Massachusetts Institute of Technology
Department of Urban Studies and Planning

11.520: A Workshop on Geographic Information Systems

11.188: Urban Planning and Social Science Laboratory

GIS Principles & Methods

September 14, 2005, Joseph Ferreira, Jr.

(including contributions from Visiting Prof. Zhong-Ren Peng who taught the Fall 2003 class)

Administrative notes regarding lab exercises and schedule

- Lab Exercises #2: we've made some minor edits regarding how to control the labeling (it's different in new version, ArcGIS 9.1)
- Lab Exercise grading
    - we aren't going to grade every detail
    - you'll get a 'check' = okay, 'check-plus' = especially good, or 'check-minus' = not as complete as we had hoped.
    - all together, the lab exercises count for 25% of semester grade.
- Lab Exercise purpose:
    - quick start with basic ArcGIS tools and features
    - highlight important ideas and methods
    - assist you in becoming more self-sufficient with ArcGIS help pages
    - as semester progresses, they will be less cookbook and a little more open ended
    - ***Don't just push the buttons to get the 'right' answer*** **-** pause to think about what you are trying to do, what info/tools are needed, and why ArcGIS is organized in a particular way.

General Approach to the Course

- Understand the “What.”
    - What phenomena are we interested in studying? – Learning and discovering.
- Think about the “Why.”
    - Why are 'spatial analysis' and GIS tools relevant? – Critical thinking.
- Master the “How.”
    - How do we solve the problem? – decompose a question into spatial analysis and visualization components that can be handled by the data and software.

How to distinguish different geographic information?

- How do we represent geographic location?
- How do we represent objects in space?
- Are all maps equal? (Scale or level of geographic detail)
- Must geographic information be mappable? (Shortest path algorithm)
    - Data, Information and Knowledge - where does GIS fit in?
        - Data – Raw geographic facts, context free.
        - Information – the interpretation of data.

- Knowledge – interpreted information based on a particular content, experience and purpose.

Why Spatial information is special?

- 80% of all information includes spatial component
    - Data, Information and Knowledge - relevant at every level.
    - Urban planning is inherently spatial.
    - Spatial ***relationships*** are as relevant as spatial location.
    - It takes spatial analysis to understand their relationship.
    - Spatial data are usually voluminous.
    - Presentation as a map often takes a huge amount of data.
    - Visualization and data consistency require use of particular map projections and spatial reference system.
    - Distinguish among: images of a place (streetscape), aerial photo of a place (orthophoto), and a cartographic map of the same place (Mapquest)
    - Distinguish among: Mapquest, NOAA hurricane map, NOAA data buoy center , EPA's Enviromapper, MIT OrthoTools, traffic reports, …, and ArcGIS

Where is knowledge of geographic location, spatial analysis/manipulation/visualization capability

What is GIS?

- GIS is a computer-based information system that enables capture, modeling, manipulation, retrieval, analysis and presentation of geographically referenced data. (Worboys, 1997)

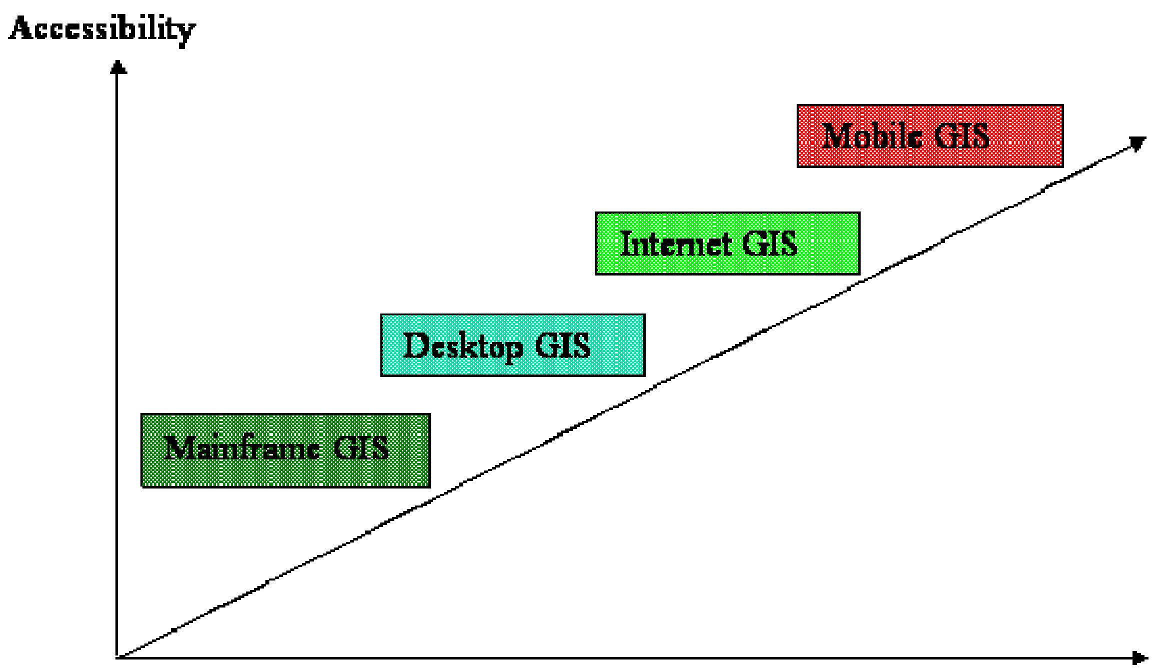
Other definitions of GIS

- A container of maps in digital form.
  - A computerized tool for solving geographic problems.
  - A spatial decision support system.
  - A tool for revealing what is otherwise invisible in geographic information
  - A tool for automatically performing operations on geographic data.

Components of GIS

- Hardware,
- Software,
- Data,
- People, (humanware)
- Procedure,
- Network (Internet).

Evolution of GIS: A Timeline from 1970s to now

- 

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  - The following contents of today's lecture is derived from Longley, Goodchild, Maguire and Rhind, *Geographic Information Systems and Science*, 2001, as organized by Prof. Zhong-Ren Peng for 11.520 in Fall 2003.

- ## GISytems, GIScience, GIStudies, and GIServices
  - ■ GISystems – A computerized tool that helps solve geographic problems.

- ■ GIScience – A scientific approach to the fundamental issues arising from geographic information.
- ■ GIStudies – the systematic study of society's use of geographic information, including institutional, organizational and procedural issues.
- ■ GIServices – The business of providing GIS data and analysis tools to GIS users.
- These concepts are derived from Longley, e al, (2001)

- Some Examples of GIS Applications
  - ■ Resources inventory (what is available at where?)
  - ■ Network Analysis (How to get to a place in the shortest amount of time?)
  - ■ Location Analysis (Where is the best place to locate a shopping mall?)
  - ■ Terrain Analysis (What is the danger zone for a natural disaster? Visibility analysis)
  - ■ Spatio-Temporal Analysis (What has changed at what locations over the last twenty years, and why?)

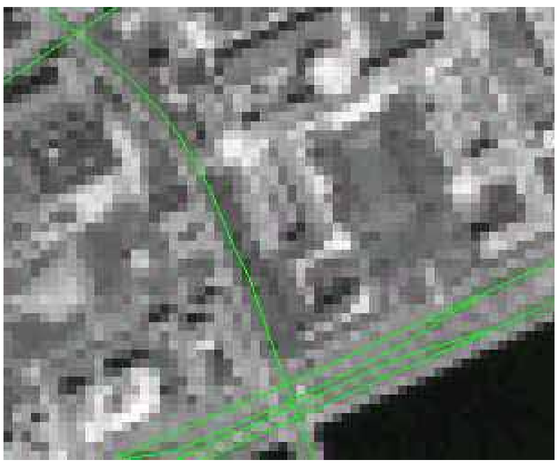
- **Overview of ArcGIS software**
  - What are the various parts of ArcGIS and what do they do
  - How is ArcMap organized
  - Understanding the 'vector' and 'raster' data models underlying ArcGIS

- **'Vector' data models for geospatial location**
  - Geometry model:
    - boundary representation 'vector' model
    - points (sales), lines (streets), and polygons (block groups)
    - assign spatial feature ID to each spatial object
  - Attribute data model
    - relational tables linked to spatial features via ID

    - graphical interface to utilize geometry/attribute links
- Complications
    - islands, lakes, overpasses
    - share edges?, move links when you move points?
    - ambiguity: summer/winter wetland boundaries
    - scale, generalization, conflation, slivers
    - Coordinate systems and projections
- Thematic mapping - tip of iceberg regarding GIS applications
    - Symbology
        - many options
        - review 'symbology' page of layer properties
        - review ArcGIS help files for symbology
    - Different classification schemes (show help page):
        - Equal Interval
        - Natural Breaks
        - Quantile
        - Standard Deviation
    - Normalization: people or population density - Why do we care? (show examples)

Raster vs. vector data models

- regular grid on top of spatial features (instead of encoding boundary)
- pixel brightness in orthophoto of Boston
- Vector: points, lines, polygons
    - Coverages: old Arc/Info a directory per layer, plus INFO files
    - Shapefiles: .shp, .shx, .dbf files (and possibly others)
    - Spatial Database Engine (SDE): retrieved dynamically from a database server
- Raster: orthophotos scanned maps, grids
    - orthophoto has been 'unwarped' and registered to a coordinate system
    - ortho can be treated as raster coverage layer where darkness of pixel is proportional to attribute of interest
    - ArcGIS has 'spatial analyst' extensions to create and manipulate raster data layers and combine them via 'map algebra'



Boston/Cambridge Streets superimposed on orthophoto. Zoomed-in view shows raster nature of the ortho.

- MITOrthoTools
    - Installing the 'button'
    - What it does
        - pass window size and coordinate system information to web service on ortho server
        - add returned image as registered raster layer in ArcMap
    - Later in semester, we'll use other web services that adhere to interoperable geospatial service protocols promoted by the Open Geospatial Consortium

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Last modified 14 September 2005 [jf]