Title

Unit 51 - GIS Application Areas

Authors

Unit 51, CC in GIS
Cowen, David
Ferguson, Warren

Publication Date

1990

Peer reviewed

UNIT 51 - GIS APPLICATION AREAS

UNIT 51 - GIS APPLICATION AREAS

Compiled with assistance from David Cowen, University of South Carolina and Warren Ferguson, Ferguson Cartotech

---

For Information that Supplements the Contents of this Unit:

[Links to the following resources have been omitted.]

- Cartography Resources on the Web (Virtual Library) -- NOAA homepage; terrain mapping; educational cartography resource and site; digital relief and elevation; desktop mapping; etc.
- Online Resourses for Earth Sciences (ORES) (B.Thoen) -- Resources by subject (e.g.digital data, forestry, mapping): resource references; FAQs; URL examples.
- Resources for Geographers (U of Western Ontario) -- GIS; remote sensing; USG; other geospatial sites.
- GIS (from USGS) -- What is a GIS? How does a GIS work? What's special about a GIS? Applications of GIS.
- GIS Application Areas(Geographer's Craft) -- Natural resources management; facilities management; land management; street networks.
- Applied Environmental GIS (AEGIS) -- Projects which address a variety of environmental issues in which GIS solutions are appropriate; sample images (e.g. fire hazard, soil permeability).
- Current GIS Market -- Important issues (e.g. data structure, database management, functions/operations); GIS World Chart and unaddressed issues; object oriented programming; etc.
- International GIS and Remote Sensing Services -- Arc/Info tutorial; Digital Land Systems Research (DLSR); Environmental Resource Information Network (ERIN); Environmental Systems Resource Institute (ESRI); European Science Foundation (GIS data program); IDRISI homepage.
- GIS/Remote Sensing Publications Online
- Remote sensing -- GIS and other related fields; organizations; satellite data; sites; etc.
- United Nations Environment Programme (UNEP) -- Global resource information database; environmental data sets, including: biodiversity, human-related; soils; vegetation.

This begins a 6 part section which reviews the spectrum of different applications of GIS. We have tried to include examples from all the areas in which GIS is currently actively employed. You may want to rearrange, enhance or revise major portions of these units to suit the needs and interests of your students.

UNIT 51 - GIS APPLICATION AREAS

Compiled with assistance from David Cowen, University of South Carolina and Warren Ferguson, Ferguson Cartotech

A. INTRODUCTION

- GIS technology, data structures and analytical techniques are gradually being incorporated into a wide range of management and decision-making operations

- numerous examples of applications of GIS are available in many different journals and are frequent topics of presentations at conferences in the natural and social sciences

- in order to understand the range of applicability of GIS it is necessary to characterize the multitude of applications in some logical way so that similarities and differences between approaches and needs can be examined an understanding of this range of needs is critical for those who will be dealing with the procurement and management of a GIS

Functional classification

- one way to classify GIS applications is by functional characteristics of the systems
- this would include a consideration of:

  1. characteristics of the data such as:
     - themes
     - precision required
     - data model
  2. GIS functions
     - which of the range of possible GIS functions does the application rely on?
       - e.g. address matching, overlay?
  3. products
     - e.g. does the application support queries, one-time video maps and/or hardcopy maps?

- a classification based on these characteristics quickly becomes fuzzy since GIS is a flexible tool whose great strength is the ability to integrate data themes, functionality and output

GIS as a decision support tool

- another way to classify GIS is by the kinds of decisions that are supported by the GIS
- several definitions of GIS identify its role in decision- making
- decision support is an excellent goal for GIS, however:
  - decisions range from major (which foreign aid project to support with limited budget?) to minor (which way to turn at next intersection?)
  - difficult to know when GIS was used to make decisions except in cases of major decisions
- decision support is a good basis for definition of GIS, but not for differentiating between applications since individual GIS systems are generally used to make several different kinds of decisions

Core groups of GIS activity

- GIS field is a loose coalescence of groups of users, managers, academics and professionals all working with spatial information
- each group has a distinct educational and "cultural" background

each has associated societies, magazines and journals, conferences, traditions
- as a result, each identifies itself with particular ways of approaching particular sets of problems

- interactions occur between groups through joint memberships, joint conferences, umbrella organizations

- these groups or cultures, then, are another basis for characterizing application areas

- the core groups of GIS activity can be seen to be comprised of:

1. mature technologies which interact with GIS, sharing its technology and creating data for it

    - surveying and engineering
    - cartography
    - remote sensing

2. management and decision-making groups
    - resource inventory and management
    - urban planning (Urban Information Systems)
    - land records for taxation and ownership control (Land Information Systems)

    - facilities management (AM/FM)
    - marketing and retail planning
    - vehicle routing and scheduling

3. science and research activities at universities and government labs

- this and the next 5 units (Units 52-56) examine each of these groups of GIS activity seeking to find distinctions and similarities between them

- begin in this unit with a quick review of the relationship between the mature technologies and GIS and finish with a look at the role of GIS in science

B. CARTOGRAPHY

- there are two areas of GIS application in cartography: 1. automation of the map-making process 2. production of new forms of maps resulting from analysis, manipulation of data
    - the second is closer to the concept of GIS although both use similar technology

Computers in cartography

- first efforts to automate the map-making process occurred in early 1960s

- major advantage of automation is in ease of editing
    - objects can be moved around digital map without redrafting
    - scale and projection change are relatively easy

- differences between automated mapping and GIS are frequently emphasized
  - mapping requires: knowledge of positions of objects, limited number of attributes
  - GIS requires: knowledge of positions of objects, attributes, relationships between objects
  - hence distinction between "cartographic" and "topological" databases

- "analytical" cartography involves analysis of mapped data
  - has much in common with some aspects of GIS analysis

- cartography plays a vital role in the success of GIS
  - supplies principles of design of map output products - how to make them easy to read and interpret?
    - see: Units 17 and 49
  - represents centuries of development of expertise in compiling, handling, displaying geographical data

- widespread feeling that conversion to digital technology:
  - is inevitable
  - will revolutionize the field through new techniques

Organizations

- both professional and academic organizations in most countries
  - International Cartographic Association (ICA)

- well-developed training and education programs, journals, continuing research

Adoption

- now is some use of digital technology in almost all aspects of the map production process

- the term "desktop mapping" emphasizes the accessibility of one form of automated cartography in the same way that page formatting programs have led to the success of "desktop publishing"

C. SURVEYING AND ENGINEERING

- surveying is concerned with the measurement of locations of objects on the Earth's surface, particularly property boundaries
  - all 3 dimensions are important - vertical as well as horizontal positions
  - accuracy below 0.1 m is necessary

- the locations of a limited number of sites are fixed extremely accurately through precision instruments and measurements
  - these sites are monuments or benchmarks - the geodetic control network
  - this is the function of geodesy or geodetic science

- using these accurate benchmarks for reference, large numbers of locations can then be accurately determined relative to the fixed monuments

- surveying is an important supplier of data to GIS
  - however, it is not directly concerned with role of GIS as a decision-making tool
- some civil engineers now use GIS technology, especially digital elevation models and associated functionality, to assist in planning construction
  - e.g. to make calculations of quantities of earth to be moved in construction projects such as building highways
  - e.g. to visualize the effects of major construction projects such as dams

Recent advances in technology

- instruments:
  - locations captured by measuring device in digital form, downloaded to database - the "total station"
  - new GPS (global positioning system) instruments determine location from satellites, supplementing the geodetic control network
- direct linkage of surveying instruments to spatial databases
  - thus suppliers of surveying equipment have entered the GIS field as vendors

Characteristics of application area

- scale:
  - large - surveying often accurate to mm
  - engineering calculations require high DEM resolution
- data model:
  - survey data is exclusively vector
- lineage:
  - for legal reasons the source of survey data is important
    - e.g. instruments, benchmarks used, name of surveyor, date
  - most systems do not yet allow such lineage information to be stored directly with the data

Organizations

- surveying and engineering are mature professional fields based on scientific methods, with organizations, conferences, courses, journals, systems of accreditation
- introduction of GIS technology has not radically altered the profession

D. REMOTE SENSING

- like surveying, is a data producing field
- acquires knowledge about the Earth's surface from airborne or space platforms

- elaborate, well-developed technology and techniques
  - instruments for data capture - high spatial and spectral resolution
  - transmission of data, processing, archiving
  - interpreting and classifying images

- two major roles for GIS concepts:
  - quality and value of product is enhanced by use of additional ("ancillary") data to improve accuracy of classification
    - e.g. knowledge of ground elevation from a DEM allows shadows to be removed from images
  - to be useful in decision-making, product needs to be combined with other layers less readily observed from space
    - e.g. political boundaries

- remote sensing continues to be an active research area
  - new instruments need to be evaluated for applications in different fields
  - careful research is needed to realize the enormous potential of the technology
  - volume of accumulated data is increasing rapidly

Characteristics of application area

- scale:
  - a full range of spatial resolutions, depending on altitude, characteristics of instrument

- data model:
  - data is captured exclusively in raster form (pixels)
  - classified images may be converted to vector form for output, or for input to GIS systems

- interfacing with GIS is a current development direction
  - both areas have developed extensive software systems
  - in remote sensing, systems include image processing functionality
  - interfacing is not difficult technically - however, there may be substantial incompatibilities in data models, format standards and spatial resolution
  - many GIS vendors include functions to convert data from remote sensing systems and to display vector data on satellite image backdrops
  - true integration of vector GIS and raster image processing systems is not yet available

Organizations

- because of continuing emphasis on research, there is heavy representation from government and academic research

- the growth curve of remote sensing occurred about a decade earlier than GIS

E. SCIENCE AND RESEARCH

- growing interest in using GIS technology to support scientific research
  - to support investigations of global environment - global science
  - to search for factors causing patterns of disease - epidemiology
  - to understand changes in patterns of settlement, distributions of population groups within cities - anthropology, demography, social geography
  - to understand relationships between species distribution and habitats - landscape ecology

- GIS has been called an enabling technology for science because of the breadth of potential uses as a tool

- Ron Abler (Pennsylvania State University) has compared GIS to tools like microscopes, Xerox machines, telescopes in its potential for support of research

Analogy to statistical packages

- major statistical packages - SAS, SPSS, BMD, S etc. - developed over past 20 years
  - primarily developed to apply statistical tools in scientific research
  - subsequent applications in consulting, business
  - recent introduction of graphics, mapping capabilities for display of results, e.g. SAS/GRAPH

- unlike statistical packages, GIS development has been driven by applications other than scientific research

- lack of tools for spatial analysis has meant that the role of location in explaining phenomena has been difficult to evaluate
  - locational information has been available in map libraries but hard to interface with other information, not part of digital research environment

- potential for GIS to play an important role in scientific research

  - GIS supports spatial analysis as statistical packages support statistical analysis

Characteristics of application area

- scale:
  - very large (archaeology) to very small (global science)

- functionality:
  - overlay to combine, correlate different variables
  - ability to interface GIS with complex modeling packages, statistical packages
  - interpolation
  - visualization of data
  - potential for 3D, time-dependent applications

Organizations

- no forum for exclusive discussion of role of GIS in science (similar problems in

statistics)
    - particularly in the non-technical fields in the social sciences

- discussion confined to individual disciplines

- geography is the only discipline with a general concern for spatial analysis and supporting tools
    - however, in most US universities geography is a small, relatively weak and unknown discipline
    - in other countries, (e.g. UK) geography is recognized as a strong traditional discipline, with distinguished roots in social and physical science research

REFERENCES

Abler, R.F., 1987. "Awards, rewards and excellence: keeping geography alive and well," Professional Geographer 40:135-40. Source of the reference in Section E.

Bylinsky, Gene, 1989. "Managing with electronic maps," Fortune, April, 1989. Important popular review of GIS as a decision tool.

EXAM AND DISCUSSION QUESTIONS

1. Some have argued that the best way to classify GIS applications is through the data they use. How would the results differ from the taxonomy proposed in this Unit?

2. What significant groups are missing from this taxonomy of GIS applications? What areas of application might develop in the future?

3. Do you accept the analogy between GIS and statistical packages presented in this Unit? In the long term, which would you expect to have the more significant role in supporting scientific activity? Why?

4. Which branches of science would have most use for a GIS as an enabling technology? Which would have least use for it?

5. It has been argued that GIS is an extremely dangerous tool in epidemiology, because of its potential for identifying all sorts of spurious correlations between environmental factors and the occurrence of disease. Do you agree, and if so, what steps would you recommend to reduce the potential for misuse?

Last Updated: August 30, 1997.