Chapter 11

The Future of GIS

FUTURE DATA

Easy access to digital data

- The future holds immense promise for new types of data, more complete data, higher-resolution data, and more timely data.
- The entire mechanism for GIS data delivery has been revolutionized by the Internet and by the search tools built upon the structure of the World Wide Web.
  - This single trend has had, and will continue to have, the most impact on the field of GIS.
- The majority of GIS work now involves bringing into the system a base layer of public-domain data and enriching it by capturing new layers pertinent to a particular GIS problem.

Remote Sensing and GIS

- New spacecraft with the next generation of space instruments will provide an extremely rich set of both new and existing forms of data.
  - NASA's Earth Observation System (EOS), IKONOS, Landsat 7, IRS, SPOT, SIR, RADARSAT, ERS, JERS, Spring 2000, CORONA, LANYARD, and ARGON, *etc*,.
- Coupled with this plethora of new systems is a completely new infrastructure for data access, searching, and distribution.
  - For example, EOSDIS, EROS Data Center
- The successful launch of Landsat 7 moved satellite data from the U.S. government back into the public domain.
  - As a result, remotely sensed information finds its way back into the GIS mainstream, especially in the form of integrated GIS databases and GPS ground observations.

- Another major switch in policy will be the return to a continuous data stream.
  - Continuous coverage will allow far more images showing and contrasting changes, especially in the environment.
  - The AVHRR-based land-cover and vegetation index mapping conducted by scientists at the EROS data center.
- The demand upon software that converts between raster and vector data will increase, as will intelligent software for correcting lines and boundaries that come from pixel-based images.
  - The prospects for automatic up-to-date maps seem bright.

GPS as data source for GIS

- Another critical step in data provision has been the ability, using GPS to go directly to the field to collect data rather than relying on maps.
  - GIS layers can quickly and efficiently be brought into registration for overlay and comparative analysis.
  - The GIS-to-GPS link is now such that many GPS receivers and their data loggers can write data directly into GIS formats or include satellite images, air photos, or regular photographs directly in the field.

- The flexibility of GPS system has evolved a technology that is becoming standard equipment in public and private vehicles.
  - They are integrated with in-vehicle navigation systems that also use inertial navigation and stored digital street maps.
  - Data that are of great locational accuracy is greatly benefiting GIS.
  - These easily available data are now being used for variety of purposes like hunting, travel, and driving etc.
  - GPS has also found use in fleet vehicles such as the trucking and moving industries, and in the delivery business.

Image Maps and GIS

- Another significant new data source now exists owing to the arrival of **digital orthophotoquads**.
  - Digital orthophotoquads are geometrically corrected air photos with some cartographic annotation.
  - It is used as a background image for GIS, over which field and existing geocoded data are assembled.
  - The primary function of the orthophoto will be to assure the same type of layer-to-layer registration.
- The digital raster graphic (DRG) is a scanned image of a U.S. Geological Survey (USGS) topographic map.
  - These maps make excellent starting points for GIS projects, and they often contain many features that can be extracted for use, such as contour lines and building footprints.

Data Exchange and GIS

- The final prospect for GIS data is the one of exchange.
- There is a need to build a formal structure for data exchanges, and the several new standards for data transfer have already had a major impact on this issue.
- Standards will have a great impact on the future of GIS. With formal, explicitly defined formats for features, open exchange will be easy and data will no longer be a constraint to GIS use.
- In United States, map data have evolved the Spatial Data Transfer Standard (SDTS), now formalized as the FIPS 173 (a FIPS is a Federal Information Processing Standard).
- A critical element of data exchange is simply finding out who has data that already exist about a geographic area.
  - As data become more and available, the metadata systems will become increasingly useful for sorting through the huge quantity of available digital map data.

Location-Based Services and GIS

- Location-based services (LBSs) are computer-based services that exploit information about where a user is located in geographic space.
  - Location-based services take advantage of GPS, but also may rely on E911.
  - Many Web-based services already exist, often using map providers like MapQuest to provide maps and directions along with the geographic search capacity.
- Users of LBS so far seem to be either vehicle-based, where the GPS and computer are in the car and used to query geographically ordered information, or mobile.
  - LBS uses selected subsets of GIS functionality, but delivers them to the user on demand.
  - Most applications are in navigation route finding, and space constrained search.

- One unresolved issue with LBS is how ‘open’ the geographic information will be because the privacy issues and possible abuse of information is of great concern and obvious.

Future Hardware

- Hardware for GIS has gone through at least four revolutions in the last decade: the workstation, network, microcomputer, and mobility revolutions.

The Workstation Revolution

- The workstation revolution has given GIS an operating platform that has all of the necessary power and storage to work with massive databases.
- The capability of a workstation has gone from megabytes to gigabytes of storage, while increasing the size of RAM beyond 64 megabytes and the processor speed well above and beyond the capabilities of most mainframe computers.
- Along with the expansion of the workstation has been the spread of Unix, the TCP/IP communications protocol, and graphical user interfaces.
- The more powerful systems of the future and the falling price of workstations seem to make this the preferred GIS work environment for large-scale projects.

The Network Revolution

- The Internet has become a primary means for data exchange and information search and retrieval.
  - Many GIS packages, including Arc/Info, GRASS, and IDRISI, have support services on the Internet's network conference groups.
  - The national spatial data infrastructure, a linked distributed database of public GIS information with common metadata, is being built upon the capabilities of the Internet and the WWW.
- Many commercial GISs have now developed modules that allow entire GISs to be Web-enabled.
  - The GIS can be searched, queried, or analyzed over the Web and the results displayed locally on a client using software tools such as Java and a standard browser.
  - These include ESRI's Internet Map Server, MapInfo's MapXtreme, and Intergraph's GeoMedia WebMap.

- Full GIS functionality is rarely delivered over the Internet; these systems usually feature simplified user interfaces and simplified data searching and map construction.
  - If complete functionality were deliverable, then the GIS user could simply pay for their use over the network when desired.

The Microcomputer Revolution

- The microcomputer has matured and increased in power significantly, making this platform widely distributed, relatively inexpensive and easily capable of running many GIS packages.
- The present-day systems have crossed the size and power threshold and become useful professional and educational GIS platforms.
- The implication of this revolution has been largely one of broad distribution
  - GIS can now go almost anywhere a microcomputer can go.

The Mobility Revolution

- The fourth major technological revolution represented by microcomputers has been the trend toward mobility.
  - Here, driving forces have been the laptop, portable, subportable, and even palm-top computer.
  - The PCMCIA and USB interface allowing easily transferable data storage and interoperability of devices; and the mobile communications and GPS technology that now accompany them.
- Some GIS vendors now offer limited versions of their GIS for use on highly portable devices, such as the Palm Pilot and Compaq iPAQ.
  - Among these are MapInfo and ESRI, with the ArcPad software.
  - When these devices are coupled with a GPS card, often available as a plug-in on a PCMCIA card, they become completely mobile GIS systems in their own right.

- Added to the continued miniaturization of computer and communications equipment, personal mobility of GIS hardware has reached and gone far smaller than the field portable minimum level.
  - Along with these new capabilities come the terms ubiquitous computing and augmented reality.
    - Ubiquitous computing : go anywhere, remain connected to the Internet via cellular telephone
    - Augmented reality : in which the GIS data view can be superimposed on the ‘real’ view by direct entry into the human vision field.
  - These are prototypes now, but are apparently already in use in some professions.

The Impact of The Revolutions

- The workstation and all its characteristics will continue to dominate the GIS workplace as the primary tool for advanced applications, but will become immensely more powerful.
  - Many processes now performed as input/output or file manipulation operations will be possible to do inside the workstation RAM in real time.
  - Parallel processing will allow real-time processing of imagery in new ways, promising immense speedup in processing.
- The Internet can deliver far more than data and metadata (data about data).
  - It can deliver information, advice, and assistance, often tailored to a specific environment or GIS package.
  - The Internet can offer formal means for the dissemination of ideas and research.
  - It can also remove the GIS analyst almost entirely from the traditional workplace.

- Both the power and the increased flexibility of the microcomputer have been pivotal in penetrating new fields of GIS application and in the domain of GIS education.
  - New fields to GIS are archaeology, forestry, epidemiology, emergency management, real estate, marketing, and a host of others; In every instance, the first steps in these areas were taken by new users in a microcomputer environment.
  - The trend toward the microcomputer classroom with a networked server running shared software licenses is broad and GIS has entered the curriculum in some places.
- Increased mobility has also generated many new GIS uses.
  - The migration of software and hardware for image processing and remote sensing into the mobile environment offers many exciting prospects.

FUTURE PROSPECTS OF HARDWARE

- Some of the trends on the edges of computer science and engineering have real prospects for GIS application.
  - stereo and head-mounted displays;
  - input and output devices that are worn;
  - parallel and self-maintaining fault-tolerant computers;
  - mass storage and computing power much greater and faster than that available today.
- A vision of a future GIS system might be;
  - A pocket-held integrated GIS, GPS, and image-processing computer capable of real-time mapping on a display worn as a pair of stereo sunglasses.
  - Data capture would consist of walking around and looking at objects, and speaking their names and attributes into an expert-system-based interpreter
  - And it encodes and structures the data and transmits them immediately to a central network accessible storage location.

- Another future prospect is that of the data analyst becoming a data explorer, delving into three-dimensional realistic visualizations of the data, seeking out patterns and structure instead of the user of the simple statistical analysis of today..
- Regardless of the actual hardware used, there is little doubt that the tools and devices required for GIS work will become commonplace in the very near future.
- The likelihood of GIS hardware being a limiting factor in the GIS future is minimal.

FUTURE SOFTWARE

Software Trends

- The first major trend over the last few years has been in operating systems.
- Today, operating systems can ‘multitask’, working on two problems at once, with ease.
- Early systems were somewhat poor at user interaction, yet the revolutionary Apple Macintosh system led to a significant improvement in user simplicity and comprehensiveness.
  - That is, every application could use a standard and commonly understood set of menus instead of making its own flavor.
- Most recently, operating systems that run on multiple platforms have flourished, including UNIX.
- The ability to divorce standard operations such as printing and digitizer communication from the GIS led to some major improvements.

The User Interface and WIMPs

- The computer era has seen radical changes in the very nature of both the computer and GIS user interfaces.
  - Early systems used only the screen and the keyboard to communicate to the user.
  - Systems now have a mouse, pointing devices such as a track ball or light pen, multiple windows on the screen, sound, animation, and many other options.
- Most significant has been the rise of the ***WIMP***(windows, icons, menus, and pointers) interface.
  - Windows are multiple simultaneous screens on a single display, usually serving different tasks and fully under user control.
  - Icons can be attached to tasks and used to activate them.
  - Many user interfaces place a set of menus along a bar at the top of the screen, controlling more and more specific tasks as one goes from left to right.

- Pointers are devices for communicating location on the screen and in windows, and they most commonly take the form of a mouse or a track ball.

- The map itself is a useful metaphor, and a future GIS can easily be imagined in which the map and its elements are used to manage and manipulate the data.
    - This is already what a GIS does, but the user-interactive element would be a new addition to the GIS system.
    - Several systems already use icons as elements of a process or transformation model to track sequences of operations.
    - The GUIs will probably allow the user to specify tasks independent of the data, in the abstract.

The Raster versus Vector Debate

- The last few years have seen almost every GIS package become capable of supporting both raster and vector data structures, and in some cases many others besides.
  - This has become the sort of single super-flexible data structure that many sought to develop in the early days of GIS research.
- Systems can take advantage of the strengths of a particular structure for a particular operation.
- The disadvantage is that the transformation between data structures often entails significant error in and of itself and can lead to some serious problems in GIS analysis.
- In the future, GIS software is likely to have incorporated the strengths of the various structures and should be capable of intelligently converting data between structures without the intervention of the GIS user.

Object – Oriented GIS

- Another major development in the software world has been languages, and now databases, that support ‘objects,’ called object-oriented systems.
- Object-oriented programming systems (OOPSs) allow the definition of standard ‘classes’ that contain all the properties of an object.
- In addition, we can encode the fact that points often have data conversion or analysis constraints.
- This approach has allowed the development of entire GIS packages, and is seen as a way of building far more intelligent GIS systems in the future.
- While the OOPS is not the tool for all GIS operations or systems, it is indeed a powerful way of modelling data and will influence the future of GIS software significantly.

Distributed Databases

- A major transition within the GIS industry has been the movement toward distributed databases. This has happened at two levels,
- First within a local area network.
  - Data and software have migrated from individual hard disks to file servers, computers dedicated solely to disk storage and moving information over the local network to the client workstations or sometimes microcomputers.
  - A distributed data system can lead to a large-scale reduction in storage duplication.
- Second, connection to the Internet
  - This has made it possible to have distributed databases on a massive scale.
  - It is possible to let the organizations maintain a library of data and to download the data sets of interest only when they are needed.

  - Various network search tools such as WAIS, Netscape, Archie, Gopher, and Mosaic have made the metadata accessibility possible, leading to some major breakthroughs in Internet-wide distributed databases.
- Increasingly, GIS companies and shareware services are using the Internet as the primary means by which support is delivered.
- The data services will turn increasingly to custom services and data enhancement as a means to survive and prosper.

GIS User Needs

- Another issue of interest to the future of GIS is how the industry will continue to develop.
- The GIS industry must continue to exploit both types of environment.
  - This means, taking large systems and packaging them small, or taking lessons learned by advanced users and translating them for the general user.
- The GIS users themselves have become a sort of self-help facility.
  - As GIS packages become more complex but also more user friendly, these user groups will converge on some common principles for GIS use.
  - These principles should be, and are, shared with all users.

GIS Software Research

- Some of the future expectations for GIS software are the results of research now under way.
- Researches on the impact on GIS of supporting geographic and attribute data from many time periods.
  - The implications on the design of the GIS to facilitate use, automatic update, for instance, or automatic selection of the most up-to-date version of every feature are now being integrated into the GIS's functions.
- Researches on use of the more recent object-oriented programming systems and database managers as the tools with which to construct GISs.
  - The advantage : the features within the GIS can be described in advance, categorized by types, and that actual data represent an 'instance' of one of these types or 'classes' of object.

  - The disadvantage : they are often memory and computationally intensive and that their sophistication is unnecessary for most of the basic GIS operations.
- Researches on the user interface with GIS.
  - More advanced user interfaces could be icon driven and could use a symbolic manipulation language.
  - Even more sophisticated interfaces are obviously possible, and we have yet to even start work on effective use of interfaces for multimedia, interactive, and animated GIS systems.

GIS Interoperability

- An effort is currently under way to standardize and publish a set of specifications for GIS functions and capabilities, allowing a standard language and a higher degree of mobility among systems.
  - OPEN/GIS, is an attempt to repeat the success that an open description of the user interface had for GUIs, an effort known as Open/Systems, which gave us OpenLook and Motif.
- The last, and a major trend as far as interoperability is concerned, is the arrival of the standards for spatial data, the spatial data transfer standard (FIPS 173).
  - This standard means that data that comply with the standard will be able to move directly into a GIS with all the stored characteristics, topology, attributes, and graphics fully intact.
  - This effort is already close to realization, and most GIS vendors have declared their intent to support the standard in the very near future.

FUTURE ISSUES AND PROBLEMS

Privacy

- An issue that raises itself again and again as GIS databases become more and more widespread is that of personal privacy.
- GIS offers the integration of the data from individauls through their common geography.
  - Although it is to the public benefit, the more local and individual the link, the more the issue of personal privacy arises.
- As GIS becomes used in lawsuits, voting district delineation, and in mapping of property, the legal profession will come increasingly to use GIS as the means by which data are collected and transformed, analyses are conducted, and conclusions are drawn.
  - GIS offers the mapping and analysis processes full accountability, and this must be stressed in the future if GIS is not to become yet another courtroom gimmick, like computer graphics, as far as the law is concerned.

Data Ownership

- There are two philosophies about GIS data ownership.
  - At the one extreme, the federal government produces and distributes digital data in common formats at the marginal cost of distribution, the ‘cost of fulfilling user requests’.
  - At the opposite extreme lie the groups who believe that GIS data are a commodity, a product to be protected by copyright and patent and sold only at a profit.
- There is a great deal of motive to produce a data set that may sell many times, but little motive to map a corner of the country with little demand and poor existing digital maps.
  - Extended to the international context, neither will there be a motive to map for GIS the poorest and most needy nations.

Scientific Visualization

- A critical issue for the future of GIS is the degree to which the systems become integrated with those new parts of computer graphics and cartography most suitable for GIS applications.
- Scientific visualization seeks to use the processing power of the human mind, coupled with the imaging and display capabilities of sophisticated computer graphics systems, to seek out empirical patterns and relationships visible in data but beyond the powers of detection using standard statistical and descriptive methods.
- GIS should move toward full integration with the tools and techniques of scientific visualization and has much to gain by doing so.
  - It would greatly enhance the analysis and modelling component of GIS use, and in a way that is inherently compatible with a GIS and the tools in the GIS toolbox..

- New software allows the user of a GIS not only to map and analyze three-dimensional distributions, but also to model and display them in new ways.
  - simulated hill-shading, illuminated contour, gridded perspective and realistic perspective views, and stepped statistical surfaces.
- In addition, new types of display have expanded the suite of interaction means for the GIS user remarkably.
  - such as stereo screens with shutters and head-mounted displays, along with the new types of three-dimensional input devices, gloves, track balls, and three-dimensional digitizers.
- The possibilities of animated and interactive cartography are remarkable, and may strongly influence the future of GIS.
  - Animation has a particular role to play in showing time sequences in GIS applications.

New Focus

- Science has become increasingly focused on issues of global importance.
  - GIS has an immense amount to offer this global science.
  - Global distributions need mapping, global mapping needs map projections, and the understanding of flows and circulations are based on an understanding of spatial processes.
  - Global data collection efforts for GIS are now under way, and organizations use GIS to attack global problems such as crop-yield estimation and famine prediction.
- More and more the traditional boundaries between disciplines in the sciences and the social sciences have disappeared.
  - GIS is able to integrate data from a variety of contexts and sources and seek out interrelationships based on geography, the mapping of distributions, and visualization.