maps - survey of Wikimedia map proposals on Wikipedia:Meta

) Please add additional notes, references and examples here(!

Dynamically created web maps

These maps are created on demand each time the user reloads the webpages, often from dynamic data sources, such as databases. The webserver generates the map using a web map server or a self written software. Bhoosampada by Indian Space Research Organizations.

Online atlases

Atlas projects often went through a renaissance when they made a transition to a web based project. In the past, atlas projects often suffered from expensive map production, small circulation and limited audience. Updates were expensive to produce and took a long time until they hit the public. Many atlas projects, after moving to the web, can now reach a wider audience, produce cheaper, provide a larger number of maps and map types and integrate with and benefit from other web resources. Some atlases even ceased their printed editions after going online, sometimes offering printing on demand features from the online edition. Some atlases (primarily from North America) also offer raw data downloads of the underlying geospatial data sources.

Realtime web maps

Realtime maps show the situation of a phenomenon in close to realtime (only a few seconds or minutes delay). Data is collected by sensors and the maps are generated or updated at regular intervals or immediately on demand. Examples are weather maps, traffic maps or vehicle monitoring systems.

Static web maps

A USGS DRG - a static map

Static web pages are view only with no animation and interactivity. They are only created once, often manually and infrequently updated. Typical graphics formats for static web maps are PNG, JPEG, GIF, or TIFF (e.g., drg) for raster files, SVG, PDF or SWF for vector files. Often, these maps are scanned paper maps and had not been designed as screen maps. Paper maps have a much higher resolution and information density than typical computer displays of the same physical size, and might be unreadable when displayed on screens at the wrong resolution.[5[

Advantages of web maps

A surface weather analysis for the United States on October 21, 2006.

Web maps can easily deliver up to date information. If maps are generated automatically from databases, they can display information in almost realtime. They don't need to be printed, mastered and distributed. Examples:

A map displaying election results, as soon as the election results become available.

A map displaying the traffic situation near realtime by using traffic data collected by sensor networks.

A map showing the current locations of mass transit vehicles such as buses or trains, allowing patrons to minimize their waiting time at stops or stations, or be aware of delays in service.

Weather maps, such as NEXRAD.

Software and hardware infrastructure for web maps is cheap. Web server hardware is cheaply available and many open source tools exist for producing web maps.

Product updates can easily be distributed. Because web maps distribute both logic and data with each request or loading, product updates can happen every time the web user reloads the application. In traditional cartography, when dealing with printed maps or interactive maps distributed on offline media (CD, DVD, etc.), a map update caused serious efforts, triggering a reprint or remastering as well as a redistribution of the media. With web maps, data and product updates are easier, cheaper, and faster, and can occur more often.

They work across browsers and operating systems. If web maps are implemented based on open standards, the underlying operating system and browser do not matter.

Web maps can combine distributed data sources. Using open standards and documented APIs one can integrate (mash up) different data sources, if the projection system, map scale and data quality match. The use of centralized data sources removes the burden for individual organizations to maintain copies of the same data sets. The downside is that one has to rely on and trust the external data sources.

Web maps allow for personalization. By using user profiles, personal filters and personal styling and symbolization, users can configure and design their own maps, if the web mapping systems supports personalization. Accessibility issues can be treated in the same way. If users can store their favourite colors and patterns they can avoid color combinations they can't easily distinguish (e.g. due to color blindness.(

Web maps enable collaborative mapping. Similar to the Wikipedia project, web mapping technologies, such as DHTML/Ajax, SVG, Java, Adobe Flash, etc. enable distributed data acquisition and collaborative efforts. Examples for such projects are the OpenStreetMap project or the Google Earth community. As with other open projects, quality assurance is very important, however!

Web maps support hyperlinking to other information on the web. Just like any other web page or a wiki, web maps can act like an index to other information on the web. Any sensitive area in a map, a label text, etc. can provide hyperlinks to additional information. As an example a map showing public transport options can directly link to the corresponding section in the online train time table.

It is easy to integrate multimedia in and with web maps. Current web browsers support the playback of video, audio and animation (SVG, SWF, QuickTime, and other multimedia frameworks.(

Disadvantages of web maps and problematic issues

Reliability issues – the reliability of the internet and web server infrastructure is not yet good enough. Especially if a web map relies on external, distributed data sources, the original author often cannot guarantee the availability of the information.

Geodata are expensive – Unlike in the US, where geodata collected by governmental institutions is usually available for free or cheap, geodata is usually very expensive in Europe or other parts of the world.

Bandwidth issues – Web maps usually need a relatively high bandwidth.

Limited screen space – As with other screen based maps, web maps have the problem of limited screen space. This is in particular a problem for mobile web maps and location based services where maps have to be displayed in very small screens with resolutions as low as 100×100 pixels. Hopefully, technological advances will help to overcome these limitations.

Quality and accuracy issues – Many web maps are of poor quality, both in symbolization, content and data accuracy.

Complex to develop – Despite the increasing availability of free and commercial tools to create web mapping and web GIS applications, it is still a complex task to create interactive web maps. Many technologies, modules, services and data sources have to be mastered and integrated.

Immature development tools – Compared to the development of standalone applications with integrated development tools, the development and debugging environments of a conglomerate of different web technologies is still awkward and uncomfortable.

Copyright issues – Many people are still reluctant to publish geodata, especially in light of the fact that geodata are expensive in some parts of the world. They fear copyright infringements of other people using their data without proper requests for permission.

Privacy issues – With detailed information available and the combination of distributed data sources, it is possible to find out and combine a lot of private and personal information of individual persons. Properties and estates of individuals are now accessible through high resolution aerial and satellite images throughout the world to anyone.

History of web mapping

Event types

Cartography-related events

Technical events directly related to web mapping

General technical events

Events relating to Web standards

This section contains some of the milestones of web mapping, online mapping services and atlases.[6[

۱۹۸۹-۹۰: Birth of the WWW, WWW invented at CERN for the exchange of research documents.[7[

:۰۷-۱۹۹۳ Xerox PARC Map Viewer, The first mapserver based on CGI/Perl, allowed reprojection styling and definition of map extent.

:۱۹۹۴ The World Wide Earthquake Locator, the first interactive web mapping mashup was released, based on the Xerox PARC map view.

:۰۶-۱۹۹۴ The National Atlas of Canada, The first version of the National Atlas of Canada was released. Can be regarded as the first online atlas.

:۱۹۹۵ The Gazetteer for Scotland, The prototype version of the Gazetteer for Scotland was released. The first geographical database with interactive mapping.

:۱۹۹۵ MapGuide, First introduced as Argus MapGuide.

:۰۲-۱۹۹۶ Mapquest, The first popular online Address Matching and Routing Service with mapping output.

:۰۶-۱۹۹۶ MultiMap, The UK-based MultiMap website launched offering online mapping, routing and location based services. Grew into one of the most popular UK web sites.

:۱۱-۱۹۹۶ Geomedia WebMap 1.0, First version of Geomedia WebMap, already supports vector graphics through the use of ActiveCGM.[8[

-۱۹۹۶ fall: MapGuide, Autodesk acquired Argus Technologies.and introduced Autodesk MapGuide 2.0.

National Atlas of the United States logo

:۰۶-۱۹۹۷ US Online National Atlas Initiative, The USGS received the mandate to coordinate and create the online National Atlas of the United States of America [2.[

:۰۷-۱۹۹۷ UMN MapServer 1.0, Developed as Part of the NASA ForNet Project. Grew out of the need to deliver remote sensing data across the web for foresters.

:۰۶-۱۹۹۸ Terraserver USA, A Web Map Service serving aerial images (mainly b+w) and USGS DRGs was released. One of the first popular WMS. This service is a joint effort of USGS, Microsoft and HP.

:۰۷-۱۹۹۸ UMN MapServer 2.0, Added reprojection support (PROJ.4.(

:۰۸-۱۹۹۸ MapObjects Internet Map Server, ESRI's entry into the web mapping business.

:۰۸-۱۹۹۹ National Atlas of Canada, 6th edition, This new version was launched at the ICA 1999 conference in Ottawa. Introduced many new features and topics. Is being improved gradually, since then, and kept up-to-date with technical advancements.

:۰۲-۲۰۰۰ ArcIMS 3.0, The first public release of ESRI's ArcIMS.

:۰۶-۲۰۰۰ ESRI Geography Network, ESRI founded Geography Network to distribute data and web map services.

:۰۶-۲۰۰۰ UMN MapServer 3.0, Developed as part of the NASA TerraSIP Project. This is also the first public, open source release of UMN Mapserver. Added raster support and support for TrueType fonts (FreeType.(

:۰۶-۲۰۰۱ MapScript [3] 1.0 for UMN MapServer, Adds a lot of flexibility to UMN MapServer solutions.

:۰۹-۲۰۰۱ Tirolatlas, A highly interactive online atlas, the first to be based on the SVG standard.

:۰۶-۲۰۰۲ UMN MapServer 3.5, Added support for PostGIS and ArcSDE. Version 3.6 adds initial OGC WMS support.

:۰۷-۲۰۰۲ ArcIMS 4.0, Version 4 of the ArcIMS web map server.

Screenshot from NASA World Wind

:۰۶-۲۰۰۳ NASA World Wind, NASA World Wind Released. An open virtual globe that loads data from distributed resources across the internet. Terrain and buildings can be viewed 3 dimensionally. The (XML based) markup language allows users to integrate their own personal content. This virtual globe needs special software and doesn't run in a web browser.

:۰۷-۲۰۰۳ UMN MapServer 4.0, Adds 24bit raster output support and support for PDF and SWF.

:۰۷-۲۰۰۴ OpenStreetMap, an open source, open content world map founded by Steve Coast.

:۰۲-۲۰۰۵ Google Maps, The first version of Google Maps. Based on raster tiles organized in a quad tree scheme, data loading done with XMLHttpRequests. This mapping application became highly popular on the web, also because it allowed other people to integrate google map services into their own website.

:۰۴-۲۰۰۵ UMN MapServer 4.6, Adds support for SVG.

:۰۶-۲۰۰۵ Google Earth, The first version of Google Earth was released building on the virtual globe metaphor. Terrain and buildings can be viewed 3 dimensionally. The KML (XML based) markup language allows users to integrate their own personal content. This virtual globe needs special software and doesn't run in a web browser.

:۰۵-۲۰۰۶ WikiMapia Launched

۰۱-۲۰۰۹ Nokia makes Ovi Maps free on its smartphones.

Web mapping technologies

The potential number of technologies to implement web mapping projects is almost infinite. Any programming environment, programming language and serverside framework can be used to implement web mapping projects. In any case, both server and client side technologies have to be used. Following is a list of potential and popular server and client side technologies utilized for web mapping.

Spatial databases are usually object relational databases enhanced with geographic data types, methods and properties. They are necessary whenever a web mapping application has to deal with dynamic data (that changes frequently) or with huge amount of geographic data. Spatial databases allow spatial queries, sub selects, reprojections, geometry manipulations and offer various import and export formats. A popular example for an open source spatial database is PostGIS. MySQL also implements some spatial features, although not as mature as PostGIS. Commercial alternatives are Oracle Spatial or spatial extensions of Microsoft SQL Server and IBM DB2. The OGC Simple Features for SQL Specification is a standard geometry data model and operator set for spatial databases. Most spatial databases implement this OGC standard.

WMS servers can generate maps on request, using parameters, such as map layer order, styling/symbolization, map extent, data format, projection, etc. The OGC Consortium defined the WMS standard to define the map requests and return data formats, while other systems use standards like Tile Map Service for a similar purpose. Typical image formats for the map result are PNG, JPEG, GIF or SVG. There are open source WMS Servers such as UMN Mapserver and Mapnik. Commercial alternatives exist from most commercial GIS vendors, such as ESRI ArcIMS and CadCorp.

Graphics tablet

From Wikipedia, the free encyclopedia

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Not to be confused with Tablet computer.

This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. (September 2007(

Wacom Bamboo Capture tablet and pen

A graphics tablet or digitizer is a computer input device that enables a user to hand-draw images and graphics, similar to the way a person draws images with a pencil and paper. These tablets may also be used to capture data or handwritten signatures. It can also be used to trace an image from a piece of paper which is taped or otherwise secured to the surface. Capturing data in this way, either by tracing or entering the corners of linear poly-lines or shapes is called digitizing.

The device consists of a flat surface upon which the user may "draw" or trace an image using an attached stylus, a pen-like drawing apparatus. The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor.

Some tablets are intended as a general replacement for a mouse as the primary pointing and navigation device for desktop computers.

Contents

History

The first electronic handwriting tablet was the Telautograph, patented by Elisha Gray in 1888.[1] Elisha Gray is best known as a contemporaneous inventor of the telephone to Alexander Graham Bell.

The first graphics tablet resembling contemporary tablets and used for handwriting recognition by a computer was the Stylator in 1957.[2] Better known (and often mis-stated as the first digitizer tablet) is the RAND Tablet[3] also known as the Grafacon (for Graphic Converter), introduced in 1964. The RAND Tablet employed a grid of wires under the surface of the pad that encoded horizontal and vertical coordinates in a small magnetic signal. The stylus would receive the magnetic signal, which could then be decoded back as coordinate information.

The acoustic tablet, or spark tablet, used a stylus that generated clicks with a spark plug. The clicks were then triangulated by a series of microphones to locate the pen in space.[4] The system was fairly complex and expensive, and the sensors were susceptible to interference by external noise.

Digitizers were popularized in the mid 1970s and early 1980s by the commercial success of the ID (Intelligent Digitizer) and BitPad manufactured by the Summagraphics Corp. These digitizers were used as the input device for many high-end CAD (Computer Aided Design) systems as well as bundled with PC's and PC based CAD software like AutoCAD.

Summagraphics also made an OEM version of its BitPad which was sold by Apple Computer as the Apple Graphics Tablet accessory to their Apple II. These tablets used a magnetostriction technology which used wires made of a special alloy stretched over a solid substrate to accurately locate the tip of a stylus or the center of a digitizer cursor on the surface of the tablet. This technology also allowed Proximity or "Z" axis measurement.

The first home computer graphics tablet was the KoalaPad. Though originally designed for the Apple II, the Koala eventually broadened its applicability to practically all home computers with graphics support, examples of which include the TRS-80 Color Computer, Commodore 64, and Atari 8-bit family. Competing tablets were eventually produced; the tablets produced by Atari were generally considered to be of high quality.

In 1981, musician Todd Rundgren created the first color graphics tablet software for personal computers, which was licensed to Apple as the Utopia Graphics Tablet System.[5[

In the 1980s, several vendors of graphics tablets began to include additional functions, such as handwriting recognition and on-tablet menus.[6][7[

Operation

There have been many attempts to categorize the technologies that have been used for graphics tablets:

Passive tablets

Passive tablets,[8] most notably those by Wacom, make use of electromagnetic induction technology, where the horizontal and vertical wires of the tablet operate as both transmitting and receiving coils (as opposed to the wires of the RAND Tablet which only transmit). The tablet generates an electromagnetic signal, which is received by the LC circuit in the stylus. The wires in the tablet then change to a receiving mode and read the signal generated by the stylus. Modern arrangements also provide pressure sensitivity and one or more switches (similar to the buttons on a mouse), with the electronics for this information present in the stylus itself, not the tablet. On older tablets, changing the pressure on the stylus nib or pressing a switch changed the properties of the LC circuit, affecting the signal generated by the pen, which modern ones often encode into the signal as a digital data stream. By using electromagnetic signals, the tablet is able to sense the stylus position without the stylus having to even touch the surface, and powering the pen with this signal means that devices used with the tablet never need batteries. Activslate 50, the model used with Promethean Ltd white boards, also uses a hybrid of this technology.[9[

Active tablets

Active tablets differ in that the stylus used contains self-powered electronics that generate and transmit a signal to the tablet. These styli rely on an internal battery rather than the tablet for their power, resulting in a bulkier stylus. Eliminating the need to power the pen means that such tablets may listen for pen signals constantly, as they do not have to alternate between transmit and receive modes, which can result in less jitter.

Optical tablets

Optical tablets operate by a very small digital camera in the stylus, and then doing pattern matching on the image of the paper. The most successful example is the technology developed by Anoto.

Acoustic tablets

Early models were described as spark tablets—a small sound generator was mounted in the stylus, and the acoustic signal picked up by two microphones placed near the writing surface. Some modern designs are able to read positions in three dimensions.[10][11[

Electromagnetic tablets

Wacom's are one example of a graphics tablet that works by generating and detecting an electromagnetic signal: in the Wacom design, the signal is generated by the pen, and detected by a grid of wires in the tablet. Other designs such as those by Pencept generate a signal in the grid of wires in the tablet, and detect it in the pen.

Capacitive tablets

These tablets have also been designed to use an electrostatic or capacitive signal. Scriptel's designs are one example of a high-performance tablet detecting an electrostatic signal. Unlike the type of capacitive design used for touchscreens, the Scriptel design is able to detect the position of the pen while it is in proximity to, or hovering above, the tablet. Many multi-touch tablets use capacitive sensing.[12][13[

For all these technologies, the tablet can use the received signal to also determine the distance of the stylus from the surface of the tablet, the tilt (angle from vertical) of the stylus, and other information in addition to the horizontal and vertical positions.

Compared to touch-sensitive touchscreens, a graphics tablet generally offers much higher precision, the ability to track an object which is not touching the tablet, and can gather much more information about the stylus, but is typically more expensive, and can only be used with the special stylus or other accessories.

Some tablets, especially inexpensive ones aimed at young children, come with a corded stylus, using technology similar to older RAND tablets, although this design is no longer used on any normal tablets.

Styli

Puck

After styli, pucks are the most commonly used tablet accessory. A puck is a mouse-like device that can detect its absolute position and rotation. This is opposed to mice, which can only sense their relative velocity on a surface (most tablet drivers are capable of allowing a puck to emulate a mouse in operation, and many pucks are marketed as "mice".) Pucks range in size and shape, some are externally indistinguishable from a mouse, while others are fairly large device with dozens of buttons and controls. Professional pucks often have a reticle or loupe which allows the user to see the exact point on the tablet's surface targeted by the puck, for detailed tracing and computer aided design (CAD) work.

Embedded LCD tablets

Some graphics tablets incorporate an LCD into the tablet itself, allowing the user to draw directly on the display surface.[14[

Graphics tablet/screen hybrids offer advantages over both touch screens and ordinary tablets. Unlike touch screens, they offer pressure sensitivity, and their resolution is generally higher.[citation needed] While their pressure sensitivity and resolution are typically no better than those of ordinary tablets, they offer the additional advantage of directly seeing the location of the physical pen device relatively to the image on the screen. This often allows for increased accuracy and a more tactile, "real" feeling to the use of the device.

Wacom holds many patents on the key technologies for graphic tablets,[15] which forces competitors to use other technologies or license Wacom's. The displays are often sold for thousands of dollars. For instance, the Wacom Cintiq series ranges from just below US$1,000 to over US$2,000.

Some commercially available graphics tablet-screen hybrids include:

Cintiq from Wacom

Hitachi Starboard

Yiynova's DP10 and MSP19 products

USync's PenStar products

SenTIP from Hanvon

The GD Itronix "Duo Touch" tablet PC products

The p-active XPC-1710a and XPC-1910a

There have also been do it yourself projects where conventional used LCD monitors and graphics tablets have been converted to a graphics tablet-screen hybrid.[16][17[

Uses

Graphics tablets, because of their stylus-based interface and ability to detect some or all of pressure, tilt, and other attributes of the stylus and its interaction with the tablet, are widely considered[according to whom?] to offer a very natural way to create computer graphics, especially two-dimensional computer graphics. Indeed, many graphics packages can make use of the pressure (and, sometimes, stylus tilt or rotation) information generated by a tablet, by modifying the brush size, shape, opacity, color, or other attributes based on data received from the graphics tablet.

In East Asia, graphics tablets, known as "pen tablets", are widely used in conjunction with input-method editor software (IMEs) to write Chinese, Japanese, Korean characters (CJK). The technology is popular and inexpensive and offers a method for interacting with the computer in a more natural way than typing on the keyboard, with the pen tablet supplanting the role of the computer mouse. Uptake of handwriting recognition among users who use alphabetic scripts has been slower.

Graphics tablets are also very commonly found in the artistic world. Using a pen on a graphics tablet combined with a graphics-editing program, such as Adobe Photoshop, gives artists a lot of precision while creating digital drawings. Photographers can also find working with a graphics tablet during their post processing can really speed up tasks like creating a detailed layer mask or dodging and burning.

Educators make use of tablets in classrooms to project handwritten notes or lessons and to allow students to do the same, as well as providing feedback on student work submitted electronically. Online teachers may also use a tablet for marking student work, or for live tutorials or lessons, especially where complex visual information or mathematical equations are required.

Tablets are also popular for technical drawings and CAD, as one can typically put a piece of paper on them without interfering with their function.

Finally, tablets are gaining popularity as a replacement for the computer mouse as a pointing device.[when?] They can feel more intuitive to some users than a mouse, as the position of a pen on a tablet typically corresponds to the location of the pointer on the GUI shown on the computer screen. Those artists using a pen for graphics work will as a matter of convenience use a tablet and pen for standard computer operations rather than put down the pen and find a mouse.

Graphics tablets are available in various sizes and price ranges; A6-sized tablets being relatively inexpensive and A3-sized tablets far more expensive. Modern tablets usually connect to the computer via a USB interface.

Map projection

From Wikipedia, the free encyclopedia

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A medieval depiction of the Ecumene (1482, Johannes Schnitzer, engraver), constructed after the coordinates in Ptolemy's Geography and using his second map projection

A map projection is any method of representing the surface of a sphere or other three-dimensional body on a plane. Map projections are necessary for creating maps. All map projections distort the surface in some fashion. Depending on the purpose of the map, some distortions are acceptable and others are not; therefore different map projections exist in order to preserve some properties of the sphere-like body at the expense of other properties. There is no limit to the number of possible map projections.

Contents

Background

For simplicity of description, most of this article assumes that the surface to be mapped is that of a sphere. In reality, the Earth and other large celestial bodies are generally better modeled as oblate spheroids, whereas small objects such as asteroids often have irregular shapes. These other surfaces can be mapped as well. Therefore, more generally, a map projection is any method of "flattening" into a plane a continuous surface having curvature in all three spatial dimensions.

Projection is not limited to perspective projections, such as those resulting from casting a shadow on a screen, or the rectilinear image produced by a pinhole camera on a flat film plate. Rather, any mathematical function transforming coordinates from the curved surface to the plane is a projection.

Carl Friedrich Gauss's Theorema Egregium proved that a sphere cannot be represented on a plane without distortion. Since any map projection is a representation of a sphere's surface on a plane, all map projections distort. Every distinct map projection distorts in a distinct way. The study of map projections is the characterization of these distortions.

A map of all or part of Earth's surface is a flat representation of a curved surface. Therefore a map projection must have been used to create the map, and, conversely, maps could not exist without map projections. Maps can be more useful than globes in many situations: they are more compact and easier to store; they readily accommodate an enormous range of scales; they are viewed easily on computer displays; they can facilitate measuring properties of the terrain being mapped; they can show larger portions of the Earth's surface at once; and they are cheaper to produce and transport. These useful traits of maps motivate the development of map projections.

Metric properties of maps

An Albers projection shows areas accurately, but distorts shapes.

Many properties can be measured on the Earth's surface independently of its geography. Some of these properties are:

- Area
- Shape
- Direction
- Bearing
- Distance
- Scale

Map projections can be constructed to preserve one or more of these properties, though not all of them simultaneously. Each projection preserves or compromises or approximates basic metric properties in different ways. The purpose of the map determines which projection should form the base for the map. Because many purposes exist for maps, many projections have been created to suit those purposes.

Another consideration in the configuration of a projection is its compatibility with data sets to be used on the map. Data sets are geographic information; their collection depends on the chosen datum (model) of the Earth. Different datums assign slightly different coordinates to the same location, so in large scale maps, such as those from national mapping systems, it is important to match the datum to the projection. The slight differences in coordinate assignation between different datums is not a concern for world maps or other vast territories, where such differences get shrunk to imperceptibility.

Which projection is best?

The mathematics of projection do not permit any particular map projection to be "best" for everything. Something will always get distorted. Therefore a diversity of projections exists to service the many uses of maps and their vast range of scales.

Modern national mapping systems typically employ a transverse Mercator or close variant for large-scale maps in order to preserve conformality and low variation in scale over small areas. For smaller-scale maps, such as those spanning continents or the entire world, many projections are in common use according to their fitness for the purpose.[1[

Thematic maps normally require an equal area projection so that phenomena per unit area are shown in correct proportion.[2] However, representing area ratios correctly necessarily distorts shapes more than many maps that are not equal-area. Hence reference maps of the world often appear on compromise projections instead. Due to the severe distortions inherent in any map of the world, within reason the choice of projection becomes largely one of æsthetics.

The Mercator projection, developed for navigational purposes, has often been used in world maps where other projections would have been more appropriate.[3][4][5][6] This problem has long been recognized even outside professional circles. For example a 1943 New York Times editorial states:

> The time has come to discard [the Mercator] for something that represents the continents and directions less deceptively... Although its usage... has diminished... it is still highly popular as a wall map apparently in part because, as a rectangular map, it fills a rectangular wall space with more map, and clearly because its familiarity breeds more popularity.[7[

A controversy in the 1980s over the Peters map motivated the American Cartographic Association (now Cartography and Geographic Information Society) to produce a series of booklets (including Which Map is Best[8]) designed to educate the public about map projections and distortion in maps. In 1989 and 1990, after some internal debate, seven North American geographic organizations adopted a resolution recommending against using any rectangular projection (including Mercator and Gall–Peters) for reference maps of the world.[6][9[

Construction of a map projection

The creation of a map projection involves two steps:

Selection of a model for the shape of the Earth or planetary body (usually choosing between a sphere or ellipsoid). Because the Earth's actual shape is irregular, information is lost in this step.

Transformation of geographic coordinates (longitude and latitude) to Cartesian (x,y) or polar plane coordinates. Cartesian coordinates normally have a simple relation to eastings and northings defined on a grid superimposed on the projection.

Some of the simplest map projections are literally projections, as obtained by placing a light source at some definite point relative to the globe and projecting its features onto a specified surface. This is not the case for most projections, which are defined only in terms of mathematical formulae that have no direct geometric interpretation.

Choosing a projection surface

A Miller cylindrical projection maps the globe onto a cylinder.

A surface that can be unfolded or unrolled into a plane or sheet without stretching, tearing or shrinking is called a developable surface. The cylinder, cone and of course the plane are all developable surfaces. The sphere and ellipsoid are not developable surfaces. As noted in the introduction, any projection of a sphere or an ellipsoid onto a plane will have to distort the image.

(To compare, one cannot flatten an orange peel without tearing and warping it(.

One way of describing a projection is first to project from the Earth's surface to a developable surface such as a cylinder or cone, and then to unroll the surface into a plane. While the first step inevitably distorts some properties of the globe, the developable surface can then be unfolded without further distortion.

Aspects of the projection

This transverse Mercator projection is mathematically the same as a standard Mercator, but oriented around a different axis.

Once a choice is made between projecting onto a cylinder, cone, or plane, the aspect of the shape must be specified. The aspect describes how the developable surface is placed relative to the globe: it may be normal (such that the surface's axis of symmetry coincides with the Earth's axis), transverse (at right angles to the Earth's axis) or oblique (any angle in between). The developable surface may also be either tangent or secant to the sphere or ellipsoid. Tangent means the surface touches but does not slice through the globe; secant means the surface does slice through the globe. Moving the developable surface away from contact with the globe never preserves or optimizes metric properties, so that possibility is not discussed further here.

Scale

A globe is the only way to represent the earth with constant scale throughout the entire map in all directions. A map cannot achieve that property for any area, no matter how small. It can, however, achieve constant scale along specific lines.

Some possible properties are:

The scale depends on location, but not on direction. This is equivalent to preservation of angles, the defining characteristic of a conformal map.

Scale is constant along any parallel in the direction of the parallel. This applies for any cylindrical or pseudocylindrical projection in normal aspect.

Combination of the above: the scale depends on latitude only, not on longitude or direction. This applies for the Mercator projection in normal aspect.

Scale is constant along all straight lines radiating from a particular geographic location. This is the defining characteristic of an equidistant projection such as the Azimuthal equidistant projection. There are also projections (Maurer, Close) where true distances from two points are preserved.[10][11[

Choosing a model for the shape of the Earth

Projection construction is also affected by how the shape of the Earth is approximated. In the following section on projection categories, the earth is taken as a sphere in order to simplify the discussion. However, the Earth's actual shape is closer to an oblate ellipsoid. Whether spherical or ellipsoidal, the principles discussed hold without loss of generality.

Selecting a model for a shape of the Earth involves choosing between the advantages and disadvantages of a sphere versus an ellipsoid. Spherical models are useful for small-scale maps such as world atlases and globes, since the error at that scale is not usually noticeable or important enough to justify using the more complicated ellipsoid. The ellipsoidal model is commonly used to construct topographic maps and for other large- and medium-scale maps that need to accurately depict the land surface.

A third model of the shape of the Earth is the geoid, a complex and more accurate representation of the global mean sea level surface that is obtained through a combination of terrestrial and satellite gravity measurements. This model is not used for mapping because of its complexity, but rather is used for control purposes in the construction of geographic datums. (In geodesy, plural of "datum" is "datums" rather than "data".) A geoid is used to construct a datum by adding irregularities to the ellipsoid in order to better match the Earth's actual shape. It takes into account the large-scale features in the Earth's gravity field associated with mantle convection patterns, and the gravity signatures of very large geomorphic features such as mountain ranges, plateaus and plains.

Historically, datums have been based on ellipsoids that best represent the geoid within the region that the datum is intended to map. Controls (modifications) are added to the ellipsoid in order to construct the datum, which is specialized for a specific geographic region (such as the North American Datum). A few modern datums, such as WGS84 which is used in the Global Positioning System, are optimized to represent the entire earth as well as possible with a single ellipsoid, at the expense of accuracy in smaller regions.

Classification

A fundamental projection classification is based on the type of projection surface onto which the globe is conceptually projected. The projections are described in terms of placing a gigantic surface in contact with the earth, followed by an implied scaling operation. These surfaces are cylindrical (e.g. Mercator), conic (e.g., Albers), or azimuthal or plane (e.g. stereographic). Many mathematical projections, however, do not neatly fit into any of these three conceptual projection methods. Hence other peer categories have been described in the literature, such as pseudoconic, pseudocylindrical, pseudoazimuthal, retroazimuthal, and polyconic.

Another way to classify projections is according to properties of the model they preserve. Some of the more common categories are:

Preserving direction (azimuthal), a trait possible only from one or two points to every other point

Preserving shape locally (conformal or orthomorphic(

Preserving area (equal-area or equiareal or equivalent or authalic(

Preserving distance (equidistant), a trait possible only between one or two points and every other point

Preserving shortest route, a trait preserved only by the gnomonic projection

Because the sphere is not a developable surface, it is impossible to construct a map projection that is both equal-area and conformal.

Projections by surface

Cylindrical

See also: List of map projections#Cylindrical

The Mercator projection shows courses of constant bearing as straight lines.

The term "normal cylindrical projection" is used to refer to any projection in which meridians are mapped to equally spaced vertical lines and circles of latitude (parallels) are mapped to horizontal lines.

The mapping of meridians to vertical lines can be visualized by imagining a cylinder whose axis coincides with the Earth's axis of rotation. This cylinder is wrapped around the Earth, projected onto, and then unrolled.

By the geometry of their construction, cylindrical projections stretch distances east-west. The amount of stretch is the same at any chosen latitude on all cylindrical projections, and is given by the secant of the latitude as a multiple of the equator's scale. The various cylindrical projections are distinguished from each other solely by their north-south stretching (where latitude is given by ϕ:(

North-south stretching equals east-west stretching (secant ϕ): The east-west scale matches the north-south scale: conformal cylindrical or Mercator; this distorts areas excessively in high latitudes (see also transverse Mercator.(

North-south stretching grows with latitude faster than east-west stretching (secant² ϕ): The cylindric perspective (= central cylindrical) projection; unsuitable because distortion is even worse than in the Mercator projection.

North-south stretching grows with latitude, but less quickly than the east-west stretching: such as the Miller cylindrical projection (secant[4ϕ/5.([

North-south distances neither stretched nor compressed (1): equirectangular projection or "plate carrée."

North-south compression precisely the reciprocal of east-west stretching (cosine ϕ): equal-area cylindrical. This projection has many named specializations differing only in the scaling constant. Some of those specializations are the Gall–Peters or Gall orthographic, Behrmann, and Lambert cylindrical equal-area). This kind of projection divides north-south distances by a factor equal to the secant of the latitude, preserving area at the expense of shapes.

In the first case (Mercator), the east-west scale always equals the north-south scale. In the second case (central cylindrical), the north-south scale exceeds the east-west scale everywhere away from the equator. Each remaining case has a pair of identical latitudes of opposite sign (or else the equator) at which the east-west scale matches the north-south-scale.

Normal cylindrical projections map the whole Earth as a finite rectangle, except in the first two cases, where the rectangle stretches infinitely tall while retaining constant width.

Pseudocylindrical

A sinusoidal projection shows relative sizes accurately, but grossly distorts shapes. Distortion can be reduced by "interrupting" the map.

Pseudocylindrical projections represent the central meridian and each parallel as a single straight line segment, but not the other meridians. Each pseudocylindrical projection represents a point on the Earth along the straight line representing its parallel, at a distance which is a function of its difference in longitude from the central meridian.

Sinusoidal: the north-south scale and the east-west scale are the same throughout the map, creating an equal-area map. On the map, as in reality, the length of each parallel is proportional to the cosine of the latitude. Thus the shape of the map for the whole earth is the region between two symmetric rotated cosine curves.[12[

The true distance between two points on the same meridian corresponds to the distance on the map between the two parallels, which is smaller than the distance between the two points on the map. The true distance between two points on the same parallel—and the true area of shapes on the map—are not distorted. The meridians drawn on the map help the user to realize the shape distortion and mentally compensate for it.

Collignon projection, which in its most common forms represents each meridian as 2 straight line segments, one from each pole to the equator.

Mollweide

Goode homolosine

Eckert IV

Ecker IV projection SW.jpg

Eckert VI

Ecker VI projection SW.jpg

Kavrayskiy VII

Tobler hyperelliptical

Hybrid

The HEALPix projection combines an equal-area cylindrical projection in equatorial regions with the Collignon projection in polar areas.

Conical

Albers conic

Equidistant conic

Lambert conformal conic

Pseudoconical

Bonne

Werner cordiform, upon which distances are correct from one pole, as well as along all parallels.

Continuous American polyconic

Azimuthal (projections onto a plane(

An azimuthal equidistant projection shows distances and directions accurately from the center point, but distorts shapes and sizes elsewhere.

Azimuthal projections have the property that directions from a central point are preserved and therefore great circles through the central point are represented by straight lines on the map. Usually these projections also have radial symmetry in the scales and hence in the distortions: map distances from the central point are computed by a function r(d) of the true distance d, independent of the angle; correspondingly, circles with the central point as center are mapped into circles which have as center the central point on the map.

The mapping of radial lines can be visualized by imagining a plane tangent to the Earth, with the central point as tangent point.

The radial scale is r'(d) and the transverse scale r(d)/(R sin(d/R)) where R is the radius of the Earth.

Some azimuthal projections are true perspective projections; that is, they can be constructed mechanically, projecting the surface of the Earth by extending lines from a point of perspective (along an infinite line through the tangent point and the tangent point's antipode) onto the plane:

The gnomonic projection displays great circles as straight lines. Can be constructed by using a point of perspective at the center of the Earth. r(d) = c tan(d/R); a hemisphere already requires an infinite map,[13][14[

The General Perspective Projection can be constructed by using a point of perspective outside the earth. Photographs of Earth (such as those from the International Space Station) give this perspective.

The orthographic projection maps each point on the earth to the closest point on the plane. Can be constructed from a point of perspective an infinite distance from the tangent point; r(d) = c sin(d/R).[15] Can display up to a hemisphere on a finite circle. Photographs of Earth from far enough away, such as the Moon, give this perspective.

The azimuthal conformal projection, also known as the stereographic projection, can be constructed by using the tangent point's antipode as the point of perspective. r(d) = c tan(d/2R); the scale is c/(2R $\cos^2$(d/2R)).[16] Can display nearly the entire sphere on a finite circle. The full sphere requires an infinite map.

Other azimuthal projections are not true perspective projections:

Azimuthal equidistant: r(d) = cd; it is used by amateur radio operators to know the direction to point their antennas toward a point and see the distance to it. Distance from the tangent point on the map is proportional to surface distance on the earth (;[17] for the case where the tangent point is the North Pole, see the flag of the United Nations(

Lambert azimuthal equal-area. Distance from the tangent point on the map is proportional to straight-line distance through the earth: r(d) = c sin(d/2R)[18[

Logarithmic azimuthal is constructed so that each point's distance from the center of the map is the logarithm of its distance from the tangent point on the Earth. r(d) = c ln(d/d0); locations closer than at a distance equal to the constant d0 are not shown (,[19] figure 6-5(

Projections by preservation of a metric property

A stereographic projection is conformal and perspective but not equal area or equidistant.

Conformal

Conformal map projections preserve angles locally. These are some conformal projections:

Mercator – rhumb lines are represented by straight segments

Transverse Mercator

Stereographic - shape of circles is conserved

Roussilhe

Lambert conformal conic

Peirce quincuncial projection

Adams hemisphere-in-a-square projection

Guyou hemisphere-in-a-square projection

Equal-area

"Area preserving maps" redirects here. For the mathematical concept, see Measure-preserving dynamical system.

The equal-area Mollweide projection

These are some projections that preserve area:

Gall orthographic (also known as Gall–Peters, or Peters, projection(

Albers conic

Lambert azimuthal equal-area

Lambert cylindrical equal-area

Mollweide

Hammer

Briesemeister

Sinusoidal

Werner

Bonne

Bottomley

Goode's homolosine

Hobo–Dyer

Collignon

Tobler hyperelliptical

Snyder’s equal-area polyhedral projection, used for geodesic grids.

Equidistant

A two-point equidistant projection of Asia

These are some projections that preserve distance from some standard point or line:

Equirectangular—distances along meridians are conserved

Plate carrée—an Equirectangular projection centered at the equator

Azimuthal equidistant—distances along great circles radiating from centre are conserved

Equidistant conic

Sinusoidal—distances along parallels are conserved

Werner cordiform distances from the North Pole are correct as are the curved distance on parallels

Soldner

Two-point equidistant: two "control points" are arbitrarily chosen by the map maker. Distance from any point on the map to each control point is proportional to surface distance on the earth.

Gnomonic

The Gnomonic projection is thought to be the oldest map projection, developed by Thales in the 6th century BC

Great circles are displayed as straight lines:

Gnomonic projection

Retroazimuthal

Direction to a fixed location B (the bearing at the starting location A of the shortest route) corresponds to the direction on the map from A to B:

Littrow—the only conformal retroazimuthal projection

Hammer retroazimuthal—also preserves distance from the central point

Craig retroazimuthal aka Mecca or Qibla—also has vertical meridians

Compromise projections

The Robinson projection was adopted by National Geographic Magazine in 1988 but abandoned by them in about 1997 for the Winkel Tripel.

Compromise projections give up the idea of perfectly preserving metric properties, seeking instead to strike a balance between distortions, or to simply make things "look right". Most of these types of projections distort shape in the polar regions more than at the equator. These are some compromise projections:

Robinson

van der Grinten

Aerial photography

From Wikipedia, the free encyclopedia

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The Georgian terrace of Royal Crescent (Bath, England) from a hot air balloon

London Docklands in the fog from a Eurocopter AS355

Aerial photography is the taking of photographs of the ground from an elevated position. The term usually refers to images in which the camera is not supported by a ground-based structure. Cameras may be hand held or mounted, and photographs may be taken by a photographer, triggered remotely or triggered automatically. Platforms for aerial photography include fixed-wing aircraft, helicopters, balloons, blimps and dirigibles, rockets, kites, poles, parachutes, and vehicle mounted poles. Aerial photography should not be confused with Air-to-Air Photography, when aircraft serve both as a photo platform and subject.

Contents

History

Honoré Daumier, "Nadar élevant la Photographie à la hauteur de l'Art" (Nadar elevating Photography to Art), published in Le Boulevard, May 25, 1862.

Aerial photography was first practiced by the French photographer and balloonist Gaspard-Félix Tournachon, known as "Nadar", in 1858 over Paris, France.[1[

'Boston, as the Eagle and the Wild Goose See It'

However, the photographs he produced no longer exist and therefore the earliest surviving aerial photograph is titled 'Boston, as the Eagle and the Wild Goose See It.' Taken by James Wallace Black and Samuel Archer King on October 13, 1860, it depicts Boston from a height of 630m.[2[

The first use of a motion picture camera mounted to a heavier-than-air aircraft took place on April 24, 1909 over Rome in the 3:28 silent film short, Wilbur Wright und seine Flugmaschine.

The first special semiautomatic aerial camera was designed in 1911 by Russian military engineer — Colonel Potte V. F.[3] This aerial camera was used during World War I.

The use of aerial photography for military purposes was expanded during World War I by many other aviators such as Fred Zinn. One of the first notable battles was that of Neuve Chapelle.

The first commercial aerial photography company in the UK was Aerofilms Ltd, founded by World War I veterans Francis Wills and Claude Graham White. Wills had served as an Observer with the Royal Naval Air Service during the Great War, and was the driving force behind the expansion of the company from an office and a bathroom (for developing films) in Hendon to a business with major contracts in Africa and Asia as well as in the UK. Co-founder Graham-White was a pioneer aviator who had achieved fame by making the first night flight in 1910. The entire Aerofilms oblique collection, comprising some 1.26 million negatives and 2000 print albums, is now held in the archive of National Monuments Record (England) in Swindon, UK.

Aerial mapping came into use on the battlefronts during World War I. In January 1918, General Allenby used five Australian pilots from No. 1 Squadron AFC to photograph a 624 square miles (1,620 km2) area in Palestine as an aid to correcting and improving maps of the Turkish front. Lieutenants Leonard Taplin, Allan Runciman Brown, H. L. Fraser, Edward Patrick Kenny, and L. W. Rogers photographed a block of land stretching from the Turkish front lines 32 miles (51 km) deep into their rear areas. Beginning 5 January, they flew with a fighter escort to ward off enemy fighters. Using Royal Aircraft Factory BE.12 and Martinsyde airplanes, they not only overcame enemy air attacks, but also bucked 65 mile per hour winds, antiaircraft fire, and malfunctioning equipment to complete their task circa 19 January 1918.[4[

One of the most successful pioneers of the commercial use of aerial photography was by Sherman Fairchild who started his own aircraft firm Fairchild Aircraft to develop and build specialized aircraft for high altitude aerial survey missions.[5] One Fairchild aerial survey aircraft in 1935 carried unit that combined two synchronized cameras, and each camera having five six inch lenses with a ten inch lenses and took photos from

23,000 feet. Each photo covered two hundred and twenty five square miles. One of its first government contracts was an aerial survey of New Mexico to study soil erosion.[6] A year later, Fairchild introduced a better high altitude camera with nine-lens in one unit that could take a photo of 600 square miles with each exposure from 30,000 feet.[7[

With the advent of inexpensive digital cameras, many people now take candid photographs from commercial aircraft and increasingly from general aviation aircraft on private pleasure flights.

Uses of imagery

Reflection of a hot air balloon, partially obscured by a pier, an example of low-altitude aerial photography

Giza pyramid complex, photographed from Eduard Spelterini's balloon on November 21, 1904

Fogo island aerial shot taken from an Airbus cockpit by the pilot himself

Aerial photography is used in cartography[8] (particularly in photogrammetric surveys, which are often the basis for topographic maps), land-use planning,[8] archaeology,[8] movie production, environmental studies, surveillance, commercial advertising, conveyancing, and artistic projects. In the United States, aerial photographs are used in many Phase I Environmental Site Assessments for property analysis.

Aerial photography platforms

Radio-controlled aircraft

Advances in radio controlled models have made it possible for model aircraft to conduct low-altitude aerial photography. This has benefited real-estate advertising, where commercial and residential properties are the photographic subject. Full-size, manned aircraft are prohibited from low flights above populated locations.[9] Small scale model aircraft offer increased photographic access to these previously restricted areas. Miniature vehicles do not replace full size aircraft, as full size aircraft are capable of longer flight times, higher altitudes, and greater equipment payloads. They are, however, useful in any situation in which a full-scale aircraft would be dangerous to operate. Examples would include the inspection of transformers atop power transmission lines and slow, low-level flight over agricultural fields, both of which can be accomplished by a large-scale radio controlled helicopter. Professional-grade, gyroscopically stabilized camera platforms are available for use under such a model; a large model helicopter with a 26cc gasoline engine can hoist a payload of approximately seven kilograms (15 lbs.(

Recent (2006) FAA regulations grounding all commercial RC model flights have been upgraded to require formal FAA certification before permission to fly at any altitude in USA.

Because anything capable of being viewed from a public space is considered outside the realm of privacy in the United States, aerial photography may legally document features and occurrences on private property.[10[

Types of aerial photographs

Oblique photographs

Photographs taken at an angle are called oblique photographs. If they are taken from a low angle earth surface–aircraft, they are called low oblique and photographs taken from a high angle are called high or steep oblique.[11[

Vertical photographs

Vertical photographs are taken straight down.[12] They are mainly used in photogrammetry and image interpretation. Pictures that will be used in photogrammetry are traditionally taken with special large format cameras with calibrated and documented geometric properties.

Combinations

Aerial photographs are often combined. Depending on their purpose it can be done in several ways, of which a few are listed below.

Panoramas can be made by stitching several photographs taken with one hand held camera.

In pictometry five rigidly mounted cameras provide one vertical and four low oblique pictures that can be used together.

In some digital cameras for aerial photogrammetry images from several imaging elements, sometimes with separate lenses, are geometrically corrected and combined to one image in the camera.

Orthophotos

Vertical photographs are often used to create orthophotos, photographs which have been geometrically "corrected" so as to be usable as a map. In other words, an orthophoto is a simulation of a photograph taken from an infinite distance, looking straight down to nadir. Perspective must obviously be removed, but variations in terrain should also be corrected for. Multiple geometric transformations are applied to the image, depending on the perspective and terrain corrections required on a particular part of the image.

Orthophotos are commonly used in geographic information systems, such as are used by mapping agencies (e.g. Ordnance Survey) to create maps. Once the images have been aligned, or "registered", with known real-world coordinates, they can be widely deployed.

Large sets of orthophotos, typically derived from multiple sources and divided into "tiles" (each typically 256 x 256 pixels in size), are widely used in online map systems such as Google Maps. OpenStreetMap offers the use of similar orthophotos for deriving new map data. Google Earth overlays orthophotos or satellite imagery onto a digital elevation model to simulate 3D landscapes.

Aerial video

With advancements in video technology, aerial video is becoming more popular. Orthogonal video is shot from aircraft mapping pipelines, crop fields, and other points of interest. Using GPS, video may be embedded with meta data and later synced with a video mapping program.

This "Spatial Multimedia" is the timely union of digital media including still photography, motion video, stereo, panoramic imagery sets, immersive media constructs, audio, and other data with location and date-time information from the GPS and other location designs.

Aerial videos are emerging Spatial Multimedia which can be used for scene understanding and object tracking. The input video is captured by low flying aerial platforms and typically consists of strong parallax from non-ground-plane structures. The integration of digital video, global positioning systems (GPS) and automated image processing will improve the accuracy and cost-effectiveness of data collection and reduction. Several different aerial platforms are under investigation for the data collection.

Raster graphics

From Wikipedia, the free encyclopedia

) Redirected from Raster images(

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The smiley face in the top left corner is a bitmap image. When enlarged, individual pixels appear as squares. Zooming in further, they can be analyzed, with their colors constructed by adding the values for red, green and blue.

In computer graphics, a raster graphics image, or bitmap, is a dot matrix data structure representing a generally rectangular grid of pixels, or points of color, viewable via a monitor, paper, or other display medium. Raster images are stored in image files with varying formats (see comparison of graphics file formats.(

A bitmap corresponds bit-for-bit with an image displayed on a screen, generally in the same format used for storage in the display's video memory, or maybe as a device-independent bitmap. A bitmap is technically characterized by the width and height of the image in pixels and by the number of bits per pixel (a color depth, which determines the number of colors it can represent.(

The printing and prepress industries know raster graphics as contones (from "continuous tones") and refer to vector graphics as "line work."

Contents

Etymology

The word "raster" has its origins in the Latin rastrum (a rake), which is derived from radere (to scrape). It originally referred to the raster scan of cathode ray tube (CRT) video monitors, which paints the image line by line by magnetically steering a focused electron beam. By association, it came also to refer to a rectangular grid of pixels. See also rastrum, a device for drawing musical staff lines.

Resolution

Raster graphics are resolution dependent. They cannot scale up to an arbitrary resolution without loss of apparent quality. This property contrasts with the capabilities of vector graphics, which easily scale up to the quality of the device rendering them. Raster graphics deal more practically than vector graphics with photographs and photo-realistic images, while vector graphics often serve better for typesetting or for graphic design. Modern computer-monitors typically display about 72 to 130 pixels per inch (PPI), and some modern consumer printers can resolve 2400 dots per inch (DPI) or more; determining the most appropriate image resolution for a given printer-resolution can pose difficulties, since printed output may have a greater level of detail than a viewer can discern on a monitor. Typically, a resolution of 150 to 300 pixel per inch works well for 4-color process (CMYK) printing.

However, for printing technologies that perform color mixing through dithering rather than through overprinting (virtually all home and office, inkjet and laser printers included), printer DPI and image PPI have a very different meaning, and this can be misleading. Because, through the dithering process, the printer builds a single image pixel out of several printer dots to increase color depth, the printer's DPI setting must be set far higher than the desired PPI to ensure sufficient color depth without sacrificing image resolution. Thus, for instance, printing an image at 250 PPI may actually require a printer setting of 1200 DPI.[1[

Raster-based image editors

Raster-based image editors, such as Painter, Photoshop, MS Paint, and GIMP, revolve around editing pixels, unlike vector-based image editors, such as Xfig, CorelDRAW, Adobe Illustrator, or Inkscape, which revolve around editing lines and shapes (vectors). When an image is rendered in a raster-based image editor, the image is composed of millions of pixels. At its core, a raster image editor works by manipulating each individual pixel. Most pixel-based image editors work using the RGB color model, but some also allow the use of other color models such as the CMYK color model.

Scanned-display computer graphics

An early scanned display with raster computer graphics was invented in the late 1960s by A. Michael Noll at Bell Labs,[2] but its patent application filed February 5, 1970 was abandoned at the Supreme Court in 1977 over the issue of the patentability of computer software.[citation nee

Photogrammetry

From Wikipedia, the free encyclopedia

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Photogrammetry is the practice of determining the geometric properties of objects from photographic images. Photogrammetry is as old as modern photography and can be dated to the mid-nineteenth century.

In the simplest example, the distance between two points that lie on a plane parallel to the photographic image plane can be determined by measuring their distance on the image, if the scale (s) of the image is known. This is done by multiplying the measured distance by 1/s.

Algorithms for photogrammetry typically express the problem as that of minimizing the sum of the squares of a set of errors. This minimization is known as bundle adjustment and is often performed using the Levenberg–Marquardt algorithm.

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Photogrammetric methods

Georg Wiora's data model of photogrammetry [1[

Photogrammetry uses methods from many disciplines, including optics and projective geometry. The data model on the right shows what type of information can go into and come out of photogrammetric methods.

The 3D co-ordinates define the locations of object points in the 3D space. The image co-ordinates define the locations of the object points' images on the film or an electronic imaging device. The exterior orientation of a camera defines its location in space and its view direction. The inner orientation defines the geometric parameters of the imaging process. This is primarily the focal length of the lens, but can also include the description of lens distortions. Further additional observations play an important role: With scale bars, basically a known distance of two points in space, or known fix points, the connection to the basic measuring units is created.

Each of the four main variables can be an input or an output of a photogrammetric method.

Photogrammetry has been defined by the American Society for Photogrammetry and Remote Sensing (ASPRS) as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena.[1[

Integration

Photogrammetric data with dense range data from scanners complement each other. Photogrammetry is more accurate in the x and y direction while range data are generally more accurate in the z direction. This range data can be supplied by techniques like LiDAR, laser scanners (using time of flight, triangulation or interferometry), white-light digitizers and any other technique that scans an area and returns x, y, z coordinates for multiple discrete points (commonly called "point clouds"). Photos can clearly define the edges of buildings when the point cloud footprint can not. It is beneficial to incorporate the advantages of both systems and integrate them to create a better product.

A 3D visualization can be created by georeferencing the aerial photos and LiDAR data in the same reference frame, orthorectifying the aerial photos, and then draping the orthorectified images on top of the LiDAR grid. It is also possible to create digital terrain models and thus 3D visualisations using pairs (or multiples) of aerial photographs or satellite (e.g. SPOT satellite imagery). Techniques such as adaptive least squares stereo matching are then used to produce a dense array of correspondences which are transformed through a camera model to produce a dense array of x, y, z data which can be used to produce digital terrain model and orthoimage products. Systems which use these techniques, e.g. the ITG system, were developed in the 1980s and 1990s but have since been supplanted by LiDAR and radar-based approaches, although these techniques may still be useful in deriving elevation models from old aerial photographs or satellite images.

Applications

Video of a 3d model of Horatio Nelson bust in Monmouth Museum, Wales, produced using photogrammetry.ogv

Video of a 3d model of Horatio Nelson bust in Monmouth Museum, produced using photogrammetry.

Photogrammetry is used in different fields, such as topographic mapping, architecture, engineering, manufacturing, quality control, police investigation, and geology, as well as by archaeologists to quickly produce plans of large or complex sites and by meteorologists as a way to determine the actual wind speed of a tornado where objective weather data cannot be obtained. It is also used to combine live action with computer-generated imagery in movie post-production; The Matrix is a good example of the use of photogrammetry in film (details are given in the DVD extras.(

This method is commonly employed in collision engineering, especially with automobiles. When litigation for accidents occurs and engineers need to determine the exact deformation present in the vehicle, it is common for several years to have passed and the only evidence that remains is crime scene photographs taken by the police. Photogrammetry is used to determine how much the car in question was deformed, which relates to the amount of energy required to produce that deformation. The energy can then be used to determine important information about the crash (such as the velocity at time of impact.(

Stereophotogrammetry

A more sophisticated technique, called stereophotogrammetry, involves estimating the three-dimensional coordinates of points on an object. These are determined by measurements made in two or more photographic images taken from different positions (see stereoscopy). Common points are identified on each image. A line of sight (or ray) can be constructed from the camera location to the point on the object. It is the intersection of these rays (triangulation) that determines the three-dimensional location of the point. More sophisticated algorithms can exploit other information about the scene that is known a priori, for example symmetries, in some cases allowing reconstructions of 3D coordinates from only one camera position.

Remote sensing

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For the technique in archaeological surveying, see remote sensing (archaeology). For the claimed psychic ability, see remote viewing. For the electrical measurement technique, see four-terminal sensing.

Synthetic aperture radar image of Death Valley colored using polarimetry.

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. 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 emitted from aircraft or satellites).[1][2[

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Overview

Mapping The Future With Landsat.ogv

This video is about how Landsat was used to identify areas of conservation in the Democratic Republic of the Congo, and how it was used to help map an area called MLW in the norh.

There are two main types of remote sensing: passive remote sensing and active remote sensing.[3] Passive sensors detect natural radiation that is emitted or reflected by the object or surrounding areas. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples of passive remote sensors include film photography, infrared, charge-coupled devices, and radiometers. Active collection, on the other hand, emits 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, speed and direction of an object.

Remote sensing makes it possible to collect data on dangerous or inaccessible areas. Remote sensing applications include monitoring deforestation in areas such as the Amazon Basin, glacial features in Arctic and Antarctic regions, and depth sounding of coastal and ocean depths. Military collection during the Cold War made use of stand-off collection of data about dangerous border areas. Remote sensing also replaces costly and slow data collection on the ground, ensuring in the process that areas or objects are not disturbed.

Orbital platforms collect and transmit data from different parts of the electromagnetic spectrum, which in conjunction with larger scale aerial or ground-based sensing and analysis, provides researchers with enough information to monitor trends such as El Niño and other natural long and short term phenomena. Other uses include different areas of the earth sciences such as natural resource management, agricultural fields such as land usage and conservation, and national security and overhead, ground-based and stand-off collection on border areas.[4[

By satellite, aircraft, spacecraft, buoy, ship, and helicopter images, data is created to analyze and compare things like vegetation rates, erosion, pollution, forestry, weather, and land use. These things can be mapped, imaged, tracked and observed. The process of remote sensing is also helpful for city planning, archaeological investigations, military observation and geomorphological surveying.

Data acquisition techniques

The basis for multispectral collection and analysis is that of examined areas or objects that reflect or emit radiation that stand out from surrounding areas.

Applications of remote sensing data

Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Doppler radar is used by local law enforcements' monitoring of speed limits and in enhanced meteorological collection such as wind speed and direction within weather systems. Other types of active collection includes plasmas in the ionosphere. Interferometric synthetic aperture radar is used to produce precise digital elevation models of large scale terrain (See RADARSAT, TerraSAR-X, Magellan.(

Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so. By measuring the height and wavelength of ocean waves, the altimeters measure wind speeds and direction, and surface ocean currents and directions.

Light detection and ranging (LIDAR) is well known in examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology. Vegetation remote sensing is a principal application of LIDAR.

Radiometers and photometers are the most common instrument in use, collecting reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors, followed by microwave, gamma ray and rarely, ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere.

Stereographic pairs of aerial photographs have often been used to make topographic maps by imagery and terrain analysts in trafficability and highway departments for potential routes.

Simultaneous multi-spectral platforms such as Landsat have been in use since the 70's. These thematic mappers take images in multiple wavelengths of electro-magnetic radiation (multi-spectral) and are usually found on Earth observation satellites, including (for example) the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, deforestation, and examine the health of indigenous plants and crops, including entire farming regions or forests.

Hyperspectral imaging produces an image where each pixel has full spectral information with imaging narrow spectral bands over a contiguous spectral range. Hyperspectral imagers are used in various applications including mineralogy, biology, defence, and environmental measurements.

Within the scope of the combat against desertification, remote sensing allows to follow-up and monitor risk areas in the long term, to determine desertification factors, to support decision-makers in defining relevant measures of environmental management, and to assess their impacts.[5[

Geodetic

Overhead geodetic collection was first used in aerial submarine detection and gravitational data used in military maps. This data revealed minute perturbations in the Earth's gravitational field (geodesy) that may be used to determine changes in the mass distribution of the Earth, which in turn may be used for geological studies.

Acoustic and near-acoustic

Sonar: passive sonar, listening for the sound made by another object (a vessel, a whale etc.); active sonar, emitting pulses of sounds and listening for echoes, used for detecting, ranging and measurements of underwater objects and terrain.

Seismograms taken at different locations can locate and measure earthquakes (after they occur) by comparing the relative intensity and precise timing.

To coordinate a series of large-scale observations, most sensing systems depend on the following: platform location, what time it is, and the rotation and orientation of the sensor. High-end instruments now often use positional information from satellite navigation systems. The rotation and orientation is often provided within a degree or two with electronic compasses. Compasses can measure not just azimuth (i. e. degrees to magnetic north), but also altitude (degrees above the horizon), since the magnetic field curves into the Earth at different angles at different latitudes. More exact orientations require gyroscopic-aided orientation, periodically realigned by different methods including navigation from stars or known benchmarks.

Resolution impacts collection and is best explained with the following relationship: less resolution=less detail & larger coverage, More resolution=more detail, less coverage. The skilled management of collection results in cost-effective collection and avoid situations such as the use of multiple high resolution data which tends to clog transmission and storage infrastructure.

Data processing

See also: Inverse problem

Generally speaking, remote sensing works on the principle of the inverse problem. While the object or phenomenon of interest (the state) may not be directly measured, there exists some other variable that can be detected and measured (the observation), which may be related to the object of interest through the use of a data-derived computer model. The common analogy given to describe this is trying to determine the type of animal from its footprints. For example, while it is impossible to directly measure temperatures in the upper atmosphere, it is possible to measure the spectral emissions from a known chemical species (such as carbon dioxide) in that region. The frequency of the emission may then be related to the temperature in that region via various thermodynamic relations.

The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolutions.

Spatial resolution

The size of a pixel that is recorded in a raster image – typically pixels may correspond to square areas ranging in side length from 1 to 1,000 metres (3.3 to 3,300 ft.(

Spectral resolution

The wavelength width of the different frequency bands recorded – usually, this is related to the number of frequency bands recorded by the platform. Current Landsat collection is that of seven bands, including several in the infra-red spectrum, ranging from a spectral resolution of 0.07 to 2.1 μm. The Hyperion sensor on Earth Observing-1 resolves 220 bands from 0.4 to 2.5 μm, with a spectral resolution of 0.10 to 0.11 μm per band.

Radiometric resolution

The number of different intensities of radiation the sensor is able to distinguish. Typically, this ranges from 8 to 14 bits, corresponding to 256 levels of the gray scale and up to 16,384 intensities or "shades" of colour, in each band. It also depends on the instrument noise.

Temporal resolution

The frequency of flyovers by the satellite or plane, and is only relevant in time-series studies or those requiring an averaged or mosaic image as in deforesting monitoring. This was first used by the intelligence community where repeated coverage revealed changes in infrastructure, the deployment of units or the modification/introduction of equipment. Cloud cover over a given area or object makes it necessary to repeat the collection of said location.

In order to create sensor-based maps, most remote sensing systems expect to extrapolate sensor data in relation to a reference point including distances between known points on the ground. This depends on the type of sensor used. For example, in conventional photographs, distances are accurate in the center of the image, with the distortion of measurements increasing the farther you get from the center. Another factor is that of the platen against which the film is pressed can cause severe errors when photographs are used to measure ground distances. The step in which this problem is resolved is called georeferencing, and involves computer-aided matching up of points in the image (typically 30 or more points per image) which is extrapolated with the use of an established benchmark, "warping" the image to produce accurate spatial data. As of the early 1990s, most satellite images are sold fully georeferenced.

In addition, images may need to be radiometrically and atmospherically corrected.

Radiometric correction

Gives a scale to the pixel values, e. g. the monochromatic scale of 0 to 255 will be converted to actual radiance values.

Topographic correction

In the rugged mountains, as a result of terrain, each pixel which receives the effective illumination varies considerably different. In remote sensing image, the pixel on the shady slope receives weak illumination and has a low radiance value, in contrast, the pixel on the sunny slope receives strong illumination and has a high radiance value. For the same objects, the pixel radiance values on the shady slope must be very different from that on the sunny slope. Different objects may have the similar radiance values. This spectral information changes seriously affected remote sensing image information extraction accuracy in the mountainous area. It became the main obstacle to further application on remote sensing images. The purpose of topographic correction is to eliminate this effect, recovery true reflectivity or radiance of objects in horizontal conditions. It is the premise of quantitative remote sensing application.

Atmospheric correction

eliminates atmospheric haze by rescaling each frequency band so that its minimum value (usually realised in water bodies) corresponds to a pixel value of 0. The digitizing of data also make possible to manipulate the data by changing gray-scale values.

Interpretation is the critical process of making sense of the data. The first application was that of aerial photographic collection which used the following process; spatial measurement through the use of a light table in both conventional single or stereographic coverage, added skills such as the use of photogrammetry, the use of photomosaics, repeat coverage, Making use of objects' known dimensions in order to detect modifications. Image Analysis is the recently developed automated computer-aided application which is in increasing use.

Object-Based Image Analysis (OBIA) is a sub-discipline of GIScience devoted to partitioning remote sensing (RS) imagery into meaningful image-objects, and assessing their characteristics through spatial, spectral and temporal scale.

Old data from remote sensing is often valuable because it may provide the only long-term data for a large extent of geography. At the same time, the data is often complex to interpret, and bulky to store. Modern systems tend to store the data digitally, often with lossless compression. The difficulty with this approach is that the data is fragile, the format may be archaic, and the data may be easy to falsify. One of the best systems for archiving data series is as computer-generated machine-readable ultrafiche, usually in typefonts such as OCR-B, or as digitized half-tone images. Ultrafiches survive well in standard libraries, with lifetimes of several centuries. They can be created, copied, filed and retrieved by automated systems. They are about as compact as archival magnetic media, and yet can be read by human beings with minimal, standardized equipment.

Data processing levels

To facilitate the discussion of data processing in practice, several processing “levels” were first defined in 1986 by NASA as part of its Earth Observing System[6] and steadily adopted since then, both internally at NASA (e. g.,[7]) and elsewhere (e. g.,[8]); these definitions are:

Level	Description
۰	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts (e. g., synchronization frames, communications headers, duplicate data) removed.
۱a	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e. g., platform ephemeris) computed and appended but not applied to the Level 0 data (or if applied, in a manner that level 0 is fully recoverable from level 1a data.(
۱b	Level 1a data that have been processed to sensor units (e. g., radar backscatter cross section, brightness temperature, etc.); not all instruments have Level 1b data; level 0 data is not recoverable from level 1b data.
۲	Derived geophysical variables (e. g., ocean wave height, soil moisture, ice concentration) at the same resolution and location as Level 1 source data.
۳	Variables mapped on uniform spacetime grid scales, usually with some completeness and consistency (e. g., missing points interpolated, complete regions mosaicked together from multiple orbits, etc.(.
۴	Model output or results from analyses of lower level data (i. e., variables that were not measured by the instruments but instead are derived from these measurements.(

A Level 1 data record is the most fundamental (i. e., highest reversible level) data record that has significant scientific utility, and is the foundation upon which all subsequent data sets are produced. Level 2 is the first level that is directly usable for most scientific applications; its value is much greater than the lower levels. Level 2 data sets tend to be less voluminous than Level 1 data because they have been reduced temporally, spatially, or spectrally. Level 3 data sets are generally smaller than lower level data sets and thus can be dealt with without incurring a great deal of data handling overhead. These data tend to be generally more useful for many applications. The regular spatial and temporal organization of Level 3 datasets makes it feasible to readily combine data from different sources.

History

The TR-1 reconnaissance/surveillance aircraft.

The 2001 Mars Odyssey used spectrometers and imagers to hunt for evidence of past or present water and volcanic activity on Mars.

The modern discipline of remote sensing arose with the development of flight. The balloonist G. Tournachon (alias Nadar) made photographs of Paris from his balloon in 1858. Messenger pigeons, kites, rockets and unmanned balloons were also used for early images. With the exception of balloons, these first, individual images were not particularly useful for map making or for scientific purposes.[citation needed[

Systematic aerial photography was developed for military surveillance and reconnaissance purposes beginning in World War I and reaching a climax during the Cold War with the use of modified combat aircraft such as the P-51, P-38, RB-66 and the F-4C, or specifically designed collection platforms such as the U2/TR-1, SR-71, A-5 and the OV-1 series both in overhead and stand-off collection. A more recent development is that of increasingly smaller sensor pods such as those used by law enforcement and the military, in both manned and unmanned platforms. The advantage of this approach is that this requires minimal modification to a given airframe. Later imaging technologies would include Infra-red, conventional, doppler and synthetic aperture radar.[citation needed[

The development of artificial satellites in the latter half of the 20th century allowed remote sensing to progress to a global scale as of the end of the Cold War. Instrumentation aboard various Earth observing and weather satellites such as Landsat, the Nimbus and more recent missions such as RADARSAT and UARS provided global measurements of various data for civil, research, and military purposes. Space probes to other planets have also provided the opportunity to conduct remote sensing studies in extraterrestrial environments, synthetic aperture radar aboard the Magellan spacecraft provided detailed topographic maps of Venus, while instruments aboard SOHO allowed studies to be performed on the Sun and the solar wind, just to name a few examples.[citation needed[

Recent developments include, beginning in the 1960s and 1970s with the development of image processing of satellite imagery. Several research groups in Silicon Valley including NASA Ames Research Center, GTE and ESL Inc. developed Fourier transform techniques leading to the first notable enhancement of imagery data.[citation needed[

Training and Education

Remote Sensing has a growing relevance in the modern information society. It represents a key technology as part of the aerospace industry and bears increasing economic relevance - new sensors e.g. TerraSAR-X & RapidEye are developed constantly and the demand for skilled labour is increasing steadily. Furthermore, remote sensing exceedingly influences everyday life, ranging from weather forecasts to reports on climate change or natural disasters. As an example, 80% of the German students use the services of Google Earth; in 2006 alone the software was downloaded 100 million times. But studies has shown that only a fraction of them know more about the data they are working with. [9] There exists a huge knowledge gap between the application and the understanding of satellite images. Remote sensing only plays a tangential role in schools, regardless of the political claims to strengthen the support for teaching on the subject. [10] A lot of the computer software explicitly developed for school lessons has not yet been implemented due to its complexity. Thereby, the subject is either not at all integrated into the curriculum or does not pass the step of an interpretation of analogue images. In fact, the subject of remote sensing requires a consolidation of physics and mathematics as well as competences in the fields of media and methods apart from the mere visual interpretation of satellite images. Many teachers have great interest in the subject “remote sensing”, being motivated to integrate this topic into teaching, provided that the curriculum is considered. In many cases, this encouragement fails because of confusing information. [11] In order to integrate remote sensing in a sustainable manner organizations like the EGU or digital earth encourages the development of learning modules and learning portals (e.g. FIS - Remote Sensing in School Lessons or Landmap - Spatial Discovery) promoting media and method qualifications as well as independent working.

Remote Sensing software

Remote Sensing data is processed and analyzed with computer software, known as a remote sensing application. A large number of proprietary and open source applications exist to process remote sensing data. Remote Sensing Software packages include:

TNTmips from MicroImages,

PCI Geomatica made by PCI Geomatics, the leading remote sensing software package in Canada,

IDRISI from Clark Labs,

Image Analyst from Intergraph,

and RemoteView made by Overwatch Textron Systems.

Dragon/ips is one of the oldest remote sensing packages still available, and is in some cases free.

Open source remote sensing software includes:

OSSIM,

Opticks (software,(

Orfeo toolbox

Others mix remote sensing GIS capability are: GRASS GIS, ILWIS, QGIS, and TerraLook.

According to an NOAA Sponsored Research by Global Marketing Insights, Inc. the most used applications among Asian academic groups involved in remote sensing are as follows: ERDAS 36% (ERDAS IMAGINE 25% & ERMapper 11%); ESRI 30%; ITT Visual Information Solutions ENVI 17%; MapInfo 17%.

Among Western Academic respondents as follows: ESRI 39%, ERDAS IMAGINE 27%, MapInfo 9%, AutoDesk 7%, ITT Visual Information Solutions ENVI 17%

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Geometric networks

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A geometric network is an object commonly used in geographic information systems to model a series of interconnected features. A geometric network is similar to a graph in mathematics and computer science, and can be described and analyzed using theories and concepts similar to graph theory. Geometric networks are often used to model road networks and public utility networks (such as electric, gas, and water utilities).[1[

Contents

Composition of a Geometric Network

A geometric network is composed of edges that are connected. Connectivity rules for the network specify which edges are connected and at what points they are connected, commonly referred to as junction or intersection points. These edges can have weights or flow direction assigned to them, which dictate certain properties of these edges that affect analysis results[2] . In the case of certain types of networks, source points (points where flow originates) and sink points (points where flow terminates) may also exist. In the case of utility networks, a source point may correlate with an electric substation or a water pumping station, and a sink point may correlate with a service connection at a residential household.[3][4[

Functions

Networks define the interconnectedness of features. Through analyzing this connectivity, paths from one point to another on the network can be traced and calculated. Through optimization algorithms and utilizing network weights and flow, these paths can also be optimized to show specialized paths, such as the shortest path between two points on the network, as is commonly done in the calculation of driving directions. Networks can also be used to perform spatial analysis to determine points or edges that are encompassed in a certain area or within a certain distance of a specified point. This has applications in hydrology and urban planning, among other fields.

Applications

Routing: for calculating driving directions, paths from one point of interest to another, locating nearby points of interest

Urban Planning: for site suitability studies, and traffic and congestion studies.

Electric Utility Industry: for modeling an electrical grid in GIS, tracing from a generation source

Other Public Utilities: for modeling water distribution flow and natural gas distribution...

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Geostatistics

From Wikipedia, the free encyclopedia

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Not to be confused with statistical geography.

This article includes a list of references, but its sources remain unclear because it has insufficient inline citations. Please help to improve this article by introducing more precise citations. (January 2009(

Geostatistics is a branch of statistics focusing on spatial or spatiotemporal datasets. Developed originally to predict probability distributions of ore grades for mining operations,[1] it is currently applied in diverse disciplines including petroleum geology, hydrogeology, hydrology, meteorology, oceanography, geochemistry, geometallurgy, geography, forestry, environmental control, landscape ecology, soil science, and agriculture (esp. in precision farming). Geostatistics is applied in varied branches of geography, particularly those involving the spread of diseases (epidemiology), the practice of commerce and military planning (logistics), and the development of efficient spatial networks. Geostatistical algorithms are incorporated in many places, including geographic information systems (GIS) and the R statistical environment.

Contents

Background

Geostatistics is intimately related to interpolation methods, but extends far beyond simple interpolation problems. Geostatistical techniques rely on statistical model that is based on random function (or random variable) theory to model the uncertainty associated with spatial estimation and simulation.

A number of simpler interpolation methods/algorithms, such as inverse distance weighting, bilinear interpolation and nearest-neighbor interpolation, were already well known before geostatistics.[2] Geostatistics goes beyond the interpolation problem by considering the studied phenomenon at unknown locations as a set of correlated random variables.

Let Z(x) be the value of the variable of interest at a certain location x. This value is unknown (e.g. temperature, rainfall, piezometric level, geological facies, etc.). Although there exists a value at location x that could be measured, geostatistics considers this value as random since it was not measured, or has not been measured yet. However, the randomness of Z(x) is not complete, but defined by a cumulative distribution function (cdf) that depends on certain information that is known about the value Z(x:(

F(\mathit{z}, \mathbf{x}) = \operatorname{Prob} \lbrace Z(\mathbf{x}) \leqslant \mathit{z} \mid \text{information} \rbrace .

Typically, if the value of Z is known at locations close to x (or in the neighborhood of x) one can constrain the pdf of Z(x) by this neighborhood: if a high spatial continuity is assumed, Z(x) can only have values similar to the ones found in the neighborhood. Conversely, in the absence of spatial continuity Z(x) can take any value. The spatial continuity of the random variables is described by a model of spatial continuity that can be either a parametric function in the case of variogram-based geostatistics, or have a non-parametric form when using other methods such as multiple-point simulation or pseudo-genetic techniques.

By applying a single spatial model on an entire domain, one makes the assumption that Z is a stationary process. It means that the same statistical properties are applicable on the entire domain. Several geostatistical methods provide ways of relaxing this stationarity assumption.

In this framework, one can distinguish two modeling goals:

Estimating the value for Z(x), typically by the expectation, the median or the mode of the pdf f(z,x). This is usually denoted as an estimation problem.

Sampling from the entire probability density function f(z,x) by actually considering each possible outcome of it at each location. This is generally done by creating several alternative maps of Z, called realizations. Consider a domain discretized in N grid nodes (or pixels). Each realization is a sample of the complete N-dimensional joint distribution function

F(\mathbf{z}, \mathbf{x}) = \operatorname{Prob} \lbrace Z(\mathbf{x}_1) \leqslant z_1, Z(\mathbf{x}_2) \leqslant z_2, ..., Z(\mathbf{x}_N) \leqslant z_N \rbrace .

In this approach, the presence of multiple solutions to the interpolation problem is acknowledged. Each realization is considered as a possible scenario of what the real variable could be. All associated workflows are then considering ensemble of realizations, and consequently ensemble of predictions that allow for probabilistic forecasting. Therefore, geostatistics is often used to generate or update spatial models when solving inverse problems.[3][4[

A number of methods exist for both geostatistical estimation and multiple realizations approaches. Several reference books provide a comprehensive overview of the discipline.[5][6][7][8][9][10][11][12][13][14][15[

Methods

Estimation

Kriging

Main article: Kriging

Kriging is a group of geostatistical techniques to interpolate the value of a random field (e.g., the elevation, z, of the landscape as a function of the geographic location) at an unobserved location from observations of its value at nearby locations.

Indicator kriging

Main article: Multiple-indicator kriging

Multiple-indicator kriging (MIK) is a recent advance on other techniques for mineral deposit modeling and resource block model estimation, such as ordinary kriging. Initially, MIK showed considerable promise as a new method that could more accurately estimate overall global mineral deposit concentrations or grade

Geocoding

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For other uses, see Geocoding (disambiguation.(

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Geocoding is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or zip codes (postal codes). With geographic coordinates the features can be mapped and entered into Geographic Information Systems, or the coordinates can be embedded into media such as digital photographs via geotagging.

Reverse geocoding is the opposite: finding an associated textual location such as a street address, from geographic coordinates.

A geocoder is a piece of software or a (web) service that helps in this process.

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Address interpolation

A simple method of geocoding is address interpolation. This method makes use of data from a street geographic information system where the street network is already mapped within the geographic coordinate space. Each street segment is attributed with address ranges (e.g. house numbers from one segment to the next). Geocoding takes an address, matches it to a street and specific segment (such as a block, in towns that use the "block" convention). Geocoding then interpolates the position of the address, within the range along the segment.

Example

Take for example: 742 Evergreen Terrace

Let's say that this segment (for instance, a block) of Evergreen Terrace runs from 700 to 799. Even-numbered addresses fall on the east side of Evergreen Terrace, with odd-numbered addresses on the west side of the street. 742 Evergreen Terrace would (probably) be located slightly less than halfway up the block, on the east side of the street. A point would be mapped at that location along the street, perhaps offset a distance to the east of the street centerline.

Complicating factors

However, this process is not always as straightforward as in this example.

Difficulties arise when

distinguishing between ambiguous addresses such as 742 Evergreen Terrace and 742 W Evergreen Terrace.

attempting to geocode new addresses for a street that is not yet added to the geographic information system database.

While there might be 742 Evergreen Terrace in Springfield, there might also be a 742 Evergreen Terrace in Shelbyville. Asking for the city name (and state, province, country, etc. as needed) can solve this problem. Boston, Massachusetts[1] has multiple "100 Washington Street" locations because several cities have been annexed without changing street names, thus requiring use of unique postal codes or district names for disambiguation.

Geocoding accuracy can be greatly improved by first utilizing good address verification practices. Address verification will confirm the existence of the address and will eliminate ambiguities. Once the valid address is determined, it is very easy to geocode and determine the latitude/longitude coordinates.

Finally, several caveats on using interpolation:

The typical attribution of a street segment assumes that all even numbered parcels are on one side of the segment, and all odd numbered parcels are on the other. This is often not true in real life.

Interpolation assumes that the given parcels are evenly distributed along the length of the segment. This is almost never true in real life; it is not uncommon for a geocoded address to be off by several thousand feet.

Interpolation also assumes that the street is straight. If a street is curved then the geocoded location will not necessarily fit the physical location of the address.

Segment Information (esp. from sources such as TIGER) includes a maximum upper bound for addresses and is interpolated as though the full address range is used. For example, a segment (block) might have a listed range of 100-199, but the last address at the end of the block is 110. In this case, address 110 would be geocoded to 10% of the distance down the segment rather than near the end.

Most interpolation implementations will produce a point as their resulting address location. In reality, the physical address is distributed along the length of the segment, i.e. consider geocoding the address of a shopping mall - the physical lot may run a distance along the street segment (or could be thought of as a two-dimensional space-filling polygon which may front on several different streets - or worse, for cities with multi-level streets, a three-dimensional shape that meets different streets at several different levels) but the interpolation treats it as a singularity.

A very common error is to believe the accuracy ratings of a given map's geocodable attributes. Such accuracy currently touted by most vendors has no bearing on an address being attributed to the correct segment, being attributed to the correct side of the segment, nor resulting in an accurate position along that correct segment. With the geocoding process used for U.S. Census TIGER datasets, 5-7.5% of the addresses may be allocated to a different census tract, while 50% of the geocoded points might be located to a different property parcel.[2[

The accuracy of geocoded data can also have a bearing on the quality of research that can be done using this data. One study [3] by a group of Iowa researcher's found that the common method of geocoding using TIGER datasets as described above, can cause a loss of as much as 40% of the power of a statistical analysis.An alternative is to use orthophoto or image coded data such as the Address Point data from Ordnance Survey in the UK, but such datasets are generally expensive.

Because of this, it is quite important to avoid using interpolated results except for non-critical applications, such as pizza delivery. Interpolated geocoding is usually not appropriate for making authoritative decisions, for example if life safety will be affected by that decision. Emergency services, for example, do not make an authoritative decision based on their interpolations; an ambulance or fire truck will always be dispatched regardless of what the map says.

Other techniques

Other means of geocoding might include locating a point at the centroid (center) of a land parcel, if parcel (property) data is available in the geographic information system database. In rural areas or other places lacking high quality street network data and addressing, GPS is useful for mapping a location. For traffic accidents, geocoding to a street intersection or midpoint along a street centerline is a suitable technique. Most highways in developed countries have mile markers to aid in emergency response, maintenance, and navigation. It is also possible to use a combination of these geocoding techniques - using a particular technique for certain cases and situations and other techniques for other cases. In contrast to geocoding of structured postal address records, toponym resolution maps place names in unstructured document collections to their corresponding spatial footprints.

Research

Recent research has introduced a new approach to the control and knowledge aspects of geocoding, by using an agent-based paradigm.[4] In addition to the new paradigm for geocoding, additional correction techniques and control algorithms have been developed.[5] The approach represents the geographic elements commonly found in addresses as individual agents. This provides a commonality and duality to control and geographic representation. In addition to scientific publication, the new approach and subsequent prototype gained national media coverage in Australia.[6] The research was conducted at Curtin University in Perth, Western Australia.[7[

Uses

Geocoded locations are useful in many GIS analysis and cartography tasks.

Geocoding is common on the web, for services like finding driving directions to an address, or finding a list of the geographically nearest store or service locations.

Geocoding is one of several methods of obtaining geographic coordinates for geotagging media, such as photographs or RSS items.

Privacy concerns

The proliferation and ease of access to geocoding (and reverse-geocoding) services raises privacy concerns. For example, in mapping crime incidents, law enforcement agencies aim to balance the privacy rights of victims and offenders, with the public's right to know. Law enforcement agencies have experimented with alternative geocoding techniques that allow them to mask a portion of the locational detail (e.g., address specifics that would lead to identifying a victim or offender). As well, in providing online crime mapping to the public, they also place disclaimers regarding the locational accuracy of points on the map, acknowledging these location masking techniques, and impose terms of use for the information

Counter-mapping

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This article is written like a personal reflection or essay rather than an encyclopedic description of the subject. Please help improve it by rewriting it in an encyclopedic style. (March 2012(

Counter-mapping refers to efforts to map "against dominant power structures, to further seemingly progressive goals".[1] The term was coined by Nancy Peluso[2] in 1995 to describe the commissioning of maps by forest users in Kalimantan, Indonesia, as a means of contesting state maps of forest areas that typically undermined indigenous interests. The resultant counter-hegemonic maps had the ability to strengthen forest users' resource claims.[2] There are numerous expressions closely related to counter-mapping: ethnocartography, alternative cartography, mapping-back, counter-hegemonic mapping, and public participatory mapping.[3] Moreover, the terms: critical cartography, subversive cartography, bioregional mapping, and remapping are sometimes used synonymously with counter-mapping, but in practice encompass much more.[3[

Whilst counter-mapping still primarily refers to indigenous cartographic efforts, it is increasingly being applied to non-indigenous mapping initiatives in economically developed countries.[3] Such counter-mapping efforts have been facilitated by processes of neoliberalism,[4] and technological democratisation.[2] Examples of counter-mapping include attempts to demarcate and protect traditional territories, community mapping, Public Participatory Geographical Information Systems, and mapping by a relatively weak state to counter the resource claims of a stronger state.[5] The power of counter-maps to advocate policy change in a bottom-up manner led commentators to affirm that counter-mapping should be viewed as a tool of governance.[6[

Despite its emancipatory potential, counter-mapping has not gone without criticism. There is a tendency for counter-mapping efforts to overlook the knowledge of women, minorities, and other vulnerable, disenfranchised groups.[7] From this perspective, counter-mapping is only empowering for a small subset of society, whilst others become further marginalised.[8[

Contents

Origins

Nancy Peluso, Professor of forest policy, coined the term 'counter-mapping' in 1995, having examined the implementation of two forest mapping strategies in Kalimantan. One set of maps belonged to state forest managers, and the international financial institutions that supported them, such as the World Bank. This strategy recognised mapping as a means of protecting local claims to territory and resources to a government that had previously ignored them.[2] The other set of maps had been created by Indonesian NGOs, who often contract international experts to assist with mapping village territories.[2] The goal of the second set of maps was to co-opt the cartographic conventions of the Indonesian state, to legitimise the claims by the Dayak people, indigenous to Kalimantan, to the rights to forest use.[3] Counter-mappers in Kalimantan have acquired GIS technologies, satellite technology, and computerised resource management tools, consequently making the Indonesian state vulnerable to counter-maps.[2] As such, counter-mapping strategies in Kalimantan have led to successful community action to block, and protest against, oil palm plantations and logging concessions imposed by the central government.[2[

It must, however, be recognised that counter-mapping projects existed long before coinage of the term.[3] Counter-maps are rooted in map art practices that date to the early 20th century; in the mental maps movement of the 1960s; in indigenous and bioregional mapping; and parish mapping.[9[

Parish Maps Project

In 1985, the charity Common Ground launched the Parish Maps Project, a bottom-up initiative encouraging local people to map elements of the environment valued by their parish.[10] Since then, more than 2,500 English parishes have made such maps (for instance, Salle, see right).[9] Parish mapping projects aim to put every local person in an 'expert' role.[11] Clifford[12] exemplifies this notion, affirming: "making a parish map is about creating a community expression of values, and about beginning to assert ideas for involvement. It is about taking the place in your own hands". The final map product is typically an artistic artefact, usually painted, and often displayed in village halls or schools.[13] By questioning the biases of cartographic conventions and challenging predominant power effects of mapping,[14] The Parish Maps Project is an early example of what Peluso[2] went on to term 'counter-mapping'

Development

Neoliberalism

The development of counter-mapping can be situated within the neoliberal political-economic restructuring of the state.[15] Prior to the 1960s, equipping a map-making enterprise was chiefly the duty of a single agency, funded by the national government.[16] In this sense, maps have conventionally been the products of privileged knowledges.[17] However, processes of neoliberalism, predominantly since the late 1970s, have reconfigured the state's role in the cartographic project.[4] Neoliberalism denotes an emphasis on markets and minimal states, whereby individual choice is perceived to have replaced the mass-production of commodities.[18] The fact that citizens are now performing cartographic functions that were once exclusively state-controlled can be partially explained through a shift from "roll-back neoliberalism", in which the state dismantled some of its functions, to "roll-out neoliberalism", in which new modes of operating have been constructed.[19] In brief, the state can be seen to have "hollowed out" and delegated some of its mapping power to citizens.[20[

Counter-mapping as neoliberal governmentality

Governmentality refers to a particular form of state power that is exercised when citizens self-discipline by acquiescing to state knowledge.[21] Historically, cartography has been a fundamental governmentality strategy,[22] a technology of power, used for surveillance and control.[23] Competing claimants and boundaries made no appearance on state-led maps.[23] This links to Foucault's[24] notion of "subjugated knowledges" - ones that did not rise to the top, or were disqualified.[22] However, through neoliberalising processes, the state has retracted from performing some of its cartographic functions.[15] Consequently, rather than being passive recipients of top-down map distribution, people now have the opportunity to claim sovereignty over the mapping process.[25] In this new regime of neoliberal cartographic governmentality the "insurrection of subjugated knowledges" occurs,[24] as counter-mapping initiatives incorporate previously marginalised voices.

Technological democratisation?

In response to technological change, predominantly since the 1980s, cartography has increasingly been democratised.[26] The wide availability of high-quality location information has enabled mass-market cartography based on Global Positioning System receivers, home computers, and the Internet.[27] The fact that civilians are using technologies which were once elitist led Brosius et al.[28] to assert that counter-mapping involves "stealing the master's tools". Nevertheless, numerous early counter-mapping projects successfully utilised manual techniques, and many still use them. For instance, in recent years, the use of simple sketch mapping approaches has been revitalised, whereby maps are made on the ground, using natural materials.[29] Similarly, the use of scale model constructions and felt boards, as means of representing cartographic claims of different groups, have become increasingly popular.[7] Consequently, Wood et al.[9] assert that counter-mappers can "make gateau out of technological crumbs."

Public Participation Geographical Information Systems

In recent years, Public Participation Geographical Information Systems (PPGIS) have attempted to take the power of the map out of the hands of the cartographic elite, putting it into the hands of the people. For instance, Kyem[30] designed a PPGIS method termed Exploratory Strategy for Collaboration, Management, Allocation, and Planning (ESCMAP). The method sought to integrate the concerns and experiences of three rural communities in the Ashanti Region of Ghana into official forest management practices.[30] Kyem[30] concluded that, notwithstanding the potential of PPGIS, it is possible that the majority of the rich and powerful people in the area would object to some of the participatory uses of GIS. For example, loggers in Ghana affirmed that the PPGIS procedures were too open and democratic.[30] Thus, despite its democratising potential, there are barriers to its implementation. More recently, Wood et al.[9] disputed the notion of PPGIS entirely, affirming that it is "scarcely GIS, intensely hegemonic, hardly public, and anything but participatory."

Counter-mapping as governance

Governance makes problematic state-centric notions of regulation, recognising that there has been a shift to power operating across several spatial scales.[31] Similarly, counter-mapping problematises state distribution of cartography, advocating bottom-up participatory mapping projects. Counter-mapping initiatives, often without state assistance, attempt to exert power. As such, counter-mapping conforms to Jessop's[20] notion of "governance without government". Another characteristic of governance is its "purposeful effort to steer, control or manage sectors or facets of society" towards a common goal.[32] Likewise, as maps exude power and authority,[33] they are a trusted medium[34] with the ability to 'steer' society in a particular direction. In brief, cartography, once the tool of kings and governments,[35] is now being used as a tool of governance - to advocate policy change from the grassroots.[6] The environmental sphere is one context in which counter-mapping has been utilised as a governance tool.[6[

Counter-mapping as environmental governance

In contrast to expert knowledges, lay knowledges are increasingly valuable to decision-makers, in part due to the scientific uncertainty surrounding environmental issues.[36] Participatory counter-mapping projects are an effective means of incorporating lay knowledges[37] into issues surrounding environmental governance. For instance, counter-maps depicting traditional use of areas now protected for biodiversity have been used to allow resource use, or to promote public debate about the issue, rather than forcing relocation.[6] For example, the World Wide Fund for Nature used the results of counter-mapping to advocate for the reclassification of several strictly protected areas into Indonesian national parks, including Kayan Mentarang and Gunung Lorentz.[6] The success of such counter-mapping efforts led Alcorn[6] to affirm that governance (grassroots mapping projects), rather than government (top-down map distribution), offers the best hope for good natural resource management. In short, it can be seen that "maps are powerful political tools in ecological and governance discussions".[6[

Types of counter-mapping

Numerous counter-mapping types exist, for instance: protest maps, map art, counter-mapping for conservation, and PPGIS. In order to emphasise the wide scope of what has come to be known as counter-mapping, three contrasting counter-mapping examples are elucidated in this section: indigenous counter-mapping, community mapping, and state counter-mapping, respectively.

Indigenous counter-mapping

Counter-mapping has been undertaken most in the Third World.[13] Indigenous peoples are increasingly turning to participatory mapping, appropriating both the state's techniques and manner of representation.[38] Counter-mapping is a tool for indigenous identity-building,[39] and for bolstering the legitimacy of customary resource claims.[2] The success of counter-mapping in realising indigenous claims can be seen through Nietschmann's[40] assertion:

More indigenous territory has been claimed by maps than by guns. And more Indigenous territory can be reclaimed and defended by maps than by guns.

“

”

Creation of Nunavut

The power of indigenous counter-mapping can be exemplified through the creation of Nunavut. In 1967, Frank Arthur Calder and the Nisaga’a Nation Tribal Council brought an action against the Province of British Columbia for a declaration that aboriginal title to specified land had not been lawfully extinguished. In 1973, the Canadian Supreme Court found that there was, in fact, an aboriginal title. The Canadian government attempted to extinguish such titles by negotiating treaties with the people who had not signed them.[9] As a first step, the Inuit Tapirisat of Canada studied Inuit land occupancy in the Arctic, resulting in the publication of the Inuit Land Use and Occupancy Project.[41] Diverse interests, such as those of hunters, trappers, fishermen and berry-pickers mapped out the land they had used during their lives.[9] As Usher[42] noted:

We were no longer mapping the 'territories' of Aboriginal people based on the cumulative observations of others of where they were…but instead, mapping the Aboriginal peoples’ own recollections of their own activities.

“

”

These maps played a fundamental role in the negotiations that enabled the Inuit to assert an aboriginal title to the 2 million km^2 in Canada, today known as Nunavut.[9] Evidently, counter-mapping is a tool by which indigenous groups can re-present the world in ways which destabilise dominant representations.[43[

Community mapping

Community mapping can be defined as: "local mapping, produced collaboratively, by local people and often incorporating alternative local knowledge".[13] OpenStreetMap is an example of a community mapping initiative, with the potential to counter the hegemony of state-dominated map distribution.[44[

OpenStreetMap

OpenStreetMap home page.

OpenStreetMap (OSM), a citizen-led spatial data collection website, was founded by Steve Coast in 2004 (see right for OSM home page). Data are collected from diverse public domain sources; of which GPS tracks are the most important, collected by volunteers with GPS receivers.[13] As of 10 January 2011 there were 340,522 registered OSM users, who had uploaded 2.121 billion GPS points onto the website.[45] The process of map creation explicitly relies upon sharing and participation; consequently, every registered OSM user can edit any part of the map. Moreover, 'map parties' - social events which aim to fill gaps in coverage, help foster a community ethos.[46] In short, the grassroots OSM project can be seen to represent a paradigm shift in who creates and shares geographic information - from the state, to society.[47] However, rather than countering the state-dominated cartographic project, some commentators have affirmed that OSM merely replicates the 'old' socio-economic order.[48] For instance, Haklay[48] affirmed that OSM users in the United Kingdom tend not to map council estates; consequently, middle-class areas are disproportionately mapped. Thus, in opposition to notions that OSM is a radical cartographic counter-culture,[49] are contentions that OSM "simply recreates a mirror copy of existing topographic mapping".[50[

State counter-mapping

What has come to be known as counter-mapping is not limited to the activities of non-state actors within a particular nation-state; relatively weak states also engage in counter-mapping in an attempt to challenge other states.[51[

Competing cartographic representations: East Timor versus Australia

East Timor's on-going effort to gain control of gas and oil resources from Australia, which it perceives at its own, is a form of counter-mapping. This dispute involves a cartographic contestation of Australia's mapping of the seabed resources between the two countries.[51] As Nevins[51] contends: whilst Australia's map is based on the status quo - a legacy of a 1989 agreement between Australia and the Indonesian occupier of East Timor at that time, East Timor's map represents an enlarged notion of what its sea boundaries should be, thereby entailing a redrawing of the map. This form of counter-mapping thus represents a claim by a relatively weak state, East Timor, to territory and resources that are controlled by a stronger state, Australia.[3] However, Nevins[51] notes that there is limited potential of realising a claim through East Timor's counter-map: counter-mapping is an effective strategy only when combined with broader legal and political strategies.[51[

Criticisms

Counter-mapping's claim to incorporate counter-knowledges, and thereby empower traditionally disempowered people, has not gone uncontested.[52] A taster of criticisms typically heralded at counter-mapping are now provided:

Counter-mapping fails to recognise that community is a constantly shifting, fluid process, too often relying on a notion of community as bounded and fixed. As such, the process of mapping communicates and naturalises who does, and who does not, belong within particular boundaries.[53[

Due to the power imbalance between indigenous claims and those of the state, the language and tools of the dominant society must be used by those under its control. The process of using another's tools can change the ideas represented, resulting in a map of unpredictable quality.[3[

Counter-mapping is in danger of becoming the 'thing to do'; a "magic bullet applied uncritically".[54[

There is a geography to the success of counter-mapping. In Tibet, counter-mapping is of limited political utility as mapmaking is not enfranchised and cannot be scaled up, for instance, to settle legal battles over land tenure and resource rights through the regulatory offices of the state.[5[

Counter-mapping projects utilising GIS require significant knowledge and computer literacy above that of lay individuals.[55[

Investment in specialised computers and software often results in prohibitive mapping costs for a large majority of local people, particularly in poor areas. As some groups prove more capable of adopting the technologies than others, counter-mapping projects can deepen divisions within communities along gender and economic lines.[56[

To summarise, whilst counter-mapping has the potential to transform map-making from "a science of princes",[57] the investment required to create a map with the ability to challenge state-produced cartography means that counter-mapping is unlikely to become a "science of the masses".[2[

Geodesy

From Wikipedia, the free encyclopedia

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This article includes a list of references, but its sources remain unclear because it has insufficient inline citations. Please help to improve this article by introducing more precise citations. (February 2009(

Geodesy

Fundamentals

- Geodesy
- Geodynamics
- Geomatics
- Cartography

Concepts

- Datum
- Distance
- Geoid
- Fig. Earth
- Geodetic system
- Geodesic
- Geog. coord. system
- Hor. pos. represent.
- Lat. / Long.
- Map proj.
- Ref. ellipsoid
- Satellite geodesy
- Spatial ref. system

Technologies

- GNSS
- GPS
- GLONASS
- IRNSS

Standards

- ED50
- ETRS89
- GRS 80
- NAD83
- NAVD88
- SAD69
- SRID
- UTM
- WGS84

History

- History of geodesy
- NAVD29

- v
- t
- e

An old geodetic pillar (1855) at Ostend, Belgium

A Munich archive with lithography plates of maps of Bavaria

Geodesy (play /dʒiːˈɒdɨsi/),[1] also named geodetics, a branch of earth sciences, is the scientific discipline that deals with the measurement and representation of the Earth, including its gravitational field, in a three-dimensional time-varying space. Geodesists also study geodynamical phenomena such as crustal motion, tides, and polar motion. For this they design global and national control networks, using space and terrestrial techniques while relying on datums and coordinate systems.

Contents

Definition

Geodesy (from Greek γεωδαισία – geodaisia, lit. "division of the Earth") is primarily concerned with positioning within the temporally varying gravity field. Somewhat obsolete nowadays, geodesy in the German speaking world is divided into "Higher Geodesy" ("Erdmessung" or "höhere Geodäsie"), which is concerned with measuring the Earth on the global scale, and "Practical Geodesy" or "Engineering Geodesy" ("Ingenieurgeodäsie"), which is concerned with measuring specific parts or regions of the Earth, and which includes surveying.

The shape of the Earth is to a large extent the result of its rotation, which causes its equatorial bulge, and the competition of geological processes such as the collision of plates and of volcanism, resisted by the Earth's gravity field. This applies to the solid surface, the liquid surface (dynamic sea surface topography) and the Earth's atmosphere. For this reason, the study of the Earth's gravity field is called physical geodesy by some.

History

Main article: History of geodesy

Geoid and reference ellipsoid

See also: Geoid

The geoid is essentially the figure of the Earth abstracted from its topographical features. It is an idealized equilibrium surface of sea water, the mean sea level surface in the absence of currents, air pressure variations etc. and continued under the continental masses. The geoid, unlike ellipsoid, is irregular and too complicated to serve as the computational surface on which to solve geometrical problems like point positioning. The geometrical separation between the geoid and the reference ellipsoid is called the geoidal undulation. It varies globally between ±110 m.

A reference ellipsoid, customarily chosen to be the same size (volume) as the geoid, is described by its semi-major axis (equatorial radius) a and flattening f. The quantity $f = (a-b)/a$, where b is the semi-minor axis (polar radius), is a purely geometrical one. The mechanical ellipticity of the Earth (dynamical flattening, symbol J_2) can be determined to high precision by observation of satellite orbit perturbations. Its relationship with the geometrical flattening is indirect. The relationship depends on the internal density distribution, or, in simplest terms, the degree of central concentration of mass.

The 1980 Geodetic Reference System (GRS80) posited a 6,378,137 m semi-major axis and a 1:298.257 flattening. This system was adopted at the XVII General Assembly of the International Union of Geodesy and Geophysics (IUGG). It is essentially the basis for geodetic positioning by the Global Positioning System and is thus also in extremely widespread use outside the geodetic community.

The numerous other systems which have been used by diverse countries for their maps and charts are gradually dropping out of use as more and more countries move to global, geocentric reference systems using the GRS80 reference ellipsoid.

Coordinate systems in space

See also: Geodetic system

The locations of points in three-dimensional space are most conveniently described by three cartesian or rectangular coordinates, X, Y and Z. Since the advent of satellite positioning, such coordinate systems are typically geocentric: the Z axis is aligned with the Earth's (conventional or instantaneous) rotation axis.

Prior to satellite geodesy era, the coordinate systems associated with a geodetic datum attempted to be geocentric, but their origins differed from the geocentre by hundreds of metres, due to regional deviations in the direction of the plumbline (vertical). These regional geodetic datums, such as ED50 (European Datum 1950) or NAD83 (North American Datum 1983) have ellipsoids associated with them that are regional 'best fits' to the geoids within their areas of validity, minimising the deflections of the vertical over these areas.

It is only because GPS satellites orbit about the geocentre, that this point becomes naturally the origin of a coordinate system defined by satellite geodetic means, as the satellite positions in space are themselves computed in such a system.

Geocentric coordinate systems used in geodesy can be divided naturally into two classes:

- Inertial reference systems, where the coordinate axes retain their orientation relative to the fixed stars, or equivalently, to the rotation axes of ideal gyroscopes; the X axis points to the vernal equinox
- Co-rotating, also ECEF ("Earth Centred, Earth Fixed"), where the axes are attached to the solid body of the Earth. The X axis lies within the Greenwich observatory's meridian plane.

The coordinate transformation between these two systems is described to good approximation by (apparent) sidereal time, which takes into account variations in the Earth's axial rotation (length-of-day variations). A more accurate description also takes polar motion into account, a phenomenon closely monitored by geodesists.

Coordinate systems in the plane

In surveying and mapping, important fields of application of geodesy, two general types of coordinate systems are used in the plane:

- Plano-polar, in which points in a plane are defined by a distance s from a specified point along a ray having a specified direction \alpha with respect to a base line or axis;
- Rectangular, points are defined by distances from two perpendicular axes called x and y. It is geodetic practice—contrary to the mathematical convention—

to let the x axis point to the North and the y axis to the East.

Rectangular coordinates in the plane can be used intuitively with respect to one's current location, in which case the x axis will point to the local North. More formally, such coordinates can be obtained from three-dimensional coordinates using the artifice of a map projection. It is not possible to map the curved surface of the Earth onto a flat map surface without deformation. The compromise most often chosen—called a conformal projection—preserves angles and length ratios, so that small circles are mapped as small circles and small squares as squares.

An example of such a projection is UTM (Universal Transverse Mercator). Within the map plane, we have rectangular coordinates x and y. In this case the North direction used for reference is the map North, not the local North. The difference between the two is called meridian convergence.

It is easy enough to "translate" between polar and rectangular coordinates in the plane: let, as above, direction and distance be \alpha and s respectively, then we have

\ begin{matrix} x &=& s \cos \alpha\\ y &=& s \sin \alpha \end{matrix {

The reverse transformation is given by:

\ begin{matrix} s &=& \sqrt{x^2 + y^2}\\ \alpha &=& \arctan{(y/x)}. \end{matrix {

Heights

In geodesy, point or terrain heights are "above sea level", an irregular, physically defined surface. Therefore a height should ideally not be referred to as a coordinate. It is more like a physical quantity, and though it can be tempting to treat height as the vertical coordinate z, in addition to the horizontal coordinates x and y, and though this actually is a good approximation of physical reality in small areas, it quickly becomes invalid for regional considerations.[specify[

Heights come in the following variants:

- Orthometric heights
- Normal heights
- Geopotential heights

Each has its advantages and disadvantages. Both orthometric and normal heights are heights in metres above sea level, whereas geopotential numbers are measures of potential energy (unit: m^2 s−2) and not metric. Orthometric and normal heights differ in the precise way in which mean sea level is conceptually continued under the continental masses. The reference surface for orthometric heights is the geoid, an equipotential surface approximating mean sea level.

None of these heights is in any way related to geodetic or ellipsoidial heights, which express the height of a point above the reference ellipsoid. Satellite positioning receivers typically provide ellipsoidal heights, unless they are fitted with special conversion software based on a model of the geoid.

Geodetic data

Because geodetic point coordinates (and heights) are always obtained in a system that has been constructed itself using real observations, geodesists introduce the concept of a geodetic datum: a physical realization of a coordinate system used for describing point locations. The realization is the result of choosing conventional coordinate values for one or more datum points.

In the case of height datums, it suffices to choose one datum point: the reference bench mark, typically a tide gauge at the shore. Thus we have vertical datums like the NAP (Normaal Amsterdams Peil), the North American Vertical Datum 1988 (NAVD88), the Kronstadt datum, the Trieste datum, and so on.

In case of plane or spatial coordinates, we typically need several datum points. A regional, ellipsoidal datum like ED50 can be fixed by prescribing the undulation of the geoid and the deflection of the vertical in one datum point, in this case the Helmert Tower in Potsdam. However, an overdetermined ensemble of datum points can also be used.

Changing the coordinates of a point set referring to one datum, so to make them refer to another datum, is called a datum transformation. In the case of vertical datums, this consists of simply adding a constant shift to all height values. In the case of plane or spatial coordinates, datum transformation takes the form of a similarity or Helmert transformation, consisting of a rotation and scaling operation in addition to a simple translation. In the plane, a Helmert transformation has four parameters; in space, seven.

A note on terminology

In the abstract, a coordinate system as used in mathematics and geodesy is, e.g., in ISO terminology, referred to as a coordinate system. International geodetic organizations like the IERS (International Earth Rotation and Reference Systems Service) speak of a reference system.

When these coordinates are realized by choosing datum points and fixing a geodetic datum, ISO uses the terminology coordinate reference system, while IERS speaks of a reference frame. A datum transformation again is referred to by ISO as a coordinate transformation. (ISO 19111: Spatial referencing by coordinates.(

Point positioning

Geodetic Control Mark (example of a deep benchmark(

Point positioning is the determination of the coordinates of a point on land, at sea, or in space with respect to a coordinate system. Point position is solved by computation from measurements linking the known positions of terrestrial or extraterrestrial points with the unknown terrestrial position. This may involve transformations between or among astronomical and terrestrial coordinate systems.

The known points used for point positioning can be triangulation points of a higher order network, or GPS satellites.

Traditionally, a hierarchy of networks has been built to allow point positioning within a country. Highest in the hierarchy were triangulation networks. These were densified into networks of traverses (polygons), into which local mapping surveying measurements, usually with measuring tape, corner prism and the familiar red and white poles, are tied.

Nowadays all but special measurements (e.g., underground or high precision engineering measurements) are performed with GPS. The higher order networks are measured with static GPS, using differential measurement to determine vectors between terrestrial points. These vectors are then adjusted in traditional network fashion. A global polyhedron of permanently operating GPS stations under the auspices of the IERS is used to define a single global, geocentric reference frame which serves as the "zero order" global reference to which national measurements are attached.

For surveying mappings, frequently Real Time Kinematic GPS is employed, tying in the unknown points with known terrestrial points close by in real time.

One purpose of point positioning is the provision of known points for mapping measurements, also known as (horizontal and vertical) control. In every country, thousands of such known points exist and are normally documented by the national mapping agencies.

Surveyors involved in real estate and insurance will use these to tie their local measurements to.

Geodetic problems

In geometric geodesy, two standard problems exist:

First geodetic problem

Given a point (in terms of its coordinates) and the direction (azimuth) and distance from that point to a second point, determine (the coordinates of) that second point.

Second (inverse) geodetic problem

Given two points, determine the azimuth and length of the line (straight line, arc or geodesic) that connects them.

In the case of plane geometry (valid for small areas on the Earth's surface) the solutions to both problems reduce to simple trigonometry. On the sphere, the solution is significantly more complex, e.g., in the inverse problem the azimuths will differ between the two end points of the connecting great circle, arc, i.e. the geodesic.

On the ellipsoid of revolution, geodesics may be written in terms of elliptic integrals, which are usually evaluated in terms of a series expansion; for example, see Vincenty's formulae.

In the general case, the solution is called the geodesic for the surface considered. The differential equations for the geodesic can be solved numerically.

Geodetic observational concepts

Here we define some basic observational concepts, like angles and coordinates, defined in geodesy (and astronomy as well), mostly from the viewpoint of the local observer.

The plumbline or vertical is the direction of local gravity, or the line that results by following it. It is slightly curved.

The zenith is the point on the celestial sphere where the direction of the gravity vector in a point, extended upwards, intersects it. More correct is to call it a <direction> rather than a point.

The nadir is the opposite point (or rather, direction), where the direction of gravity extended downward intersects the (invisible) celestial sphere.

The celestial horizon is a plane perpendicular to a point's gravity vector.

Azimuth is the direction angle within the plane of the horizon, typically counted clockwise from the North (in geodesy and astronomy) or South (in France.(

Elevation is the angular height of an object above the horizon, Alternatively zenith distance, being equal to 90 degrees minus elevation.

Local topocentric coordinates are azimuth (direction angle within the plane of the horizon) and elevation angle (or zenith angle) and distance.

The North celestial pole is the extension of the Earth's (precessing and nutating) instantaneous spin axis extended Northward to intersect the celestial sphere. (Similarly for the South celestial pole(.

The celestial equator is the intersection of the (instantaneous) Earth equatorial plane with the celestial sphere.

A meridian plane is any plane perpendicular to the celestial equator and containing the celestial poles.

The local meridian is the plane containing the direction to the zenith and the direction to the celestial pole.

Geodetic measurements

Stephen Merkowitz NASA's Space Geodesy Project.ogv

Project manager Stephen Merkowitz talks about his work with NASA's Space Geodesy Project, including a brief overview of the four fundamental techniques of space geodesy: GPS, VLBI, SLR, and DORIS.

The level is used for determining height differences and height reference systems, commonly referred to mean sea level. The traditional spirit level produces these practically most useful heights above sea level directly; the more economical use of GPS instruments for height determination requires precise knowledge of the figure of the geoid, as GPS only gives heights above the GRS80 reference ellipsoid. As geoid knowledge accumulates, one may expect use of GPS heighting to spread.

The theodolite is used to measure horizontal and vertical angles to target points. These angles are referred to the local vertical. The tacheometer additionally determines, electronically or electro-optically, the distance to target, and is highly automated to even robotic in its operations. The method of free station position is widely used.

For local detail surveys, tacheometers are commonly employed although the old-fashioned rectangular technique using angle prism and steel tape is still an inexpensive alternative. Real-time kinematic (RTK) GPS techniques are used as well. Data collected are tagged and recorded digitally for entry into a Geographic Information System (GIS) database.

Geodetic GPS receivers produce directly three-dimensional coordinates in a geocentric coordinate frame. Such a frame is, e.g., WGS84, or the frames that are regularly produced and published by the International Earth Rotation and Reference Systems Service (IERS.(

GPS receivers have almost completely replaced terrestrial instruments for large-scale base network surveys. For Planet-wide geodetic surveys, previously impossible, we can still mention Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) and Very Long Baseline Interferometry (VLBI) techniques. All these techniques also serve to monitor Earth rotation irregularities as well as plate tectonic motions.

Gravity is measured using gravimeters. Basically, there are two kinds of gravimeters. Absolute gravimeters, which nowadays can also be used in the field, are based directly on measuring the acceleration of free fall (for example, of a reflecting prism in a vacuum tube). They are used for establishing the vertical geospatial control. Most common relative gravimeters are spring based. They are used in gravity surveys over large areas for establishing the figure of the geoid over these areas. Most accurate relative gravimeters are superconducting gravimeters, and these are sensitive to one thousandth of one billionth of the Earth surface gravity. Twenty-some superconducting gravimeters are used worldwide for studying Earth tides, rotation, interior, and ocean and atmospheric loading, as well as for verifying the Newtonian constant of gravitation.

Units and measures on the ellipsoid

Geographical latitude and longitude are stated in the units degree, minute of arc, and second of arc. They are angles, not metric measures, and describe the direction of the local normal to the reference ellipsoid of revolution. This is approximately the same as the direction of the plumbline, i.e., local gravity, which is also the normal to the geoid surface. For this reason, astronomical position determination – measuring the direction of the plumbline by astronomical means – works fairly well provided an ellipsoidal model of the figure of the Earth is used.

One geographical mile, defined as one minute of arc on the equator, equals 1,855.32571922 m. One nautical mile is one minute of astronomical latitude. The radius of curvature of the ellipsoid varies with latitude, being the longest at the pole and the shortest at the equator as is the nautical mile.

A metre was originally defined as the 40-millionth part of the length of a meridian (the target was not quite reached in actual implementation, so that is off by 0.02% in the current definitions). This means that one kilometre is roughly equal to (1/40,000) * 360 * 60 meridional minutes of arc, which equals 0.54 nautical mile, though this is not exact because the two units are defined on different bases (the international nautical mile is defined as exactly 1,852 m, corresponding to a rounding of 1000/0.54 m to four digits.(

Temporal change

In geodesy, temporal change can be studied by a variety of techniques. Points on the Earth's surface change their location due to a variety of mechanisms:

Continental plate motion, plate tectonics

Episodic motion of tectonic origin, esp. close to fault lines

Periodic effects due to Earth tides

Postglacial land uplift due to isostatic adjustment

Various anthropogenic movements due to, for instance, petroleum or water extraction or reservoir construction.

The science of studying deformations and motions of the Earth's crust and the solid Earth as a whole is called geodynamics. Often, study of the Earth's irregular rotation is also included in its definition.

Techniques for studying geodynamic phenomena on the global scale include:

satellite positioning by GPS and other such systems,

Very Long Baseline Interferometry (VLBI(

satellite and lunar laser ranging

Regionally and locally, precise levelling,

precise tacheometers,

monitoring of gravity change,

Interferometric synthetic aperture radar (InSAR) using satellite images, etc.

Geographic Data Files

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Geographic Data Files or GDF is an interchange file format for geographic data. In contrast with generic GIS formats, GDF provides detailed rules for data capture and representation, and an extensive catalog of standard features, attributes and relationships. Most recent extension expand applicability further towards Pedestrian Navigation, 3-D map rendering, and Advanced Driver Assistance Systems (ADAS.(

GDF is commonly used for data interchange in many industries such as Automotive navigation system, fleet management, dispatch management, road traffic analysis, traffic management, Automatic Vehicle Location.

Originated as a flat plain-text file, GDF is not intended to be used directly for any large scale geographic application and normally requires conversion into a more efficient format. Consumability has been increased with most-recent developments for XML and SQL renditions.

The maps in GDF format are provided by many map vendors such as Navteq, TomTom, Mapscape BV, GeoSmart, Automotive Navigation Data, AutoNavi and NavInfo.

Contents

Standardisation

GDF is an international standard that is used to model, describe and transfer road networks and other geographic data.

The standard was initially drawn up by CEN in co-operation with digital map providers, automotive and electronic equipment manufacturers. The outcome of these standardisation efforts (CEN GDF 3.0, or ENV14825:1996) has formed the major input to a global standard created by ISO/TC204 Sub Working group 3:

ISO GDF 4.0, formally referred to ISO14825:2004, now replaced by

ISO GDF 5.0, formally referred to ISO14825:2011.

However, despite the existence of a ISO GDF standard, the nature of model abstractions as well as semantic interpretations and proprietary content extensions lead to interoperability issues between flavors of GDF map products from different vendors. In practice the GDF files are not fully interchangeable due to vendor specific extensions. To this end, GDF5.0 provides major improvements in terms of extended meta data and flags for signalling implementation choices.

The new GDF5.0

The specifications of GDF5.0 were developed and compiled between 2001 and 2008, involving experts from Australia, Canada, Czech Republic, France, Germany, Japan, Republic of Korea, the Netherlands, and the United States of America. Extensive activities towards harmonization with ISO/TC211 standards were undertaken. GDF 5.0 was published in July 2011.

Major GDF5.0 enhancements include UML model migration & refinements; harmonization with linear referencing and geo-spatial web standards; support for 3-D content and time coordinates; comprehensive character set and phonetic representations; and new XML and SQL based delivery formats.

Background and Rationale of GDF Standardization

By the late 1980s, producers and users of digital road map data became increasingly aware of the need for a common data interchange standard. Lack of such a standard was seen as an impediment to the commercial growth and success of industries using such data. Before the advent of the Intelligent Transport Systems (ITS) industry, development of spatial data interchange standards was done mostly on a regional basis and not designed for the specialised requirements of road transport-related applications.

In the 1990s, the GDF standard was instrumental in enabling the European business-to-business (B2B) market for in-vehicle navigation in that it provided interoperability for exchanging digital map data between map manufacturers and navigation system integrators. The GDF specifications provided a base for both the capturing of geographic content and the exchanging of it. Its original design foresaw a powerful, application-independent model, while its initial rendition as a standard specifically addressed the requirements for the richness of navigable map databases. Since then, GDF has evolved in terms of boosted data modelling capabilities, broadened international applicability, expanded geographic domains, and diversified exchange formats. As a result, GDF covers a wide range of application domains and has been adapted to many geo-spatial technologies.

Geographic information systems in China

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Geographic information systems (GIS) are becoming an increasingly important component of business, healthcare, security, government, trade, media, transportation and tourism industries and operations in China and GIS software are playing an increasing role in the way Chinese companies analyze and manage business operations.

History

When GIS first became widely available in the 1980s and 1990s, the only source of geographic data for China was paper maps. Several universities elected to undertake the huge task of digitizing this information so that other researchers could use it.

The two earliest projects were conducted by The Australian Consortium for the Asian Spatial Information and Analysis Network (ACASIAN) at Griffith University and the China Data Center at the University of Michigan at Ann Arbor. ACASIAN specialized solely in spatial coverages while the China Data Center included GIS coverages as a supplemented to their primary mission of providing Chinese statistical and census data.

There is a great deal of high quality GIS data being produced in China by both government organizations and private companies. Today, China's National Spatial Data Infrastructure Project, uses the WGS84 standard.

In 1991, China's first color Map Editing and Publication System, MapCAD.

In 1995, China's first National Advanced GIS Software, Computer based GIS, MapGIS.

In 2005, The fourth generation of large scale distributed structure GIS, MapGIS 7.0

In 2009, China's GIS new ero -- MapGIS K9.

Geographic Names Information System

China in the early 1980s began studies for the establishment of its Geographic Names Information System (地名信息系统), Geographic Names Information System Research Laboratory and the establishment of the National Atlas of geographical names database research.

Education

The China Association for Geographic Information System ([1] 中国地理信息系统协会), Peking University and other institutes jointly sponsored the first "Innovation and Development, 2006 College GIS Forum", in Beijing. More than 300 experts and scholars attended the forum. Sessions involved China's geographic information system (GIS) research in multi-disciplinary fields, personnel training, and technology. China has now more than 500 institutions of higher learning training GIS-related professionals, of which more than 200 universities and colleges have established a GIS lab.[1[

Industry

The GIS industry in China is worth 400 billion yuan per annum as of November 2007.[2] More than 300,000 people were involved in either building or using these systems, according to Zondy Cyber Group president Wu Xincai, who is also the president of the China Association for Geographic Information System. Almost 20,000 enterprises are estimated to have engaged in the industry. The biggest vendor of GIS in China is Zondy Cyber Group, followed by SuperMap. Around 2000 of these have GIS as a core discipline or function. The industry's rapid expansion is attributed to the country's economic development, which has led to an increase in capital input, from both government and businesses. Between 2001 and 2005 the Ministry of Information Industry allocated more than 20 million yuan to fund the development and application of GIS. GIS has been put to use in many spheres, including land survey, mineral exploitation, water conservancy and environmental protection. It also has applications in power generation, mapping, telecommunication, and the management of public administration and public services.

Geographic information systems in geospatial intelligence

From Wikipedia, the free encyclopedia

) Redirected from Geographic Information Systems in Geospatial Intelligence(

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Geographic Information Systems (GIS) new and constantly evolving role in geospatial intelligence (GEOINT) and United States (U.S.) national security allows a user to efficiently manage, analyze, and produce geospatial data, to combine GEOINT with other forms of intelligence collection, and to perform highly developed analysis and visual production of geospatial data. Therefore, GIS produces up-to-date, supported, and more reliable GEOINT to reduce uncertainty for a decisionmaker. Since GIS programs are Web-enabled, a user can constantly work with a decisionmaker to solve their GEOINT and national security related problems from anywhere in the world. There are many types of GIS software used in GEOINT and national security, such as Google Earth, ERDAS IMAGINE, GeoNetwork opensource, and Esri's ArcGIS.

Contents

Background

Geographic Information Systems (GIS(

Main article: Geographic Information Systems

A GIS is a system that incorporates software, hardware, and data for collecting, managing, analyzing, and portraying geographically referenced information. It allows the user to view, understand, manipulate, and visualize data to reveal relationships and patterns that solve problems. The user can then present the data in easily understood and disseminated forms, such as maps, reports, or charts.[1[

A user can enter different kinds of data in map form into a GIS to begin their analysis, such as United States Geological Survey (USGS) digital line graph data, contour lines, elevation maps, topographic maps, geologic maps, and satellite imagery. A user can also convert digital information into forms that a GIS can identify and utilize, such as census tabular data or Microsoft Excel files. Users can easily capture digital data in a GIS. If the data is not digital, then users will need to employ various techniques to capture the data, such as digitizing maps by hand-tracing with a computer mouse, utilizing a digitizing tablet to collect feature coordinates, using electronic scanners, or uploading Global Positioning System (GPS) coordinates.[2[

GIS applies to the geographical facets of various aspects of everyday life, such as transportation, logistics, medicine, marketing, sociology, ecology, pure and applied sciences, emergency management, and criminology. GIS is also utilized in all three areas of intelligence: national security intelligence, law enforcement intelligence, and competitive intelligence[3[

Geospatial Intelligence (GEOINT(

Main article: Geospatial Intelligence

GEOINT, known previously as imagery intelligence (IMINT), is an intelligence collection discipline that applies to national security intelligence, law enforcement intelligence, and competitive intelligence. For example, an analyst can use GEOINT to identify the route of least resistance for a military force in a hostile country, to discover a pattern in the locations of reported burglaries in a neighborhood, or to generate a map and comparison of failing businesses that a company is likely to purchase. GEOINT is also the geospatial product of a process that is focused externally, designed to reduce the level of uncertainty for a decisionmaker, and that uses information derived from all sources.[4] The National Geospatial-Intelligence Agency (NGA), who has overall responsibility for GEOINT in the U.S. Intelligence Community (IC), defines GEOINT as “information about any object—natural or man-made—that can be observed or referenced to the Earth, and has national security implications.”[5[

Some of the sources of collected imagery information for GEOINT are imagery satellites, cameras on airplanes, Unmanned Aerial Vehicles (UAV) and drones, handheld cameras, maps, or GPS coordinates.[6] Recently the NGA and IC have increased the use of commercial satellite imagery for intelligence support, such as the use of the IKONOS, Landsat, or SPOT satellites.[7] These sources produce digital imagery via electro-optical systems, radar, infrared, visible light, multispectral, or hyperspectral imageries.[8[

The advantages of GEOINT are that imagery is easily consumable and understood by a decisionmaker, has low human life risk, displays the capabilities of a target and its geographical relationship to other objects, and that analysts can use imagery world-wide in a short time. On the other hand, the disadvantages of GEOINT are that imagery is only a snapshot of a moment in time, can be too compelling and lead to ill-informed decisions that ignore other intelligence, is static and vulnerable to deception and decoys, does not depict the intentions of a target, and is expensive and subject to environmental problems.[9[

GIS use in GEOINT and National Security Intelligence

Overview

A majority of national security intelligence decisions involve geography and GEOINT. GIS allows the user to capture, manage, exploit, analyze, and visualize geographically referenced information, physical features, and other geospatial data.[10] GIS is thus a critical infrastructure for the GEOINT and national security community in manipulating and interpreting spatial knowledge in an information system. GIS extracts real world geographic or other information into datasets, maps, metadata, data models, and workflow models within a geodatabase that is used to solve GEOINT-related problems. GIS provides a structure for map and data production that allows a user to add other data sources, such as satellite or UAV imagery, as new layers to a geodatabase. The geodatabase can be disseminated and operated across any network of associated users (i.e. from the GEOINT analyst to the warfighter) and engenders a common spatial capability for all defense and intelligence domains.[11[

The map and chart production agency and imagery intelligence agency, the principal two agencies of GEOINT, use GIS to efficiently work together to solve decisionmaker's geospatial questions, to communicate effectively between their unique departments, and to provide constantly updated, accurate GEOINT to their national security and warfighter domains.[12[

Another important aspect of GIS is its ability to fuse geospatial data with other forms of intelligence collection, such as signals intelligence (SIGINT), measurement and signature intelligence (MASINT), human intelligence (HUMINT), or open source intelligence (OSINT). A GIS user can incorporate and fuse all of these types of intelligence into applications that provide corroborated GEOINT throughout an organization's information system.[13[

GIS enables efficient management of geospatial data, the fusion of geospatial data with other forms of intelligence collection, and advanced analysis and visual production of geospatial data. This produces faster, corroborated, and more reliable GEOINT that aims to reduce uncertainty for a decisionmaker.[14[

Roles[15[

Data and map production

Data fusion, data discovery through metadata catalogs, and data dissemination through Web portals and browsers

Analysis and exploitation of collected imagery or intelligence

SIGINT, GEOINT, MASINT, and other sensor analysis

Fusion of multiple forms of intelligence collection

Collaborative planning and efficient workflow management between decisionmakers, analysts, consumers, and warfighters

Suitability and temporal analysis

Stewardship: Geospatial intelligence

Related Esri Products

Distributed Geospatial Intelligence Network (DGInet(

The DGInet technology allows military and national security intelligence customers to access large multi-terabyte databases through a common Web-based interface. This gives the users the capability to quickly and easily identify, overlay, and fuse georeferenced data from various sources to create maps or support geospatial analysis. Esri designed the technology for inexperienced GIS users of national security intelligence and defense organizations in order to provide a Web-based enterprise solution for publishing, distributing, and exploiting GEOINT data among designated organizations.[16] According to Esri, the DGInet technology "uses thin clients to search massive amounts of geospatial and intelligence data using low-bandwidth Web services for data discovery, dissemination, and horizontal fusion of data and products."[17[

PLTS for ArcGIS Specialized Solutions

PLTS for ArcGIS Specialized Solutions is a group of software applications that extends ArcGIS to facilitate database driven cartographic production for geospatial and mapping agencies, nautical and aeronautical chart production, foundation mapping, and defense mapping requirements.[18] The collection of software applications includes Esri Production Mapping, Esri Nautical Solution, Esri Aeronautical Solution, and Esri Defense Mapping programs that provide quality control, easier and consistent map production, database sharing, and efficient workflow management for each program's specific type of mapping or charting.[19[

Geoprocessing

Geoprocessing is based on a framework of data transformation in GIS and is a collection of hundreds of GIS tools that manipulate geospatial or other data in GIS. A geoprocessing tool performs an operation (often the name of the tool, such as "Clip") on an existing GIS dataset and produces a new dataset as a result of the utilized tool. GIS users utilize these tools to create a workflow model that quickly and easily transforms raw data into the desired product.[20[

In GEOINT, users employ geoprocessing in similar ways. They can make geoprocessing tools resemble analytic techniques to transform large amounts of data into actionable information. In national security intelligence and defense organizations, geoprocessing notifies users to events occurring in specific areas of interest and enables domain-specific analysis applications, such as radio frequency analysis, terrain analysis, and network analysis.[21[

Tracking Analyst and Tracking Server

The ArcGIS Tracking Analyst extension enables the user to create time series visualizations to analyze time and location sensitive information. It creates a visible path from incorporated data that shows movement through space and time. The program allows the national security intelligence or defense user to track assets (such as vehicles or personnel), monitor sensors, visualize change over time, play back events, and analyze historical or real-time temporal data.[22[

The Tracking Server program is an Esri enterprise technology that integrates real-time data with GIS to disseminate information quickly and easily to decisionmakers. This program enables the user to obtain data in any format and transmit it to the necessary consumer or ArcGIS Tracking Analyst user, to conduct filters or alerts on specific attributes of incoming data or global positions, and to log data into ArcGIS Server for efficient project management and information sharing.[23[

When Tracking Server and ArcGIS Tracking Analyst are used together, a user can monitor changes in data as they occur in real-time. A national security intelligence or defense user can subscribe to real-time data over the Internet from GPS and custom data feeds to support GEOINT requirements, such as fleet management or target tracking.[24[

ArcGIS Military Analyst

The ArcGIS Military Analyst extension incorporates display and analysis tools that allow the use and production of vector and raster products, line-of-sight analysis, hillshade analysis, terrain analysis, and Military Grid Reference System (MGRS) conversion. This program also provides a basis for command, control, and intelligence (C2I) systems. National security intelligence and defense organizations use ArcGIS Military Analyst extension to integrate geospatial data with other defense data, analyze digital terrains, and prepare for battle. This program also enables such users to manage and analyze geospatial data and relationships between mission planning, logistics, and C2I.[25[

Military Overlay Editor (MOLE(

MOLE is a set of command components that enables national security intelligence and defense users to easily create, display, and edit U.S. Department of Defense MIL-STD-2525B and the North Atlantic Treaty Organization APP-6A military symbology in a map. This allows for easier and faster identification, understanding, and movement of ally and hostile forces on a map by combining GIS spatial analysis techniques with common military symbols. MOLE provides a clearer visualization of mission planning and goals for the decisionmaker, and allows a user to import, locate, and display order of battle databases.[26[

Grid Manager

Grid Manager enables the national security intelligence or defense user to create accurate, realistic grids that contain geographic location indicators based on specified shapes, scales, coordinate systems, and units. This program allows the user to create multiple grids, graticules, and borders for such map products as MGRS coordinates and tourist, topographic, parcel, street, nautical, and aeronautical maps.[27[

GIS use in the National Geospatial-Intelligence Agency (NGA(

Main article: National Geospatial-Intelligence Agency

The NGA uses GIS products to create digital nautical, aeronautical, and topographic charts and maps,[28] to perform geotechnical and coordinate system analysis, and to help solve a large variety of national security and military problems.[29][30] Since the NGA is a U.S. Department of Defense combat support agency and a member of the IC, it uses GIS to produce precise, up-to-date GEOINT for members of the U.S. Armed Forces, the IC, and other government agencies. Web-enabled GIS applications allow for fast, efficient sharing and disseminating of geospatial data, products, and intelligence from the NGA to its allies, warfighters, partners, and other agencies across the World Wide Web.[31] The NGA and Esri have successfully collaborated on providing timely, accurate, and relevant GEOINT in support of U.S. national security for the past 20 years.[32[

The NGA has created a grouping of web-based capabilities called GEOINT Online. This program allows a user to search and access all NGA GEOINT documents from wherever they are stored and from wherever the user is. GEOINT Online provides quick, easy, and reliable access to current NGA intelligence products, changes in activities or regions, information from analyst’s blogs and Intellipedia, geospatial imagery, maps and charts, major GIS commercial software packages, and GIS combinations of these products.[33] A user can also edit and format existing NGA/GIS products and maps to create, print, and download new products that fulfill current decisionmaker requirements. Ultimately, this results in the faster production of timely and relevant GEOINT data. This program allowed the NGA to change its focus from simply generating cartographic products to providing updated, accurate GEOINT to support the national security and military requirements of its customers.[34[

Geoinformatics

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Geoinformatics, also: Geographic information science (GIS)[1] and Geographic information technology (GIT)[2], is the science and the technology which develops and uses information science infrastructure to address the problems of geography, geosciences and related branches of engineering.

Contents

Overview

Geoinformatics has been described as "the science and technology dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information"[3] or "the art, science or technology dealing with the acquisition, storage, processing production, presentation and dissemination of geoinformation".[4[

Geomatics is a similarly used term which encompasses geoinformatics, but geomatics focuses more so on surveying. Geoinformatics has at its core the technologies supporting the processes of acquiring, analyzing and visualizing spatial data. Both geomatics and geoinformatics include and rely heavily upon the theory and practical implications of geodesy.

Geography and earth science increasingly rely on digital spatial data acquired from remotely sensed images analyzed by geographical information systems (GIS) and visualized on paper or the computer screen.[5[

Geoinformatics combines geospatial analysis and modeling, development of geospatial databases, information systems design, human-computer interaction and both wired and wireless networking technologies. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation.

Branches of geoinformatics include:

- Cartography
- Geodesy
- Geographic Information Systems
- Global Navigation Satellite Systems
- Photogrammetry
- Remote sensing
- Web mapping

Applications

Many fields benefit from geoinformatics, including urban planning and land use management, in-car navigation systems, virtual globes, public health, local and national gazetteer management, environmental modeling and analysis, military, transport network planning and management, agriculture, meteorology and climate change, oceanography and coupled ocean and atmosphere modelling, business location planning, architecture and archeological reconstruction, telecommunications, criminology and crime simulation, aviation and maritime transport. The importance of the spatial dimension in assessing, monitoring and modelling various issues and problems related to sustainable management of natural resources is recognized all over the world. Geoinformatics becomes very important technology to decision-makers across a wide range of disciplines, industries, commercial sector, environmental agencies, local and national government, research, and academia, national survey and mapping organisations, International organisations, United Nations, emergency services, public health and epidemiology, crime mapping, transportation and infrastructure, information technology industries, GIS consulting firms, environmental management agencies), tourist industry, utility companies, market analysis and e-commerce, mineral exploration, etc. Many government and non government agencies started to use the spatial data for managing their day to day activities.

Geomatics

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Geodesy

Fundamentals

- Geodesy
- Geodynamics
- Geomatics
- Cartography

Concepts

Datum

Distance

Geoid

Fig. Earth

Geodetic system

Geodesic

Geog. coord. system

Hor. pos. represent.

Lat. / Long.

Map proj.

Ref. ellipsoid

Satellite geodesy

Spatial ref. system

Technologies

GNSS

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IRNSS

Standards

ED50

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GRS 80

NAD83

NAVD88

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SRID

UTM

WGS84

History

History of geodesy

NAVD29

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A surveyor's shed showing equipment used for geomatics

Geomatics (also known as geospatial technology or geomatics engineering) is the discipline of gathering, storing, processing, and delivering geographic information, or spatially referenced information.

Contents

Overview and etymology

Geomatics is a relatively new scientific term, coined by Pollock and Wright in 1969, with the intention of combining the terms geodesy and geoinformatics. It includes the tools and techniques used in land surveying, remote sensing, cartography, geographic information systems (GIS), global navigation satellite systems (GPS, GLONASS, Galileo, Compass), photogrammetry, geography and related forms of earth mapping. The term was originally used in Canada, because it is similar in origin to both French and English, but has since been adopted by the International Organization for Standardization, the Royal Institution of Chartered Surveyors, and many other international authorities, although some (especially in the United States) have shown a preference for the term geospatial technology .[1[

The related field of hydrogeomatics covers the area associated with surveying work carried out on, above or below the surface of the sea or other areas of water. The older term of hydrographics was considered too specific to the preparation of marine charts, and failed to include the broader concept of positioning or measurements in all marine environments.

A geospatial network is a network of collaborating resources for sharing and coordinating geographical data, and data tied to geographical references. One example of such a network is the Open Geospatial Consortium's efforts to provide ready global access to geographic information. A number of university departments which were once titled surveying, survey engineering or topographic science have re-titled themselves as geomatics or geomatic engineering.

The rapid progress, and increased visibility, of geomatics since 1990s has been made possible by advances in computer hardware, computer science, and software engineering, as well as airborne and space observation remote sensing technologies.

The science of deriving information about an object using a sensor without physically contacting it is called remote sensing, which is a part of geomatics.

Geospatial intelligence

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National Geospatial-Intelligence Agency building at the Fort Belvoir North Area in Springfield.

Geospatial intelligence, GEOINT (GEOspatial INTelligence), GeoIntel (Geospatial Intelligence), or GSI (GeoSpatial Intelligence) is intelligence derived from the exploitation and analysis of imagery and geospatial information that describes, assesses, and visually depicts physical features and geographically referenced activities on the Earth. GEOINT consists of imagery, imagery intelligence (IMINT) and geospatial information.[1[

Contents

Amplified definition

GEOINT encompasses all aspects of imagery (including capabilities formerly referred to as Advanced Geospatial Intelligence and imagery-derived MASINT) and geospatial information and services (GI&S); formerly referred to as mapping, charting, and geodesy). It includes, but is not limited to, data ranging from the ultraviolet through the microwave portions of the electromagnetic spectrum, as well as information derived from the analysis of literal imagery; geospatial data; and information technically derived from the processing, exploitation, literal, and non-literal analysis of spectral, spatial, temporal, radiometric, phase history, polarimetric data, fused products (that is products created out of two or more data sources), and the ancillary data needed for data processing and exploitation, and signature information (to include development, validation, simulation, data archival, and dissemination). These types of data can be collected on stationary and moving targets by electro-optical (to include IR, MWIR, SWIR TIR, Spectral, MSI, HSI, HD), SAR (to include MTI), related sensor programs (both active and passive) and non-technical means (to include geospatial information acquired by personnel in the field).[2[

Here Geospatial Intelligence, or the frequently used term GEOINT, is an intelligence discipline comprising the exploitation and analysis of geospatial data and information to describe, assess, and visually depict physical features (both natural and constructed) and geographically referenced activities on the Earth. Geospatial Intelligence data sources include imagery and mapping data, whether collected by commercial satellite, government satellite, aircraft (such as Unmanned Aerial Vehicles [UAV] or reconnaissance aircraft), or by other means, such as maps and commercial databases, census information, GPS waypoints, utility schematics, or any discrete data that have locations on earth. There is an emerging recognition that "this legal definition paints with a broad brushstroke an idea of the width and depth of GEOINT"[3] and “GEOINT must evolve even further to integrate forms of intelligence and information beyond the traditional sources of geospatial information and imagery, and must move from an emphasis on data and analysis to an emphasis on knowledge.”[4[

Geospatial data, information, and knowledge

It should be noted that the definitions and usage of the terms geospatial data, geospatial information, and geospatial knowledge are not used consistently or unambiguously further exacerbating the situation. Geospatial data can (usually) be applied to the output of a collector or collection system before it is processed, i.e., data that was sensed. Geospatial Information is geospatial data that has been processed or had value added to it by a human or machine process. Geospatial knowledge is a structuring of geospatial information, accompanied by an interpretation or analysis. The terms Data, Information, Knowledge and Wisdom (DIKW) are difficult to define, but cannot be used interchangeably.

Quite simply, geospatial intelligence could be more readily defined as, data, information, and knowledge gathered about enemies (or potential enemies) that can be referenced to a particular location on, above, or below the earth's surface. The intelligence gathering method could include imagery, signals, measurements and signatures, and human sources, i.e., IMINT, SIGINT, MASINT, and HUMINT, as long as a geo-location can be associated with the intelligence.

Relationship to other "INTs"

Thus, rather than being a peer to the other "INTs", geospatial intelligence might better be viewed as the unifying structure of the earth's natural and constructed features (including elevations and depths)—whether as individual layers in a GIS or as composited into a map or chart, imagery representations of the earth, AND, the presentation of the existence of data, information, and knowledge derived from analysis of IMINT, SIGINT, MASINT, HUMINT, and other intelligence sources and disciplines.

The Intelligence, Defense, Homeland Security, and natural disaster assistance communities would all benefit from this unifying structure of foundation feature data, current and historical imagery, and the data, information and knowledge that each intelligence discipline gathers, analyzes, assesses, and presents on a globe. This unifying aspect of geospatial intelligence can be viewed as a global extent Geographic Information System (GIS) to which all community members contribute by geo-tagging their content.

Other factors

It has been suggested that GEOINT is just a new term used to identify a broad range of outputs from intelligence organizations that use a variety of existing spatial skills and disciplines including photogrammetry, cartography, imagery analysis, remote sensing, and terrain analysis. However, GEOINT is more than the sum of these parts. Spatial thinking as applied in Geospatial Intelligence can synthesize any intelligence or other data that can be conceptualized in a geographic spatial context. Geospatial Intelligence can be derived entirely independent of any satellite or aerial imagery and can be clearly differentiated from IMINT (imagery intelligence). Confusion and dissension is caused by Title 10 U.S. Code §467's separation of "imagery" or "satellite information" from "geospatial information" as imagery is generally considered just one of the forms which geospatial information might take or be derived from.

It has also been suggested[by whom?] that geospatial intelligence can be described as a product occurring at the point of delivery, i.e., by the amount of analysis which occurs to resolve particular problems, not by the type of data used. For example, a database containing a list of measurements of bridges obtained from imagery is 'information' while the development of an output using analysis to determine those bridges that are able to be utilized for specific purposes could be termed 'intelligence'. Similarly, the simple measurement of beach profiles is a classical geographic information-gathering activity, while the process of selecting a beach that matches a certain profile for a specific purpose is an analytical activity, and the output could be termed an intelligence product. In this form it is considered to be generally used by agencies requiring definitions of their outputs for descriptive and capability development purposes (or, more cynically, as a marketing strategy.(

Geospatial intelligence analysis has been light-heartedly defined as “seeing what everybody has seen and thinking what nobody has thought.”[5] However, these perspectives affirm that creating geospatial knowledge is an effortful cognitive process the analyst undertakes; it is an intellectual endeavor that arrives at a conclusion through reasoning. Geospatial reasoning creates the objective connection between a geospatial problem representation and geospatial evidence. Here one set of activities, information foraging, focuses around finding information while another set of activities, sensemaking, focuses on giving meaning to the information. The activities of foraging and sensemaking in geospatial analysis have been incorporated in the Structured Geospatial Analytic Method.[6[

De facto definition

An emerging de facto definition of geospatial intelligence is vastly different than the de jure definition expressed in U.S. Code. This new de facto definition is:

Geospatial Intelligence is a field of knowledge, a process, and a profession. As knowledge, it is information integrated in a coherent space-time context that supports descriptions, explanations, or forecasts of human activities with which decision makers take action. As a process, it is the means by which data and information are collected, manipulated, geospatially reasoned, and disseminated to decision-makers. The geospatial intelligence professional establishes the scope of activities, interdisciplinary associations, competencies, and standards in academe, government, and the private sectors.[7[

This has been suggested as an operational definition of Geospatial Intelligence which might use the moniker of GeoIntel so as to distinguish it from the more restrictive definition offered in U.S. Code Title 10, §467.

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GIS and aquatic science

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ArcGIS Server website depicting submersed aquatic vegetation.

Geographic Information Systems (GIS) has become an integral part of aquatic science and limnology. Water by its very nature is dynamic. Features associated with water are thus ever-changing. To be able to keep up with these changes, technological advancements have given scientists methods to enhance all aspects of scientific investigation, from satellite tracking of wildlife to computer mapping of habitats. Agencies like the US Geological Survey, US Fish and Wildlife Service as well as other federal and state agencies are utilizing GIS to aid in their conservation efforts.

GIS is being used in multiple fields of aquatic science from limnology, hydrology, aquatic botany, stream ecology, oceanography and marine biology. Applications include using satellite imagery to identify, monitor and mitigate habitat loss. Imagery can also show the condition of inaccessible areas. Scientists can track movements and develop a strategy to locate locations of concern. GIS can be used to track invasive species, endangered species, and population changes.

One of the advantages of the system is the availability for the information to be shared and updated at any time through the use of web-based data collection.

Contents

GIS and fish

USGS sidescan radar image over base image from Army Corps of Engineers, indicating sturgeon location and river mile.

In the past, GIS was not a practical source of analysis due to the difficulty in obtaining spatial data on habitats or organisms in underwater environments. With the advancement of radio telemetry, hydroacoustic telemetry and side-scan sonar biologists have been able to track fish species and create databases that can be incorporated into a GIS program to create a geographical representation. Using radio and hydroacoustic telemetry, biologists are able to locate fish and acquire relatable data for those sites, this data may include substrate samples, temperature, and conductivity. Side-scan sonar allows biologists to map out a river bottom to gain a representation of possible habitats that are used. These two sets of data can be overlaid to delineate the distribution of fish and their habitats for fish. This method has been used in the study of the pallid sturgeon.

Over a period of time large amounts of data are collected and can be used to track patterns of migration, spawning locations and preferred habitat. Before, this data would be mapped and overlaid manually. Now this data can be entered into a GIS program and be layered, organized and analyzed in a way that was not possible to do in the past. Layering within a GIS program allows for the scientist to look at multiple species at once to find possible watersheds that are shared by these species, or to specifically choose one species for further examination. The US Geological Survey (USGS) in, cooperation with other agencies, were able to use GIS in helping map out habitat areas and movement patterns of pallid sturgeon. At the Columbia Environmental Research Center their effort relies on a customized ArcPad and ArcGIS, both ESRI (Environmental Systems Research Institute) applications, to record sturgeon movements to streamline data collection. A relational database was developed to manage tabular data for each individual sturgeon, including initial capture and reproductive physiology. Movement maps can be created for individual sturgeon. These maps help track the movements of each sturgeon through space and time. This allowed these researchers to prioritize and schedule field personnel efforts to track, map, and recapture sturgeon.

GIS and macrophytes

Map created from GIS database depicting the movements of individual sturgeon.

Surveyed (left) and predicted (right) distributions of submersed aquatic vegetation distribution Upper Mississippi River in 1989. The survey data were from the land cover/land use geographic information created by the U.S. Geological Survey Upper Midwest Environmental Sciences Center on the basis of interpretation of aerial photography of 1989.

Macrophytes are an important part of healthy ecosystems. They provide habitat, refuge, and food for fish, wildlife, and other organisms. Though natural occurring species are of great interest so are the invasive species that occur alongside these in our environment. GIS is being used by agencies and their respective resource managers as a tool to model these important macrophyte species. Through the use of GIS resource managers can assess the distributions of this important aspect of aquatic environments through a spatial and temporal scale. The ability to track vegetation change through time and space to make predictions about vegetation change are some of the many possibilities of GIS. Accurate maps of the aquatic plant distribution within an aquatic ecosystem are an essential part resource management.

It is possible to predict the possible occurrences of aquatic vegetation. For example, the USGS has created a model for the American wild celery (Vallisneria americana) by developing a statistical model that calculates the probability of submersed aquatic vegetation. They established a web link to an Environmental Systems Research Institute (ESRI) ArcGIS Server website *Submersed Aquatic Vegetation Model to make their model predictions available online. These predictions for distribution of submerged aquatic vegetation can potentially have an effect on foraging birds by creating avoidance zones by humans. If it is known where these areas are, birds can be left alone to feed undisturbed. When there are years where the aquatic vegetation is predicted to be limited in these important wildlife habitats, managers can be alerted.

Invasive species have become a great conservation concern for resource managers. GIS allows managers to map out plant locations and abundances. These maps can then be used to determine the threat of these invasive plants and help the managers decide on management strategies. Surveys of these species can be conducted and then downloaded into a GIS system. Coupled with this, native species can be included to determine how these communities respond with each other. By using known data of preexisting invasive species GIS models could predict future outbreaks by comparing biological factors. The Connecticut Agricultural Experiment Station Invasive Aquatic Species Program (CAES IAPP) is using GIS to evaluate risk factors. GIS allows managers to georeference plant locations and abundance. This allows for managers to display invasive communities alongside native species for study and management.

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Map database management

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Map database management stems from navigation units becoming more common in automotive vehicles (see Automotive navigation system). They serve to perform usual navigation functions, such as finding a route to a desired destination and guiding the driver to it or determining the vehicle's location and providing information about nearby points of interest. Moreover, they are playing an increasingly important role in the emerging areas of Location-based services, Active safety functions and Advanced Driver Assistance Systems. Common to these functions is the requirement for an on-board map database that contains information describing the road network. Maintaining such a map database, including keeping it up to date and incorporating related information, is the subject of this article.

Contents

Content of a map database

Figure 1: Features and their respective attributes in a map database

A map database represents a road network along with associated features. Map providers choose various models of a road network as a basis to formulate a database. Commonly, such a model comprises basic elements (nodes, links and areas) of the road network and properties of those elements (location coordinates, shape, addresses, road class, speed range, etc.). The basic elements are referred to as features and the properties as attributes. Other information associated with the road network is also included, including points of interest, building shapes, and political boundaries. This is shown schematically in the image to the right. Geographic Data Files (GDF) [1] is a standardized description of such a model.

Each node represents a point location of the surface of the Earth and is represented by a pair of longitude (lon) and latitude (lat) coordinates. Each link represents a stretch of road between two nodes, and is represented by a line segment (corresponding to a straight section of road) or a curve having a shape that is generally described by intermediate points (called shape points) along the link. However, curves may also be represented by a combination of centroid (point or node), with a radius, and polar coordinates to define the boundaries of the curve. Shape points are represented by lon, lat coordinates as are nodes, but shape points do not serve the purpose of connecting links, as do nodes. Areas are two-dimensional shapes that represent things like parks, cities, blocks and are defined by their boundaries (usually formed by a closed polygon.(

Interchange format

Map providers generally collect, aggregate and supply data in a well-defined and documented file format that is specifically intended for information interchange, e.g. Navteq uses Standard Interchange Format (SIF)[2] and GDF, while Tele Atlas uses a proprietary form of GDF[3]. It is usually in a plain-text form (ASCII) consisting of fields that are easily parsed and interpreted by the various parties who will handle it. The portable format allows additions, deletions and modifications to be readily performed by simple text-editing programs.

A small number of record types are used to represent the various types of data. Each record type consists of a sequence of fields, which are either fixed length or delimited by a punctuation character such as a comma. For example, a link entity could be represented by a record of the form:

type1,label,node1,z1,node2,z2,class,number of shape points,number of lanes,speed

where type1 defines this as a link record type and label serves as an identifier to distinguish this link from all others. The z1 and z2 fields determine the vertical separation of this link from others sharing the corresponding nodes node1 and node2. Thus an overpass to a link, for example, can be represented as not connected to that link. Other record types are used to represent address information, shape-points for a link, cities and states, points of interest (POI's), etc.

The interchange format for a map database is not organized well for use by a navigation unit during runtime. Records are in an arbitrary order and therefore difficult to search and data, such as street names and coordinate values, are repeated from record to record. Consequently the database content is reorganized into a binary form more suitable for run-time operation.

Run-time format

Runtime formats are typically proprietary, preventing interoperation of maps between different navigation systems. However a new initiative called Physical Storage Format (PSF) is an industry grouping of car manufacturers, navigation system suppliers and map data suppliers whose objective is the standardization of the data format used in car navigation systems.[4]. Companies involved include BMW, Volkswagen, Daimler, Renault, ADIT, Alpine Electronics, Navigon, Bosch, DENSO, Mitsubishi, Harman Becker, Panasonic, PTV, Continental AG, Navteq, Tele Atlas and Zenrin.

The database is reorganized by a navigation provider[5][6][7] through a compilation process that includes at least the following five steps:

Check for network consistency. For example, ensure that all node pairs that should be connected by a link do have such a link and inversely all node pairs that should not be connected do not have a connecting link.

Assign identifiers (IDs) to all entities in a systematic manner.

Apply multiple sets of indices to entities to facilitate searching the database in expected ways.

Replace multiple occurrences of data items (street names, coordinates, etc.) by indices into tables containing a single copy of each such item.

Apply other compression techniques to reduce the overall size of the database.

The consistency check of step 1 is usually a very interactive and iterative process that might take weeks to complete. During this time discrepancies need to be detected, investigated and resolved.

In step 2, IDs are generally assigned sequentially as entities of each type are encountered. Any changes made to the input database from one version to another will affect the assignment of IDs to all entities. Consequently, there is little expectation of continuity in the assignment between versions.

In step 3 each applied index allows the database to be quickly searched in a specific manner. One index set applied to links can be sorted by the alphabetic order of the street names of the links. Another index set applied to links can be sorted according to the nodes to which they are connected to facilitate route planning. Yet another index set applied to nodes can be sorted according to their order of appearance along a road. In some of these cases a binary search can be performed instead of an exhaustive search and in some cases, a search process can be replaced with a simple table lookup.

Incremental update

For most navigational functions it is important to have in the vehicle an up-to-date map database, and for some functions it is critical, especially those related to active safety. A common strategy is to transfer update information to the vehicle whenever it becomes available over a wireless channel. The wireless channel might bi-directional, such as wifi and cellular phone, broadcast, such as satellite radio, FM sub-carrier or ATSC datacasting, or a combination of both. In any case it would be impractical or extremely inefficient to transmit the entire new database to replace an existing version, since it is likely to be several gigabytes in size.

Instead it is desirable to transfer just that information related to changes made to the existing database. A major difficulty is that any change made to the content of a map database generally causes changes to all assigned entity IDs and all assigned indices during the compilation process. These new IDs and indices permeate the entire compiled database so that any collection of increments will likely constitute most of the database. To overcome this difficulty, three approaches have been taken, which are briefly 1) onboard compiler 2) look-aside store 3) geographical tiles.

On-board compiler

In this case, basic changes made to the interchange format of the database are transmitted to the vehicle. Such changes are represented in transactional form consisting of additions, deletions and replacements. These changes are applied to the existing onboard database in interchange format. The interchange format for the onboard database could either be stored separately or generated as needed by “decompiling” the run-time format. The combined database is then compiled, which involves assigning IDs and applying indices.

This onboard compilation will likely be computationally intensive and require considerable memory. However, it does not need to be interactive and iterative as does the off-board compilation since consistency checks and resolution will have already been done. Furthermore, the onboard compilation can be done in the background so computation time is not critical.

Look-aside store

In this case, basic changes are also transmitted to the vehicle, but are placed into a separate memory location called a look-aside store. The changes are also represented in transactional form but may appear in any convenient format, which is not necessarily either interchange or run-time. During operation of the navigation unit, the look-aside store is searched each time the main database is accessed. Any transactions (changes) that pertain to the accessed data are then applied.

The necessity of examining the look-aside store and applying changes for each database access of course complicates the navigational algorithms and lengthens their computation time. However, this avoids the need for an onboard compiler.

Geographical tiles

In this approach, the map database is broken down into relatively small rectangular regions (tiles) that tessellate the map. The tile size is on the order of 1 km on a side. These tiles are compiled separately, so that all IDs and indices are conditioned by the particular tile to which they apply. The tiles that have changed due to basic entity or attribute changes to the database are transmitted to the vehicle, where they replace the corresponding existing tile.

Replacing tiles is considerably simpler than onboard compilation or employing a look-aside store. However, it may not be efficient for transmission. A local change to entities and attributes, regardless of the extent, requires the transmission of the entire containing tile. Furthermore, there are edge effects in which a change in an entity within one tile affects the entities in neighboring tiles. It is quite possible that a small number of entity changes will require the transmission of almost all tiles, thereby defeating the purpose of incremental updates. These problems can be address by selecting the tile size and the frequency of updating.

Attaching auxiliary data

Various navigational functions, involving active safety, driver assistance and location-based services require data that is not considered to be part of a map database and is likely supplied by a vendor other than that of the map provider. Such data needs to be cross-referenced with the entities and attributes of the main database. However, since the auxiliary data is not necessarily compiled with the main database some other means is needed to establish cross-referencing, which is referred to as attaching the auxiliary data. Two common approaches are function-specific referencing tables and generic referencing.

Function-specific referencing tables

Function-specific referencing tables provide a means for attaching function-specific data to a map-data base produced by any participating supplier. Such a table is collaboratively produced to support a specific function or class of functions involving location-based service, active-safety or advanced driver assistance. It will generally consist of a list of map elements of a specific type (e.g., links, intersections, point-of-interest locations, etc.) along with identifying attributes (e.g., street names, longitude/latitude coordinates, etc.). Additionally, each entry in the table is assigned a unique identifier. The set of entries in a table are generally selected, through consensus of all interested parties. As a practical matter the result will represent a small subset of the elements of the given type that are available in the map databases and will consist of those that are more important to the application area. After a table is formulated, it is the task of each participating supplier to determine and cross-reference the elements in their map-database that correspond to the table entries.

Figure 2: TMC locations in Metro Detroit

A widely used example is the TMC standard for location-code tables for referencing traffic data. TMC, which stands for Traffic Message Channel[8], is part of the Radio Data System (RDS), which is implemented as a sub-carrier modulation of a commercial FM broadcast signal. The TMC tables primarily provide references to point locations along major roads corresponding to intersections with other roads. A table entry identifies a point location using both contextual information (such as, region, road and section of road, name of intersection) and approximate longitude/latitude coordinates.

Identifiers assigned to entries in a table are 16-bit integers and therefore have a range of 65536 values. This is too few to cover the world, so separate tables are formulated for each country or region of a country. For a given metropolitan region, only intersections along freeways, arterials and some major roads are included. This is illustrated in the following figure for the Detroit metro area. The coverage is intended for providing traffic advisory information on high-use roads. Traffic-based route planning, on the other hand, requires coverage of all or almost all major roads and, therefore, is not adequately supported by TMC location code tables as they are currently formulated.

Generic referencing

Generic referencing is an attempt to attach data to any map database by discovering reference information through a form of map matching. The function-specific data items are assigned to elements, such as points, links or areas, that likely only approximate the corresponding map elements in a specific map database. A search of the map database is made for the best fit. To enhance the search process neighboring elements are strategically appended to each given element to help ensure that the correct solution is found in each case. For example, if the map element is a link connecting two intersections, then one or both cross streets could be appended for the sake of the search. Hopefully, this makes an incorrect match unlikely. Although the procedure is quite heuristic, a proposed standard called Agora outlines the strategy for choosing neighboring elements to append.

European consortium ActMAP

A European consortium called ActMAP (Actualize Map)[9] is (in their words) "developing standardised mechanisms to update existing map database content and enable dynamic attachment of information to the digital in-vehicle map". The ActMAP consortium comprises ERTICO (coordinator), BMW, CRF Fiat Research Centre, DaimlerChrysler, Navigon, Navteq, Tele Atlas, and Siemens VDO Automotive. They have finished most of their work and published a number of reports, which were submitted to the ISO committee TC204 WG3 for standardization. Their reports serve as a good starting point and reference for the work of this project. An important issue their reports address is dealing with the complexity of multiple map suppliers, using proprietary formats, coupled with multiple data suppliers and multiple versions of in-vehicles maps. They resolve this by using an open intermediate map format expressed with XML and based on the concepts of the ISO standard GDF 4.0. All modifications to a supplier's database are first converted to this intermediate format, stored on a server and then converted to each format used within individual vehicles. They assume that each car has a "baseline" map from a map supplier and that this baseline defines reference identifiers (e.g. map segment ID) for most features to be updated. For features with no reference identifier in the baseline, they propose using a "generic" reference that is discovered heuristically using map matching as described by a proposed standard called AGORA

A major issue not directly addressed by ActMAP is that for each new version of a supplier's map database all reference IDs are usually reassigned by a compiling process, which destroys any correspondence with IDs of previous versions. This seriously interferes with the ability to use incremental updates to generate a new version of a map database from a previous version. Another issue not resolved by ActMAP is the inability to reference and characterize subsections of road segments (for example, curves, hills, maneuver lanes, etc.) in order to update them

Participatory GIS

From Wikipedia, the free encyclopedia

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This article provides insufficient context for those unfamiliar with the subject. Please help improve the article with a good introductory style. (July 2011(

This article may document a neologism in such a manner as to promote it. Please add more reliable sources to establish its current use and the impact the term has had on its field. Otherwise consider renaming or deleting the article. (May 2011(

As defined by the participants in the Mapping for Change International Conference (PGIS'05)[1] which took place in Nairobi, Kenya in September 2005, Participatory GIS (PGIS) is an emergent practice in its own right; developing out of participatory approaches to planning and spatial information and communication management.[2][3] The practice is the result of a spontaneous merger of Participatory Learning and Action (PLA) methods with Geographic Information Technologies (GIT).[4] PGIS combines a range of geo-spatial information management tools and methods such as sketch maps, Participatory 3D Models (P3DM), aerial photographs, satellite imagery, Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to represent peoples' spatial knowledge in the forms of virtual or physical, 2 or 3 dimensional maps used as interactive vehicles for spatial learning, discussion, information exchange, analysis, decision making and advocacy.[5] Participatory GIS implies making GIT available to disadvantaged groups in society in order to enhance their capacity in generating, managing, analysing and communicating spatial information.

PGIS practice is geared towards community empowerment through measured, demand-driven, user-friendly and integrated applications of geo-spatial technologies. GIS-based maps and spatial analysis become major conduits in the process. A good PGIS practice is embedded into long-lasting spatial decision-making processes, is flexible, adapts to different socio-cultural and bio-physical environments, depends on multidisciplinary facilitation and skills and builds essentially on visual language. The practice integrates several tools and methods whilst often relying on the combination of 'expert' skills with socially differentiated local knowledge. It promotes interactive participation of stakeholders in generating and managing spatial information and it uses information about specific landscapes to facilitate broadly-based decision making processes that support effective communication and community advocacy.

If appropriately utilized,[6] the practice could exert profound impacts on community empowerment, innovation and social change.[7] More importantly, by placing control of access and use of culturally sensitive spatial information in the hands of those who generated them, PGIS practice could protect traditional knowledge and wisdom from external exploitation.

Pictometry International

From Wikipedia, the free encyclopedia

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Unbalanced scales.svg

A major contributor to this article appears to have a close connection with its subject. It may require cleanup to comply with Wikipedia's content policies, particularly neutral point of view. Please discuss further on the talk page. (June 2011(

Pictometry International Corp. Type	Private
Founded	٢٠٠٠
Founder(s)	Stephen L. Schultz
Headquarters	Henrietta, New York, US
Area served	Worldwide
Key people	Richard M. Hurwitz, CEO
Products	Geo-imaging libraries and imaging software
Employees	[١] ٣٠٠
Website	pictometry.com

Pictometry International Corp. is a Henrietta, New York[2]-based company that provides detailed aerial photography. Its images are taken at a 40 degree angle from low-flying airplanes. Its Electronic Field Study software allows a variety of measurements to be taken directly from the image, including height, distance and area as well as elevation and bearing. Contour lines can be dynamically created by the user. Its images can be overlaid with shapefiles and GIS information can be exported from the images as well.

Headquarters in Henrietta, New York

The oblique photographs show buildings, infrastructure, and land from all sides. Pictometry also shoots looking straight down from the airplane. In general, this approach results in much more visual detail than using satellite photography, because there are multiple perspectives, with overlap resulting in as many as 12 to 20 images of the same location.

The company's most numerous customers are state and local governments, which use images of cities, counties, and entire states for such things as planning and development, emergency response (police, fire and 9-1-1), and property assessment. It also has applications in insurance, real estate, roofing, solar, engineering, and utilities.[3][4][5][6] Microsoft licenses Pictometry imagery for the "Bird's Eye" feature of their Virtual Earth service.

The company estimates that 80% of the U.S. population is covered by a Pictometry image. These images may be directly licensed by Pictometry.

Since 2005, Pictometry established an international division which licenses its technology to partners in Europe, Middle East, Africa, Asia, Australia, North and South America.[7[

In 2011, Pictometry was ranked No. 5 on the list of Rochester Top 100 companies[8.[

GIS in archaeology

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GIS or Geographic Information Systems has over the last 10 years become an important tool in archaeology. Indeed, archaeologists were some of the early adopters, users, and developers of GIS and GIScience, Geographic Information Science. The combination of GIS and archaeology has been considered a perfect match, since archaeology often involves the study of the spatial dimension of human behavior over time, and all archaeology carries a spatial component.

Since archaeology looks at the unfolding of historical events through geography, time and culture, the results of archaeological studies are rich in spatial information. GIS is adept at processing these large volumes of data, especially that which is geographically referenced. It is a cost effective, accurate and fast tool. The tools made available through GIS help in data collection, its storage and retrieval, its manipulation for customized circumstances and, finally, the display of the data so that it is visually comprehensible by the user. The most important aspect of GIS in archaeology lies, however, not in its use as a pure map-making tool, but in its capability to merge and analyse different types of data in order to create new information. The use of GIS in archaeology has changed not only the way archaeologists acquire and visualise data, but also the way in which archaeologists think about space itself. GIS has therefore become more of a science than an objective tool.

Contents

GIS in survey

Survey and documentation are important to preservation and archaeology, and GIS makes this research and fieldwork efficient and precise. Research done using GIS capabilities is used as a decision making tool to prevent loss of relevant information that could impact archaeological sites and studies. It is a significant tool that contributes to regional planning and for cultural resource management to protect resources that are valuable through the acquisition and maintenance of data about historical sites.

In archaeology, GIS increases the ability to map and record data when it is used directly at the excavation site. This allows for immediate access to the data collected for analysis and visualization as an isolated study or it can be incorporated with other relevant data sources to help understand the site and its findings better.

The ability of GIS to model and predict likely archaeological sites is used by companies that are involved with utilizing vast tracts of land resources like the Department of Transportation. Section 106 of the National Preservation Act specifically requires historical sites as well as others to be assessed for impact through federally funded projects. Using GIS to assess archaeological sites that may exist or be of importance can be identified through predictive modeling. These studies and results are then used by the management to make relevant decisions and plan for future development. GIS makes this process less time consuming and more precise.

There are different processes and GIS functionalities that are used in archaeological research. Intrasite spatial analysis or distributional analysis of the information on the site helps in understanding the formation, process of change and in documentation of the site. This leads to research, analysis and conclusions. The old methods utilized for this provide limited exposure to the site and provide only a small picture of patterns over broad spaces. Predictive modeling is used through data acquisition like that of hydrography and hypsography to develop models along with archaeological data for better analysis. Point data in GIS is used to focus on point locations and to analyze trends in data sets or to interpolate scattered points. Density mapping is done for the analysis of location trends and interpolation is done to aid surface findings through the creation of surfaces through point data and is used to find occupied levels in a site. Aerial data is more commonly used. It focuses on the landscape and the region and helps interpret archaeological sites in their context and settings. Aerial data is analyzed through predictive modeling which is used to predict location of sites and material in a region. It is based on the available knowledge, method of prediction and on the actual results. This is used primarily in cultural resource management.

GIS in analysis

GIS are able to store, manipulate and combine multiple data sets, making complex analyses of the landscape possible. Catchment analysis is the analysis of catchment areas, the region surrounding the site accessible with a given expenditure of time or effort. Viewshed analysis is the study of what regions surrounding the site are visible from that site. This has been used to interpret the relationship of sites to their social landscape. Simulation is a simplified representation of reality, attempting to model phenomena by identifying key variables and their interactions. This is used to think through problem formulation, as a means of testing hypothetical predictions, and also as a means to generate data.

In recent years, it has become clear that archaeologists will only be able to harvest the full potential of GIS or any other spatial technology if they become aware of the specific pitfalls and potentials inherent in the archaeological data and research process. Archaeoinformation science attempts to uncover and explore spatial and temporal patterns and properties in archaeology. Research towards a uniquely archaeological approach to information processing produces quantitative methods and computer software specifically geared towards archaeological problem solving and understanding.

Topologically Integrated Geographic Encoding and Referencing

From Wikipedia, the free encyclopedia

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TIGER redirects here. For other uses see Tiger (disambiguation.(

TIGER logo

Topologically Integrated Geographic Encoding and Referencing, or TIGER, or TIGER/Line is a format used by the United States Census Bureau to describe land attributes such as roads, buildings, rivers, and lakes, as well as areas such as census tracts. TIGER was developed to support and improve the Bureau's process of taking the Decennial Census.

The TIGER files do not contain the census demographic data, but merely the map data. GIS can be used to merge census demographics or other data sources with the TIGER files to create maps and conduct analysis. TIGER data is available without cost because U.S. Government publications are required to be released into the public domain.

Contents

Development and maintenance

An example of a map generated using TIGER/Line data using the Global Mapper application.

Prior to the 1960 census, the Census Bureau had enumerators visit each household in the United States to have them fill out a questionnaire. The Census Bureau provided enumerators with maps, showing the assigned area to canvass. In the late 1960s, the United States Census Bureau developed Dual Independent Map Encoding (DIME), a geographic information system to handle spatial data.[1] DIME was superseded in the 1980s, with development of TIGER, which addressed problems encountered during the 1980 census with maps and geographic classifications.[2] TIGER first used with the 1990 census.

All aspects of TIGER, including the data model, data structure, user interface, software applications, and map creation process, were developed in-house by Census Bureau staff, along with help from the USGS. Hydrography, railroads, and other features were scanned or digitized from USGS topographic maps (1:100,000 scale), vertically and horizontally integrated, then combined with updated addressing data from DIME and topology added.[3] The process was largely automated with use of batch processing, though a dedicated staff manually digitized from 1:24,000 scale annotated USGS maps to make updates to early TIGER during its construction in the late 1980s.[4[

TIGER defines geographic areas and features using topology, to represent the relationships between such features on a map. TIGER enables geocoding of street addresses. However, because of temporal changes and typographical errors such as missing directionals and feature attributes, this can result in poor or incorrect matches in some areas. While the TIGER database itself models linear features and political and statistical geography, it is also linked topologically to the Census Bureau's Master Address File (MAF). The MAF and TIGER together (MAF/TIGER) are used to locate all data for purposes of collecting and tabulating the census. The Census Bureau receives a Delivery Sequence File (DSF) from the US Postal Service semi-annually and it is by use of this and select monthly field surveys that it locates new and problem addresses in MAF/TIGER. The Census Bureau also mails annual Boundary and Annexation Survey (BAS) maps to tribal, municipal, and county governments to allow them a chance to update or correct boundaries and/or linework that may be in error in TIGER. A few years before each decennial census, the Census Bureau administers a program known as the Local Update of Census Addresses (LUCA) in which it allows political jurisdictions to improve its MAF/TIGER by submitting address lists and local GIS data for inclusion in the Census.

Coverage

The TIGER/Line shapefile data includes complete coverage of the United States, Puerto Rico, the U.S. Virgin Islands, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the Midway Islands.

TIGER includes both land attributes such as roads, buildings, rivers, and lakes, as well as areas such as counties, census tracts, and census blocks. Some of the geographic areas represented in TIGER are political areas, including state and federally recognized tribal lands, cities, counties, congressional districts, and school districts. Others are statistical areas, including Metropolitan Statistical Areas (MSA), census tracts, census block groups, and census blocks. ZIP Code Tabulation Areas (ZCTA) are quasi-statistical areas which attempt to approximate, but are by no means the same as, the USPS ZIP codes.[2] ZIP codes are not truly areas, but rather a range of deliverable addresses. Some or all of a ZIP's addresses may be reassigned to another ZIP. As many as 3% of ZIP codes undergo change each quarter. Thus, the 5-digit ZCTAs are of limited value over the long term.

Future

TIGER data published through February 2007 (2006 Second Edition) were in a custom text-based format formally known as TIGER/LineTM files. In 2008, data in shapefile format was published. Future editions will be available for download in GML. The Census Bureau will also make the data available through WFS and WMS servers.[5] The data forms a base for OpenStreetMap in the USA.

Spatial Decision Support System

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This article has multiple issues. Please help improve it or discuss these issues on the talk page.

This article relies on references to primary sources or sources affiliated with the subject. (June 2008(

This article may require cleanup to meet Wikipedia's quality standards. (June 2008(

This article may contain original research. (June 2008(

It has been suggested that this article or section be merged into Geographic information system. (Discuss) Proposed since November 2009.

Spatial decision support systems (sDSS) developed in parallel with the concept of decision support systems (DSS.(

An sDSS is an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial problem.[1] It is designed to assist the spatial planner with guidance in making land use decisions. For example, when deciding where to build a new airport many contrasting criteria, such as noise pollution vs. employment prospects or the knock on effect on transportation links, which make the decision difficult. A system which models decisions could be used to help identify the most effective decision path.

An sDSS is sometimes referred to as a policy support system.

A spatial decision support system typically consists of the following components (GIS+DSS=SDSS.(

Decision support system DSS

Geographic information system GIS

In more detail that means:

A database management system – This system holds and handles the geographical data. A standalone system for this is called a geographical information system, (GIS.(

A library of potential models that can be used to forecast the possible outcomes of decisions.

An interface to aid the users interaction with the computer system and to assist in analysis of outcomes.

This concept fits dialog, data and modelling concepts outlined by Sprague and Watson as the DDM paradigm.[2[

Contents

How does an SDSS work?

An sDSS usually exists in the form of a computer model or collection of interlinked computer models, including a land use model. Although various techniques are available to simulate land use dynamics, two types are particularly suitable for sDSS. These are cellular automata (CA) based models[3] and Agent Based Models (ABM).[4[

An sDSS typically uses a variety of spatial and nonspatial information, like data on land use, transportation, water management, demographics, agriculture, climate, epidemiology, resource management or employment. By using two (or, better, more) known points in history the models can be calibrated and then projections into the future can be made to analyze different spatial policy options. Using these techniques spatial planners can investigate the effects of different scenarios, and provide information to make informed decisions. To allow the user to easily adapt the system to deal with possible intervention possibilities an interface allows for simple modification to be made.

Examples where an sDSS has been used

CommunityViz

CommunityViz is a land-use planning sDSS that works as an extension to ArcGIS geographic information system software produced by ESRI. It uses a scenario planning approach and calculates economic, environmental, social and visual impacts and indicators dynamically as users explore alternatives. Interactive 3D models and various tools for public participation and collaboration are also included. It has been commercially available since 2001.

CommunityViz web site

Environment explorer

The Environment explorer (LOV) is a spatial, dynamic model, in which land use and the effects on social, economic and ecological indicators are modeled in an integrated way. Its primary goal is to explore future developments, combining autonomous developments with alternative policy options, in relation to the quality of the environment in which inhabitants of the Netherlands live, work and recreate. Various policy options from governmental departments are translated into a spatial, dynamic image of the Netherlands future with respect to issues such as: economic activity, employment, social well-being, transportation and accessibility, and the natural environment. The model covers the whole of The Netherlands.

http://www.lumos.info/environmentexplorer.htm

LUMOCAP

LUMOCAP aims at delivering an operational tool for assessing land use changes and their impact on the rural landscape according to a Common Agricultural Policy (CAP) orientation. It focuses on the relations between the CAP and landscape changes and emphasizes the spatio-temporal dimension of the former. The core of the tool is a dynamic cellular automata based land use model. Current usage areas – Poland (2 areas), Germany / The Netherlands (1 cross border area(

http://www.riks.nl/projects/LUMOCAP

MOLAND

The aim of MOLAND is to provide a spatial planning tool that can be used for assessing, monitoring and modeling the development of urban and regional environments. The project was initiated in 1998 (under the name of MURBANDY – Monitoring Urban Dynamics) with the objective to monitor the developments of urban areas and identify trends at the European scale. The work includes the computation of indicators and the assessment of the impact of anthropogenic stress factors (with a focus on expanding settlements, transport and tourism) in and around urban areas, and along development corridors. Models now covering 23 European cities (map(

http://moland.jrc.ec.europa.eu/

MURBANDY

The overall objective of MURBANDY is to provide datasets to study past and current land uses, to develop an Earth Observation based procedure to monitor the dynamics of European cities; to develop a number of "urban" and "environmental" indicators that allow to understand these dynamics and the impact these cities have on the environment, and finally to elaborate scenarios of urban growth. Initially this project covered 5 European cities, but the project has expanded into the MOLAND project.

Zer0-M

Zer0-M aims at concepts and technologies to achieve optimised close-loop usage of all water flows in small municipalities or settlements (e.g. tourism facilities) not connected to a central wastewater treatment – the Zero Outflow Municipality (Zer0-M.(

Bike parking public interface

The Chicago Bike Parking Program within the Chicago Department of Transportation uses two datasets to plan yearly bike rack distribution. The two datasets are available publicly. They are: number of bike rack installations and number of requests for new bike racks. These two sets are divided into geographic and political boundaries called Wards. On the Bike Parking website, users can run their own queries to determine the bike parking level of service in geographic and political boundaries (including ZIP Code, and Community Area). A map will display showing color coded points indicating bike rack requests and survey status.

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