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Core Curriculum-Geographic Information Systems (1990)

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Unit 23 - History of GIS

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This unit provides a very brief review of some important milestones in the development of GIS. Of course, it is likely there are some important stages we have omitted. It is perhaps a little too early yet to get a good perspective on the history of GIS.

UNIT 23 - HISTORY OF GIS

[A. INTRODUCTION](#)

- development of GIS was influenced by:
 - key groups, companies and individuals
 - timely development of key concepts
- content of this unit is concerned with North America

- outside North America, significant developments occurred at the Experimental Cartography Unit in the UK
 - history of this group has been documented by Rhind (1988)
- this unit draws on a preliminary "genealogy of GIS" assembled in 1989 by Donald Cooke of Geographic Data Technologies Inc.

B. HISTORIC USE OF MULTIPLE THEME MAPS

- idea of portraying different layers of data on a series of base maps, and relating things geographically, has been around much longer than computers
 - maps of the Battle of Yorktown (American Revolution) drawn by the French Cartographer Louis-Alexandre Berthier contained hinged overlays to show troop movements
 - the mid-19th Century "Atlas to Accompany the Second report of the Irish Railway Commissioners" showed population, traffic flow, geology and topography superimposed on the same base map
 - Dr. John Snow used a map showing the locations of death by cholera in central London in September, 1854 to track the source of the outbreak to a contaminated well - an early example of geographical analysis

C. EARLY COMPUTER ERA

- several factors caused a change in cartographic analysis:
 - computer technology - improvements in hardware, esp. graphics
 - development of theories of spatial processes in economic and social geography, anthropology, regional science
 - increasing social awareness, education levels and mobility, awareness of environmental problems
- integrated transportation plans of 1950s and 60s in Detroit, Chicago
 - required integration of transportation information - routes, destinations, origins, time
 - produced maps of traffic flow and volume
- University of Washington, Department of Geography, research on advanced statistical methods, rudimentary computer programming, computer cartography, most active 1958-611:
 - Nystuen - fundamental spatial concepts - distance, orientation, connectivity
 - Tobler - computer algorithms for map projections, computer cartography
 - Bunge - theoretical geography - geometric basis for geography - points, lines and areas
 - Berry's Geographical Matrix of places by characteristics (attributes) - regional studies by overlaying maps of different themes - systematic studies by detailed evaluation of a single layer

D. CANADA GEOGRAPHIC INFORMATION SYSTEM (CGIS)

- Canada Geographic Information System is an example of one of the earliest GISs developed, started in the mid '60's
- is a large scale system still operating today
- its development provided many conceptual and technical contributions

Purpose

- to analyze the data collected by the Canada Land Inventory (CLI) and to produce statistics to be used in developing land management plans for large areas of rural Canada
- the CLI created maps which:
 - classify land using various themes: soil capability for agriculture recreation capability capability for wildlife (ungulates) capability for wildlife (waterfowl) forestry capability present land use shoreline
 - were developed at map scales of 1:50,000
 - use a simple rating scheme, 1 (best) to 7 (poorest), with detailed qualification codes, e.g. on soils map

_____ I see pages 62-66 in Johnston, R.J., 1983. Geography and Geographers: Anglo-American Human Geography since 1945, 2nd edition, Edward Arnold (Publishers), London.

may indicate bedrock, shallow soil, alkaline conditions

- product of CLI was 7 primary map layers, each showing area objects with homogeneous attributes
 - other map layers were developed subsequently, e.g. census reporting zones
- perception was that computers could perform analyses once the data had been input

Technological innovations

- CGIS required the development of new technology
 - no previous experience in how to structure data internally
 - no precedent for GIS operations of overlay, area measurement
 - experimental scanner had to be built for map input
- very high costs of technical development
 - cost-benefit studies done to justify the project were initially convincing
 - major cost over-runs
 - analysis behind schedule
- by 1970 project was in trouble
 - failure to deliver promised tabulations, capabilities
- completion of database, product generation under way by mid 1970s

- main product was statistical summaries of the area with various combinations of themes
- later enhancement allowed output of simple maps
- CGIS still highly regarded in late 1970s, early 1980s as center of technological excellence despite aging of database
 - attempts were made to adapt the system to new data
 - new functionality added, especially networking capability and remote access
 - however, this was too late to compete with the new vendor products of 1980s

Key innovative ideas in CGIS

overhead - Key ideas in CGIS

- use of scanning for input of high density area objects
 - maps had to be redrafted (scribed) for scanning
 - note: scribing is as labor intensive as digitizing
- vectorization of scanned images
- geographical partitioning of data into "map sheets" or "tiles" but with edgematching across tile boundaries
- partitioning of data into themes or layers
- use of absolute system of coordinates for entire country with precision adjustable to resolution of data
 - number of digits of precision can be set by the system manager and changed from layer to layer
- internal representation of line objects as chains of incremental moves in 8 compass directions rather than straight lines between points (Freeman chain code)
- coding of area object boundaries by arc, with pointers to left and right area objects
 - first "topological" system with planar enforcement in each layer, relationships between arcs and areas coded in the database
- separation of data into attribute and locational files
 - "descriptor dataset" (DDS) and "image dataset" (IDS)
 - concept of an attribute table
- implementation of functions for polygon overlay, measurement of area, user-defined circles and polygons for query

Key individual

- Roger Tomlinson, now with Tomlinson Associates, Ottawa

E. HARVARD LABORATORY

- full name - Harvard Laboratory For Computer Graphics And Spatial Analysis
- Howard Fisher, moved from Chicago to establish a lab at Harvard, initially to develop general-purpose mapping software - mid 1960s
- Harvard Lab for Computer Graphics and Spatial Analysis had major influence on the development of GIS until early 1980s, still continues at smaller scale
- Harvard software was widely distributed and helped to build the application base for GIS
- many pioneers of newer GIS "grew up" at the Harvard lab

The Harvard packages

overhead - The Harvard packages

- SYMAP
 - developed as general-purpose mapping package beginning in 1964
 - output exclusively on line printer
 - poor resolution, low quality
 - limited functionality but simple to use
 - a way for the non-cartographer to make maps
 - first real demonstration of ability of computers to make maps
 - sparked enormous interest in a previously unheard-of technology
- CALFORM (late 1960s)
 - SYMAP on a plotter
 - user avoided double-coding of internal boundaries by inputting a table of point locations, plus a set of polygons defined by sequences of point IDs
 - more cosmetic than SYMAP - North arrows, better legends
- SYMVU (late 1960s)
 - 3D perspective views of SYMAP output
 - first new form of display of spatial data to come out of a computer
- GRID (late 1960s)
 - raster cells could be displayed using the same output techniques as SYMAP
 - later developed to allow multiple input layers of raster cells, beginnings of raster GIS
 - used to implement the ideas of overlay from landscape architecture and McHarg
- POLYVRT (early 1970s)
 - converted between various alternative ways of forming area objects: SYMAP - every polygon separately, internal boundaries twice CALFORM - table of point locations plus lists of IDs DIME - see below
 - motivated by need of computer mapping packages for flexible input, transfer of boundary files between systems, growing supply of data in digital form, e.g. from Bureau of the Census

- ODYSSEY (mid 1970s)
 - extended POLYVRT idea beyond format conversion to a comprehensive analysis package based on vector data
 - first robust, efficient algorithm for polygon overlay - included sliver removal

Key individuals

- Howard Fisher - initiated Lab, development of SYMAP
- William Warntz - succeeded Fisher as Director until 1971, developed techniques, theories of spatial analysis based on computer handling of spatial data
- Scott Morehouse - move to ESRI was key link between ODYSSEY and the development of ARC/INFO
- see Chrisman (1988) for additional information on the Lab and its key personnel

F. BUREAU OF THE CENSUS

- need for a method of assigning census returns to correct geographical location
 - address matching to convert street addresses to geographic coordinates and census reporting zones
 - with geographic coordinates, data could be aggregated to user-specified custom reporting zones
- need for a comprehensive approach to census geography
 - reporting zones are hierarchically related
 - e.g. enumeration districts nest within census tracts
- 1970 was the first geocoded census
- DIME files were the major component of the geocoding approach

DIME files

- precursor to TIGER, urban areas only
- coded street segments between intersections using
 - IDs of right and left blocks
 - IDs of from and to nodes (intersections)
 - x,y coordinates
 - address ranges on each side
- this is essentially the arc structure of CGIS and the internal structure (common denominator format) of POLYVRT
- DIME files were very widely distributed and used as the basis for numerous applications

- topological ideas of DIME were refined into TIGER model
 - planar enforcement
 - 0-, 1- and 2-cell terminology
- DIME, TIGER were influential in stimulating development work on products which rely on street network databases
 - automobile navigation systems
 - driver guides to generate text driving instructions (e.g. auto rental agencies)
 - garbage truck routing
 - emergency vehicle dispatching

Urban atlases

- beginning with the 1970 census
- production of "atlases" of computer-generated maps for selected census variables for selected cities
- demonstrated the value of simple computer maps for marketing, retailing applications
 - stimulated development of current range of PC-based statistical mapping packages
- based on use of digital boundary files produced by the Bureau

G. ESRI

- Jack Dangermond founded Environmental Systems Research Institute in 1969 based on techniques, ideas being developed at Harvard Lab and elsewhere
- 1970s period of slow growth based on various raster and vector systems
- early 1980s release of ARC/INFO
 - successful implementation of CGIS idea of separate attribute and locational information
 - successful marriage of standard relational database management system (INFO) to handle attribute tables with specialized software to handle objects stored as arcs (ARC) - a basic design which has been copied in many other systems
 - "toolbox", command-driven, product-oriented user interface
 - modular design allowed elaborate applications to be built on top of toolbox
- ARC/INFO was the first GIS to take advantage of new super-mini hardware
 - GIS could now be supported by a platform which was affordable to many resource management agencies
 - emphasis on independence from specific platforms, operating systems
- initial successes in forestry applications, later diversification to many GIS markets
 - expansion to \$40 million company by 1988

REFERENCES

Special issue of *The American Cartographer* Vol 15(3), 1988, on the digital revolution in cartography - contains articles on the Harvard Lab, UK Experimental Cartography Unit, and the history of GIS.

Tomlinson, R.F., 1987. "Current and potential uses of geographical information systems," *The North American experience*. *International Journal of Geographical Information Systems* 1:203-18. Reviews GIS from beginnings to 1987, and summarizes lessons learned.

EXAM AND DISCUSSION QUESTIONS

1. Compare the Chrisman and Rhind articles in the special issue of *The American Cartographer* cited above. What roles did personalities play in the contributions of the Harvard Lab and the ECU?
2. What factors contributed to the unique development of CGIS in a department of the Canadian federal government in the mid 1960s?
3. In what ways has the concept of a geographic information system changed since the design of CGIS?
4. "The pattern of GIS development since 1965 has been largely attributable to the changing balance between the costs of hardware, communications and software development". Discuss.

Last Updated: August 30, 1997.