UNIT 1 - WHAT IS GIS?

Compiled with assistance from David Cowen, University of South Carolina

The new Core Curriculum II has an introductory unit which develops the concept from a Geographic Information Science perspective, and is worth reviewing.

For Information that Supplements the Contents of this Unit:

- Application Areas of a GIS (Geographer's Craft) -- Natural resource management; land management; street networks.
- Basic Terms and Concepts of GIS (Ludwig/U of Missouri)
- Definition of GIS (Geographer's Craft)
- GeoData Institute (U of Southampton) -- GIS terminology in glossary format.
- GIS Glossary (B.C. Environment)
- The GIS View of the World (Geographer's Craft)
- Introduction to GIS (USGS)
- What is a GIS? (Chrisman/U of Washington)
- What is a GIS? (USGS) -- How does a GIS work? What's special about a GIS? Applications of GIS.
- Glossary for The Geographer's Craft (Geographer's Craft)
- GIS and Related Technologies (U of Western Ontario) -- GIS tutorials; overview of global positioning systems (GPS); satellite remote sensing.

There are several ways you might consider beginning your introductory course in GIS. This unit attempts to put GIS into context. However, it lacks visual images and anecdotes that only the instructor can provide. There are several ways you may want to supplement this unit. Consider beginning this unit by showing an introductory video on GIS. A promotional video from a vendor demonstrating applications of GIS and types of output would be suitable. Or take the students into the lab and let them play with a packaged GIS demo.

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A. INTRODUCTION

Objectives of this unit

- to examine various definitions of GIS - what factors uniquely differentiate it from other forms of automatic geographical data handling?
- to determine origins of the field - how does GIS relate to other fields such as statistical analysis, remote sensing, computer cartography?
- to give a brief overview of the relevant application areas

What is a GIS?

- a particular form of Information System applied to geographical data
- a System is a group of connected entities and activities which interact for a common purpose

    - a car is a system in which all the components operate together to provide transportation
- an Information System is a set of processes, executed on raw data, to produce information which will be useful in decision-making
    - a chain of steps leads from observation and collection of data through analysis
    - an information system must have a full range of functions to achieve its purpose, including observation, measurement, description, explanation, forecasting, decision-making
- a Geographic Information System uses geographically referenced data as well as non-spatial data and includes operations which support spatial analysis
    - in GIS, the common purpose is decision-making, for managing use of land, resources, transportation, retailing, oceans or any spatially distributed entities
    - the connection between the elements of the system is geography, e.g. location, proximity, spatial distribution
- in this context GIS can be seen as a system of hardware, software and procedures designed to support the capture,

  management, manipulation, analysis, modeling and display of spatially-referenced data for solving complex planning and management problems

    - although many other computer programs can use spatial data (e.g. AutoCAD and statistics packages), GISs include the additional ability to perform spatial operations

Alternative names

- alternative names which people have used over the years illustrate the range of applications and emphasis

Why is GIS important?

- "GIS technology is to geographical analysis what the microscope, the telescope, and computers have been to other sciences.... (It) could therefore be the catalyst needed to dissolve the regional-systematic and human- physical dichotomies that have long plagued geography" and other disciplines which use spatial information.1
- GIS integrates spatial and other kinds of information within a single system - it offers a consistent framework for analyzing geographical data
- by putting maps and other kinds of spatial information into digital form, GIS allows us to manipulate and display geographical knowledge in new and exciting ways
- GIS makes connections between activities based on geographic proximity
    - looking at data geographically can often suggest new insights, explanations
    - these connections are often unrecognized without GIS, but can be vital to understanding and managing activities and resources
    - e.g. we can link toxic waste records with school locations through geographic

proximity

- GIS allows access to administrative records - property ownership, tax files, utility cables and pipes - via their geographical positions

Why is GIS so hot?

- high level of interest in new developments in computing

_____ 1Abler, R.F., 1988. "Awards, rewards and excellence: keeping geography alive and well," Professional Geographer, 40:135-40.

- GIS gives a "high tech" feel to geographic information
- maps are fascinating and so are maps in computers
- there is increasing interest in geography and geographic education
- GIS is an important tool in understanding and managing the environment

Market value of GIS

- Fortune Magazine, April 24, 1989 published a major, general-interest article on the significance of GIS to business:
- GIS is described as a geographical equivalent of a spreadsheet, i.e. allows answers to "what if" questions with spatial dimensions
- an example of the value of GIS given in the article is the Potlatch Corporation, Idaho
  - controls 600,000 ac of timberland in Idaho - 4,900 separate timber stands
  - old method of inventory using hand-drawn maps meant that inventory was "hopelessly out of date"
  - $180,000/year now being spent on GIS-based inventory "a bargain"
  - GIS "gives Potlatch up-to-the-minute information on the status of timber.... A forest manager sitting at a terminal can check land ownership changes in a few minutes by zooming in on a map"
  - $650,000 on hardware and software produces more than 27% annual return on investment
- GIS market
  - Dataquest projected a market of $288 million in 1988, $590 million in 1992 for GIS, growing at 35% per year
  - ESRI of Redlands, CA, developers of ARC/INFO, had 350 employees and sales of $40 million in 1988 and a reported 42% increase in sales in 1989
  - Intergraph had 1988 sales of $800 million in a more diverse but GIS-dominated market
  - the 1989 edition of GIS Sourcebook listed over 60 different "GIS" programs (though not all of these have complete GIS functionality) and over 100 GIS consultants (US)

B. CONTRIBUTING DISCIPLINES AND TECHNOLOGIES

- GIS is a convergence of technological fields and traditional disciplines
- GIS has been called an "enabling technology" because of the potential it offers for the wide variety of disciplines which must deal with spatial data
- each related field provides some of the techniques which make up GIS
    - many of these related fields emphasize data collection - GIS brings them together by emphasizing integration, modeling and analysis
- as the integrating field, GIS often claims to be the science of spatial information

Geography

- broadly concerned with understanding the world and man's place in it
- long tradition in spatial analysis
- provides techniques for conducting spatial analysis and a spatial perspective on research

Cartography

- concerned with the display of spatial information
- currently the main source of input data for GIS is maps
- provides long tradition in the design of maps which is an important form of output from GIS
- computer cartography (also called "digital cartography", "automated cartography") provides methods for digital

representation and manipulation of cartographic features and methods of visualization

Remote Sensing

- images from space and the air are major source of geographical data
- remote sensing includes techniques for data acquisition and processing anywhere on the globe at low cost, consistent update potential
- many image analysis systems contain sophisticated analytical functions
- interpreted data from a remote sensing system can be merged with other data layers in a GIS

Photogrammetry

- using aerial photographs and techniques for making accurate measurements from them, photogrammetry is the source of most data on topography (ground surface elevations) used for input to GIS

Surveying

- provides high quality data on positions of land boundaries, buildings, etc.

Geodesy

- source of high accuracy positional control for GIS

Statistics

- many models built using GIS are statistical in nature, many statistical techniques used for analysis
- statistics is important in understanding issues of error and uncertainty in GIS data

Operations Research

- many applications of GIS require use of optimizing techniques for decision-making

Computer Science

- computer-aided design (CAD) provides software, techniques for data input, display and visualization, representation, particularly in 3 dimensions
- advances in computer graphics provide hardware, software for handling and displaying graphic objects, techniques of visualization
- database management systems (DBMS) contribute methods for representing data in digital form, procedures for system design and handling large volumes of data, particularly access and update
- artificial intelligence (AI) uses the computer to make choices based on available data in a way that is seen to emulate human intelligence and decision-making - computer can act as an "expert" in such functions as designing maps, generalizing map features
    - although GIS has yet to take full advantage of AI, AI already provides methods and techniques for system design

Mathematics

- several branches of mathematics, especially geometry and graph theory, are used in GIS system design and analysis of spatial data

Civil Engineering

- GIS has many applications in transportation, urban engineering

C. MAJOR AREAS OF PRACTICAL APPLICATION

Street network-based

- address matching - finding locations given street addresses
- vehicle routing and scheduling
- location analysis, site selection
- development of evacuation plans

Natural resource-based

- management of wild and scenic rivers, recreation resources, floodplains, wetlands, agricultural lands, aquifers, forests, wildlife
- Environmental impact analysis (EIA)
- viewshed analysis
- hazardous or toxic facility siting
- groundwater modeling and contamination tracking
- wildlife habitat analysis, migration routes planning

Land parcel-based

- zoning, subdivision plan review
- land acquisition
- environmental impact statements
- water quality management
- maintenance of ownership

Facilities management

- locating underground pipes, cables
- balancing loads in electrical networks
- planning facility maintenance
- tracking energy use

D. GIS AS A SET OF INTERRELATED SUBSYSTEMS

Data Processing Subsystem

- data acquisition - from maps, images or field surveys
- data input - data must be input from source material to the digital database
- data storage - how often is it used, how should it be updated, is it confidential?

Data Analysis Subsystem

- retrieval and analysis - may be simple responses to queries, or complex statistical analyses of large sets of data

- information output - how to display the results? as maps or tables? Or will the information be fed into some other digital system?

Information Use Subsystem

- users may be researchers, planners, managers
- interaction needed between GIS group and users to plan analytical procedures and data structures

Management Subsystem

- organizational role - GIS section is often organized as a separate unit within a resource management agency (cf. the Computer Center at many universities) offering spatial database and analysis services
- staff - include System Manager, Database Manager, System Operator, System Analysts, Digitizer Operators - a typical resource management agency GIS center might have a staff of 5-7
- procedures - extensive interaction is needed between the GIS group and the rest of the organization if the system is to function effectively

In this course all of these subsystems will be examined.

REFERENCES

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Making Tools," Proceedings, GIS '87, pp. 63-71, ASPRS/ACSM, Falls Church, VA. Good review of the history of GIS and its formative influences.

Rhind, D., 1989. "Why GIS?," Arc News, Summer 1989, Vol 11(3).

EXAM AND DISCUSSION QUESTIONS

1. Compare the introductory chapters of a selection of GIS textbooks (e.g. Burrough 1986, Star and Estes 1990, Aronoff 1989). What do you learn about the diversity of definitions of GIS?

2. Define GIS from the perspectives of a) applications, b) functions, c) system structure.

3. Compare GIS to an airline reservation system. How do the information system definitions presented in this lecture apply to the airline reservation example?

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