GIS – PRESENT SCENARIO AND POTENTIAL RESEARCH AREAS

P.Venkatachalam

Centre of Studies in Resources Engineering
Indian Institute of Technology, Bombay, Powai, Mumbai, - 400 076
Corresponding Author's E-mail: pvenk@csre.iitb.ac.in

In the last two decades, there has been a spectacular growth in GIS technology. GIS has become a core technology for information resource management and decision-making in business and government. To maintain this healthy growth, the factors constraining the current state of using GIS and the trends of development that will bring a new generation in GIS must be understood. Though GIS is one of the fastest growing areas in GIS, many issues still remain as barriers in terms of data, technology, people and applications.

In the early days of GIS, the users had to acquire their own data by digitizing paper maps which was expensive and time consuming. However, the data problem has changed as vast amounts georefrenced digital data are available through government sources and commercial data suppliers. Still, the users may not have easier access to these data due to unawareness. Also the integration of available data from different sources is a complex task due to the incompatibility in storage format and cartographic specifications such as scale, map projection, accuracy and symbology. To solve this problem, government agencies and GIS industry are jointly working to develop data standards, and meta data under national geospatial data infrastructure. At the international and national levels, efforts are being taken to develop a universal standard for geographic data. Commercial GIS packages are trying to incorporate these standards that can be used by both data producers and users. Another issue about data is ownership that is closely related to the issues of copyright and cost recovery of using the data. Different policies are followed in different countries. The use of government held data is always subject to copyright laws that stop illegal copying and reselling of data. Often the complexity of data ownership and copyright issues tend to discourage the users from using the existing digital geographic data in their applications. Also it increases the possibility of users making flawed decisions as a result of inherent uncertainties present in the data. Many data are collected to satisfy legislative requirements such as demographic census, land ownership, topographic survey, resources mapping etc. It is necessary for government departments to see that these data are not misused.

Geometric incompatibility is another problem when data collected from different sources do not match. Often the data sets may be in different scales, different projections and different datums. When datum conversion and projection conversion are done using

mathematical transformations, there is no guarantee that the data sets will match with each other. Mismatching of features across the map boundaries is a costly and time-consuming task. Another issue is the database updation and maintenance. Updation of spatial database at regular intervals is a very tedious and time-consuming job. As a result, it is impossible to keep a spatial database up to date. This gives uncertainties when the data are used for solving time sensitive spatial problems. Many geographic data sets are being used with incomplete or no quality information. The provision of data quality in proper standard documentation is very essential.

Development of GIS technology is heavily dependent on the trends of the hardware and software evolution in computer industry. Many big software industries have started showing their presence in GIS market. Some database management system packages have incorporated the capabilities to handle spatial data. There are always unique features in a product that may make it more suitable for a user application than others. A user must evaluate the factors such as hardware, software, network architecture, conformance to standards, database size, cost, client base size etc. in relation to his application before the system design and implementation. One must also include mechanisms to monitor technological changes, recommend systems upgrade at appropriate time and manage transition from old to new systems environments. The availability of digital data, the quality, the time period when it was collected etc. should also be considered.

The users of GIS come from diverse technical backgrounds. They may have different degrees of understanding in GIS technology and different levels of proficiency in using computers. Their application requirements also may vary from simple desktop application to high end modeling. Senior management users must have a good understanding of technology and must be clear on what GIS can do and cannot do. Training the seniors is different from training the users who acquire technical skills to handle a GIS package. Many GIS projects failed not because of the lack of technology, but because of the lack of proper understanding by managers and end users. There is huge shortage of skilled GIS specialists who can design the systems and develop applications. Also currently teaching GIS in universities is focused more towards the use of GIS software packages rather than on the basics of GIS theory. A sound GIS education structure is needed to provide solid foundation on the theoretical aspects of GIS including the role of computer science.

In the earlier days, GIS software packages were constructed using a tool box approach. Users were constructing their applications using available commands. Each user organization has to spend for buying the software, maintenance, enhancement and building the application. Presently GIS software vendors are moving towards component based architecture such that standardized task specific applications can be developed to address the needs of particular user groups. In the early stages, GIS applications did not have easy integration with other external applications. The software functions to handle spatial data were distinctly different from other applications. Currently the trend is changed. Spatial data are incorporated within the relational database management system and processed. Also the development of GIS components is helping the user to build

customized applications in a wide variety of development environments.

GIS was evolved as a tool for information resources management. Presently the advancements in communication and information technologies in particular, the internet and multimedia technology are changing the ways by which the geographic data can be delivered, used and visualized. There is a rapid integration of GIS technology with corporate information technology and it is getting incorporated into enterprise computing environment. GIS is no more treated as a stand-alone graphics based application. In the new generation of database management tools, spatial data are encoded in tabular form along with other attributes. Data modeling techniques are well developed to absorb GIS concepts into the conventional system development process. GIS software components are getting integrated with other software components into one single application. Using these components, off-the-shelf applications can be developed with minimal customization from enterprise to enterprise. The enhanced capabilities to model and manipulate network based spatial data have increased enterprise GIS users in transportation, utility and telecommunication sectors. Recent advancements in mobile computing have helped the transmission of GIS data over a mobile device for wide variety of applications such as vehicle tracking, remote data viewing, field data collection etc. In addition, many GIS vendors provide software products for building, maintaining and using spatial data warehouses. These spatial data warehouses will help to integrate different data collections into a single repository. A major barrier in sharing spatial data among GIS users has been incompatibility between proprietary data formats. This problem is being tackled using the concept of interoperability. The objective of interoperability in GIS is to establish a data storage specification that will enable different GIS applications to access different data sets residing in different hardware platforms by means of standard data-sharing protocols such as SQL. The open GIS Consortium Inc (OGC) comprising members from government agencies, academic institutes, software and hardware vendors provides a series of specifications for sharing the data, applications and other system resources between individual GIS implementations as well as between GIS and other applications such as statistical analysis, numerical modeling, image processing, data visualization etc. Those Open GIS specifications will ensure that future generation of GIS will be more cost effective to implement and more user-friendly to operate. Another initiative taken by many countries is building National Spatial Data Infrastructure. The main aim of this initiative is to implement Geospatial Data Clearing house for easy exchange of data, application and results among users.

Among the numerous technologies that have impact on the development of GIS, the Internet is the most important tool. The World Wide Web is playing a dominant role for distributing and visualizing spatial information. A large number of GIS applications can be found on the internet and they are known as WebGIS or Internet GIS. There are a number of GIS servers developed by GIS vendors and numerous GIS applications can be found on the internet. They vary considerably in terms of objectives, functionality and levels of user-computer interaction. One can view a simple static map or view a sequence

of maps giving a cartographic animation. Internet provides users to search, preview and retrieve spatial data from spatial data catalogs. One can view the map of an area by giving location name or address. Real time images and maps can be viewed on the internet. The internet has revolutionized the user base of GIS from a small number of specialists to an infinitely large audience.

AREAS OF RESEARCH IN GIS

GIS technology has reached a reasonable level of maturity and has become a part of information technology. Parallely the study of geographic information, whether it is from the systems or the science perspectives has opened new research opportunities in the areas of computer science, geography, geomatics etc. Academic institutes are trying to list a set of research priorities in geographic information science. The data gathering technologies such as GPS, high resolution remote sensing satellite sensors, scanners and vectorizing tools produce an immense volume of geospatial data with increasing accuracy and speed. Integration of these data obtained by different technologies with different accuracies and formats is a challenging problem. Then comes the area in spatial data mining and knowledge discovery. The aim of research in this area is to develop specific techniques and approaches to extract useful and meaningful information from this large volume of spatial data. The research will address issues such as spatio-temporal knowledge representation, development of innovative, deductive and inductive spatial and spatio-temporal data mining techniques etc.

Spatial data sharing and interoperability is another research priority. Presently spatial data are available in different data formats with incomplete meta data documentation. Research in data sharing addresses the development, promotion and adoption of non-proprietary and universal meta data standards, interoperability of spatial data models and file formats and the distribution of spatial data over the internet. Another area of research is geospatial ontology and cognition. Research is needed to develop representation of geographic phenomena and processes independent of geometry but rather based on human cognition. The ontology would deal with the totality of geospatial concepts, categories, relations and processes and their interrelations at different resolutions.

Other research areas are geographic representations of three-dimensional, temporal and dynamic spatial phenomena, multiple scale representation, variable resolution representation, distributed computing, integration of well-developed algorithms in geostastitics, spatial econometrics and space time modeling within GIS environment, estimation of uncertainty in geospatial data and GIS based analysis, parallel processing to solve complex geographic problems, use of new software techniques for geographic data processing and visualization, spatial data security and so on. The GIS research community has always shown keen interest in aspects pertaining to GIS education and training. The emphasis is on preparation of course materials using multimedia and conducting the training via distance learning using internet etc. Although GIS is largely

used as a technology, the social implication resulting from the use of this technology in the society will pose the most challenging objectives for the research community.

In the academic and research front, the study of GIS technology has widened to a new scientific specialization referred to as geographic information science. New research areas are getting evolved on the concepts, techniques, applications, the implications pertaining to humanities and social sciences. Universities and colleges participate in government initiatives and do collaborative research with the hardware / software development industry, so that the use of GIS will benefit the society. GIS is a tool for development. It can be used at micro level, regional level and at macro level. GIS can provide solutions for better resources management and the protection of environment and thus improve the living condition of the mankind in this fast growing world.

REFERENCES

1. Lo C.P. and Yeung A.K.W. (2002), 'Concepts and Techniques Of Geographic Information Systems',Prentice-Hall, Inc., New Jersey.
2. P.Venkatachalam and B.Krishna Mohan (2002), 'Suggested Future Research areas in GIS', Presented in Hyderabad in a discussion meeting organized by Department of Science and Technology, New Delhi.