Title
Unit 75 - The Future of GIS

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A. INTRODUCTION

- GIS originated in the mid 1960s
  - a continuous history since then
- nevertheless, many see GIS as a phenomenon of the late 1980s
  - major growth phase began in early 1980s due to combined effects of developments in software, cost- effectiveness of hardware
- expansion in the late 1980s has been fuelled by:

  - continuing advances in computing technology
  - increasing availability of major digital datasets, e.g. TIGER
  - new application areas, e.g. political districting
  - coalescence of existing application areas, e.g. specific CAD applications, AM/FM, automated mapping, spatial analysis

- how long can growth continue?
  - will GIS interests continue to converge, or will splits develop?
  - will GIS software converge on a standard, mature product or diverge into specialized markets?
  - will the term "GIS" eventually disappear, or will associated symbols of maturity emerge - university programs, textbooks, magazines
  - what will GIS look like in 10 years? 20 years?

- this unit has 3 parts:
  - historical analogy to history of remote sensing
  - discussion of convergence/divergence issues
  - prospects for the future

B. THE REMOTE SENSING ANALOGY

Remote sensing as precursor to GIS

- major efforts began in late 1960s
  - origins of GIS and remote sensing at similar point in time

- remote sensing well funded
  - strong incentive to develop peaceful uses of space technology

  - potential value of a tool for gathering geographical data quickly and cheaply
  - remote sensing systems widely installed in universities, research organizations by late 1970s

- growth of remote sensing in 1960s and 1970s vastly outpaced growth in GIS
  - GIS virtually unknown until early 1980s

- GIS often seen as add-on to remote sensing systems
  - potential for sophisticated modeling and analysis
  - ability to merge ancillary information to improve accuracy of classification of images

- three major lessons can be learned from remote sensing analogy:

Need for formal theory

- danger that GIS will suffer in the same way as remote sensing from lack of formal theory underpinning use

- much work in remote sensing has been purely empirical, limited to specific times and

places
  - impossible to generalize many results to other places or times

- much work is on a project basis
  - little addition to general pool of knowledge

- strong theoretical framework would be basis for greater generality

- difficult to generalize results from one satellite/sensor to another
  - much basic work must be repeated for every new satellite/sensor

- effects of scale are poorly understood
  - results in unintentional "ecological fallacy" - falsely imputing results from one scale of analysis to another e.g. in US plains states, correlation may exist between % of area covered by structures and % tree cover at spatial resolutions down to approx. 200 m, but not below - trees and buildings do not generally occupy the same locations

- analysis of remote sensing data has not benefited from clear understanding of spatial effects
  - e.g. effects of spatial dependence on statistical significance - frequently lead to overstating true significance
  - many analyses treat each pixel as an independent observation, ignore spatial context

- the level of theoretical development in these areas is much higher in 1980s
  - possibility that GIS can avoid some of these mistakes
  - however GIS designers operating in the commercial sector are often not aware of problems, available theory

  - will require close liaison between basic research and GIS design

Excessive expectations

- early promise of remote sensing was high
  - e.g. possibility of remote monitoring of agricultural production, forest harvesting

- in practice, numerous problems degrade accuracy of classification
  - seasonal, diurnal changes in spectral response
  - effects of moisture

- continuing need for basic research
  - few examples of production applications - i.e. where a standard product can be developed using a standard processing method

- post-war Western society has been fascinated with technological solutions to problems
  - remote sensing and GIS are particularly attractive, combining high technology with color graphics

- difficulty of defining adequate cost/benefit measures
- at the same time, technological change can be opposed by unconvincibles, confirmed nay-sayers, Luddites
    - technological innovation can produce strong emotions on both sides which confuse rational arguments

Potential for new paradigms

- many have expected remote sensing to produce fundamental changes in the ways people think about geographical information
- however, even today the magnitudes of its future effects on affected natural sciences is not clear
    - much research still remains to be done
- minimal position: after 17 years of Landsat, remote sensing is here to stay and cannot be ignored
- maximal position:
    - remote sensing is significant factor in emergence of Global Science, major technology of Global Monitoring
    - view from space has played major role in encouraging view of planet as an integrated system
- situation in GIS has similarities:
    - just as remote sensing led to global view, GIS can lead to integrated view - need to integrate many layers of spatial information - need to couple human and physical systems e.g. need to couple human occupation, settlement processes with effects on deforestation and CO2 increase

Technical advances

- both GIS and remote sensing have benefited from developments in:
    - workstation power - PCs, file servers, mass storage
    - availability of data, software through networking
- many vendors now offer the capability of integrating both technologies in the same workstation
- much research and development in remote sensing occurred in government laboratories - NASA, etc. - funded by government
    - NASA also major source of funds for university R&D
- GIS context is very different
    - level of public funding of GIS R&D has never been high
    - GIS R&D has been funded by vendors, driven by strong market forces
    - market forces are not necessarily consistent with needs of scientific research

C. CONVERGENCE OR DIVERGENCE?

- GIS is a loose collection of interests
  - how strong are the linkages between the subcultures of GIS (units 51-56)?
  - are they strong enough for continued convergence?

- several views of possible divergences in GIS:

GIS subcultures

- each of the groups identified in units 51-56 has its own tribal customs, ways of thinking

- the ties which currently bind the subcultures - e.g. allow AM/FM people to talk a common language with forest managers - may weaken
  - current "glue" is common technology, terminology

Marketplace

- is specialization emerging in the fast-moving PC GIS market?

- possible classification of current products:
  - desktop mapping - produce simple thematic maps from input data
  - spatial analysis systems - emphasize ability to overlay, combine layers, build buffers
  - database systems - combine databases with limited geographical functions, e.g. display, data input
  - geographical spreadsheets - generalize the concept of spreadsheets by adding geographical functions, e.g. ability to merge two adjacent areas or two rows of a spreadsheet into one area or one row, for e.g. political districting applications
  - query systems - provide access to e.g. TIGER files, limited ability for geocoding, querying, finding optimum routes for vehicles
  - image processing systems - built to process remotely sensed imagery, now with added GIS functions for data integration

- are there submarkets within GIS?

  - resource management applications need high functionality
  - AM/FM applications need high data volumes, access speeds
  - vendors will pursue the most lucrative submarket

- two alternative strategies for vendors:
  - build a product to satisfy a common denominator market - product can then withstand shifts in the market
  - adapt to the most lucrative submarket - long-term survival requires new adaptation with every shift in the market

What does convergence require?

- institutions and symbols to provide focus

  - e.g. programs, departments, societies, journals, magazines, books, conferences

- education and training
  - to raise awareness of GIS technology and its applications

- a market strong enough to support continued vendor R&D, or its replacement by government R&D

- technology which can simultaneously deliver the requirements of each submarket
  - e.g. must be possible to deliver high functionality required by one submarket without detracting from high access speed required by another submarket
  - in an operating system context this is the idea of "tuning" - one common operating system can satisfy many specialized computing environments

D. PROSPECTS FOR THE FUTURE

- several different "visions" for GIS

Automated geography

- e.g. see Dobson (1983)

- almost all forms of use of geographical data can now be automated
  - maps and atlases can be queried
  - geographical information can be analyzed, used in models

- we can use digital spatial data for specific purposes or to develop general theories

- geographical information becomes much more powerful in a digital environment, e.g.
  - overlay and integration
  - measurement and simple map analysis
  - seamless browse

- some have even envisioned "the death of cartography" - the "paperless map library" - along similar lines to the "paperless office"
  - Don Cooke (Geographic Data Technologies, Inc) sees three stages in this process: 1. automating the cartographic process
    - the objective is still to produce maps 2. the map as database
    - the digital database becomes the archive, with the map as the major product 3. using the map database
    - recognizing the far greater potential of data in digital form - new products, models, analysis - with the map playing a minor role as one form of hard copy display

However:

- geographical information is used infrequently compared to text or numerical information
  - people use maps only in certain limited contexts

    - effective use of spatial information requires much higher levels of training than e.g. word processing
    - e.g. the DIDS system - developed within the Executive Office of the President to display geographical information for decision-making - was discontinued in 1983 because of inadequate use

- but the potential of automated geography may lead to much greater levels of use - people might use geographical data more frequently if they had better access to it, and if it was easier to use

Spatial information science

- GIS and its allied fields, e.g. remote sensing, add up to the makings of a science of spatial information, which would include:
    - data collection - e.g. remote sensing, surveying, photogrammetry - data compilation - classification, interpretation, cartography
    - data models - data structures, theories of spatial information
    - data display - cartography, computer graphics
    - navigation, spatial information query and access
    - spatial analysis and modeling

- spatial information is sufficiently distinct, theory and problems are sufficiently basic and difficult to justify unique identity, status of minor discipline or subdiscipline

Spatial processes

- space provides a framework within which to organize objects
    - frame is useful for accessing records, e.g. by street address
    - frame is useful for accounting, e.g. totals by county
    - frame is basis for relating objects, e.g. by proximity, adjacency, connectedness

- what role does space have as a source of explanation and understanding?
    - spatial coincidence or proximity may suggest explanation, e.g. coincidence of cancer cluster and asbestos mining operation

    - spatial proximity may be basis for prediction, e.g. more customers will go to closer store
    - spatial accounting is used as basis for much analysis, e.g. county-to-county variations in employment, health statistics
    - many processes operate in spatial frames, e.g. atmospheric, ocean dynamics
    - measures of space are variables in many processes, e.g. measures of territory in ecology, measures of market area in retailing

- significance of GIS as a scientific tool - its value in explaining, understanding the world around us - depends on significance of spatial processes

REFERENCES

Dobson, J.E., 1983. "Automated geography," Professional Geographer 35:135-43. Pages 339-

53 of the same volume include extensive discussion of Dobson's article.

Everett, J.E. and D.S. Simonett, 1976. "Principles, concepts and philosophical problems in remote sensing," in J. Lintz and D.S. Simonett, Editors, Remote Sensing of Environment, Addison-Wesley, Reading, MA, pp 85-127. A review of remote sensing from the mid-1970s with striking parallels with current debates within GIS.

EXAM AND DISCUSSION QUESTIONS

1. Review and discuss the "automated geography" debate from volume 35 of Professional Geographer.

2. What is meant by a "spatial process"? Give examples of how the spatial information in a GIS can provide the basis for understanding, explanation, and the development of theories of natural or human systems.

3. Terry Jordan, a former President of the Association of American Geographers, wrote in the AAG Newsletter that the intellectual core of Geography was endangered by "the rush to GIS and similar easily justified but non- intellectual expertise" (AAG Newsletter 23(5)). Discuss this comment.

4. Develop a vision of the GIS field for the year 2005, in terms of vendors, data sources, education programs and disciplines.

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