CIS CHANGES MAPS

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Abstract

Mapping and its discipline, cartography, have a long history. Their strong conventions often challenge new technologies. However, mapping itself is expected to experience a rapid and significant change now and in the near future, affected continuously by a series of new technologies. Computer graphics show a capability to display geographic data. Remote sensing and global positioning system (GPS) technology improve data collection. Databases provide efficient tools for managing huge volumes of geographic information. More significantly, the practical applications of geographic information systems (GISs) are rapidly modifying many traditional concepts and practices of mapping and cartography. First, this paper discusses some limitations and difficult issues caused by traditional paper maps, and then explores new map features in this digital geographic information era.

Limitations of Paper Maps

Many problems in current cartography are essentially caused by the limitations of paper map sheets.

Conflicts between Geodata Storage and Visualization: Maps have performed several major functions: displaying, storing geographic information, and doing some analysis functions. Geographic information includes both spatial and attribute information. In order to provide these functions, map designers, producers, and scientists developed and accumulated a vast amount of knowledge and technology. They are at the core of traditional cartography.

Traditional mapping is based on a combination of paper and printing technology. All kinds of information, including spatial graphs, symbols, and text, have to be printed on paper. Paper became the basic information carrier for geographic information.

A traditional map designer must handle two conflict directions. One is to store as much necessary geographic information as possible on a sheet of paper and to make the information from the map sheet as readable as possible. Considering the high cost and time-consuming process of traditional map production methods, which might take several months to several years, most maps and atlases have to be more general-purpose oriented. Even thematic maps cannot directly answer very specific questions about daily life. Map producers cannot afford to produce a map that can only answer one particular problem (for example, route to drive from a fire station to a house on fire or where an oil spill will stray in next hour). Instead, cartographers need to put much potentially useful information on a map to satisfy many needs of the readers of the map. Meanwhile, none of the map users would even expect to have a single map that answers only their particular question. Everyone must learn to find their own piece of special information from one general-purpose map. Both map designer and reader are forced to use general-purpose maps because paper maps are not good enough to support both display and storage of geographic data indefinitely at an affordable price.

Limitations of human sight: Paper maps limit information accuracy and its volume. For visual purposes, any feature less than 0.1 mm appearing on paper can be omitted. For storing more accurate data, the map scale must be large, and then the number of map sheets will increase exponentially.

Conflict between large volume of data and high-speed query: Huge volumes of information stored on maps and tables are difficult to access, especially for extracting information from such "highly impacting maps."

Update speed: A major problem for maps on paper is the speed of update, in part caused by traditional printing techniques. Updating a map means reprinting, which is expensive and time consuming.

Seamless continuous databases versus limited paper map sheets: One major limitation from paper maps is limited map sheet versus continuous natural geography. People are forced to stick many maps together to solve many problems.

Multiple data sources and function integration: One difficulty in using various map sources to solve one complex problem is that it is hard to integrate geographic information from maps with various projections and scales. Some optical equipment, scissors, and glue have been used to do difficult rubber sheeting adjustments tying overlay and/or mosaic maps together. It is very inefficient to implement a large amount of information from one map to another map.

Model analysis: One important map function is to analyze geographic information. However, analysis on paper maps is not easy or flexible. It is limited by the many inconveniences of a paper map. The following inherent weakness reduce analysis flexibility:

(a) A limited volume of information can be stored on one sheet.
(b) Maps on paper for a large area have to be divided into separate sheets.
(c) Storage of geographic information on paper can only be one fixed scale and one fixed map projection on one sheet of paper. It is difficult to mosac and overlay of paper maps with different scale or projection.
(d) Paper maps have a slow update procedure. Many analyses cannot wait that long.

Generally speaking, paper maps can only manage relatively static and limited information and are heavily dependent on human physical capabilities such as vision.

Limitation of paper physical property: Information storage on paper media can be affected by paper properties. Any natural causes that change paper properties will damage information stored on paper such as warehouse humidity, map paper fiber texture direction, painting oil, and so forth.

GIS Breaks the Limitations of Paper Maps

GIS changes the design, production, and application of maps by providing greater flexibility and advance technology. First, GIS separates the two fundamental functions of a map. A map sheet need not play the role of information storage medium any more. Computer GIS databases can store a tremendous volume of geographic information while still allowing quick access. Large bookshelves and warehouses for storage of maps and their documents are no longer necessary. Research topics relating to papers as information carriers will be useless.

The low cost of storing large volumes of information on electrical media compared to paper supports this change. Electronic media has a much higher information storage capacity than any paper. CD-ROM will be popular in dealing with all kinds of digital information in many cases. Its cost is already lower than paper. A well-knowing example is the Digital Chart of the World (DCW) consisting of four CD-ROM disks costing only several hundred dollars. It contains 1:1 Million scale global maps including eighteen layers of information. It weighs about one pound. Its size is only 4 inch x 4 inch x 1 inch. A dozen pounds of a heavily bound Atlas can be changed to a couple of light weight Considering most electrical media can be erased and rewritten, and the update period shortened, large amounts of paper can be saved.

Meanwhile, computerized GISs can handle information with tremendous speed. The database management system (DBMS) and topological spatial structure work on rapidly growing distributed network environments, making geographic information transactions at very high speed. Fast access increases the possibility to solve many particular queries on time. In a GIS environment, all information is logically stored and accessible. GIS can manage dynamic, huge volumes of data and benefit from the power of computer systems. A revolutionary advantage of a GIS is its huge potential power for geographic analysis.

GIS is powerful and can integrate different data sources. Map projections and scales are not serious barriers. Spatial information and huge volumes of text and numerical databases can be integrated and registered precisely. Conventional vector maps and remote sensing images can work together easily. Engineering survey data and GPS output can be directly input to GIS. Multimedia technology used in

GIS allows users to combine totally different types of information (e.g., voice and video, whenever and wherever it is necessary). Information from various sources and from different regions can be integrated and processed. These integration powers provide unbelievable capability for analysis and modeling researches.

Major Progress of Cartography in GIS

Computer simulation of geographic model analysis: Many geographic information analyses have progressed from quality description to quantity analyses. Geographic information featured by its huge volume and spatial property. It is difficult to do manual analyses on paper map sheets efficiently. Thus, many quantity analysis models either cannot be implemented or they have to be dramatically simplified to allow rough analysis. The results are neither precise enough nor efficient enough. In a GIS environment, many complex and comprehensive analyses models can be implemented. It makes a computer simulation available for testing, debugging, or enhancing a geographic model. This provides all geographic-related disciplines a better environment for researching geographic phenomena. Some examples include forest fire simulation model, floodwater simulation model, suitability analysis, and buffering analysis.

On-line computational analysis modules: GISs behave as an integrator allowing users to access many existing advanced and sophisticated analysis tools in computer systems developed by other disciplines. Digital computers provide many existing numerical analysis tool packages. Also, many professional packages have been developed for specific tasks. GIS links or contains digital image processing systems (ERDAS), DBMS systems (ORACLE/SYBASE/INGRES/dBASE), CAD systems (AutoCAD), chart systems (Excel), word processing systems, statistics systems (S-plus/SAS), graphics systems (Windows), and all communication functionality. Obviously, a GIS should be a completely open system from the aspects of both hardware and software.

Real-time analysis of spatial data: Real-time analysis needs a system that has a fast response time cycle, compatible to a phenomenon of investigation. Paper maps, obviously, leave a big gap to satisfy most real-time analyses. This capability allows users to face emergency situations like floodwaters, forest fires, and oil spills.

Enterprise geodata processing system: Many agencies need maps to handle their daily work. They usually have special procedures and requests to collect, manage, update, analyze, report, and display geo-related data. Paper maps limit improvement of processing efficiency in these agencies. Typical bottlenecks are large paper map warehouses, high cost of maintenance of paper maps, and slow access speed and long period of update procedure. One enterprise or agency can organize its geodata and processing into a more efficient, integrated computer system by using GIS and other software, such as office automation and large DBMSs, plus many professional special functions. A full, open GIS with distributed computational capability is suitable for enterprise systems. Specifically, these built-in GIS systems follow and support related job handling procedures. Many government agencies and large enterprises have successfully benefited from a GIS enterprise system. More and more input requests and output results from these agencies will not be for conventional paper maps.

Large Volume of Geodata Production

Now we already can find that many map products are not presented on traditional paper maps or atlases, rather it appears on different digital media such as CD-ROM, tapes, and on-line messages. Consequently, many geographic information producers moved their products from papers to digital media. Examples include DCW 1:1M published by the Defense Mapping Agency (DMA); ArcWorld

1:3M, ArcUSA 1:25,000, and ArcCity produced by ESRI; DTM and DLG produced by the United States Geological Survey (USGS); and TIGER provided by the U.S. Census Bureau satellite images from EROS. The digital format information belongs to a new extended map era: digital geographic databases. Their rapid growth shows the advantages of storing and managing large volumes of geographic information by GIS technology.

Many countries are beginning to invest heavily on nationwide projects to convert conventional geographic information, specifically maps, to a GIS digital format. Two big examples occurred in 1993. USGS announced its MAP II project of $150 million (U.S.) by using 5,000 ARC/INFO workstations to implement its digital data production. The U.S. Land Bureau launched a historical project costing $400 million (U.S.) to convert all existing land information into digital format and provide it for application. Similar large-scale projects are also implemented in the China region and many digital databases are available or will soon be available for public usage. Hong Kong SMO announced 1:1,000-scale digital data with fifty available data layers. Cities such as Haikou, Beijing, and Shanghai have also built large-scale digital geographic databases. The National Bureau of Surveying and Mapping (NBSM) will publish a nationwide 1:1 Millon digital database in the very near future. Considering the upcoming Information Super Highway era, these geodatabases will play very significant roles. These digital geographic databases will provide much more efficient foundations for all geo-related administrations, agencies, science, education, and technology.

Many major map producers in the United States already use GIS technology to produce press maps such as Thomas Bros., Automobile Association of America (AAA), and National Geography.

Conclusion

Traditional paper maps have many limitations that restrict their new applications. These limitations are dramatically broken through by GIS technology. Maps are changing in many aspects including its design concepts, formats, production, and applications.

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