Introduction to Geoprocessing

MIT GIS Services
http://libraries.mit.edu/gis/
Email: gishelp@mit.edu
Listserv for GIS announcements: mitgis@mit.edu
Characteristics of Geographic Information Systems

a. Data

1. Spatial Data - *represents features that have a known location on the earth* (vectors and rasters)

2. Attribute Data – *tabular data*

b. Users / System

1. Data Input – *create or find data*

2. Data Management

3. Data Analysis - *answer questions that may not be explicitly stated in the data*

4. Data Output – *maps, new data*

c. Software / Hardware
GIS allows you to ask spatial questions

- Where are the most crimes in Baltimore?
- Where are the police stations?
- Where are crime hotspots?
- Where should I locate a new police station?
Demographic Difference of the Intersects of the 1990 and 2000 Census Tracts

Legend

-980 - 0
1 - 834
835 - 2163
2164 - 3904
3905 - 8090

Harris County, Texas
Mt. Etna, Sicily, Italy Bands 321 and 654.
Here Band 6 is Red, Band 5 is Green, Band 4 is Blue.
➢ Notice how the thermal band 6 does not pick up the smoke, or the clouds.
➢ You can see where the hot lava flows underground in lava tubes.
➢ The hotter the signal the brighter the pixel.
Land Use / Land Cover

Westboro, Massachusetts
Digital Elevation Model (DEM)

Raster file; a sampled array of elevations for a number of ground positions at regularly spaced intervals.
Cape Town, South Africa
Landsat Image over SRTM DEM

http://photojournal.jpl.nasa.gov/jpegMod/PIA04961_modest.jpg
A computer system to digitally represent geographic objects in a variety of shapes. (Spatial data)
A computer system to digitally represent geographic objects in a variety of shapes. (Spatial data)
A computer system to digitally represent geographic objects in a variety of shapes. (Spatial data)

Polysgons
Lines
Points
A computer system to digitally represent geographic objects in a variety of shapes. (Spatial data)

- Polygons
- Lines
- Points
- Images (Pixels)
Spatial data have a database backend ("attribute table") that can be used for querying and analysis.

<table>
<thead>
<tr>
<th>ABBR</th>
<th>NAME</th>
<th>AREA</th>
<th>SUB_REGION</th>
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<th>POP2000</th>
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<td>147043.116</td>
<td>Mn</td>
<td>799065</td>
<td>885795</td>
</tr>
</tbody>
</table>
Each spatial attribute is referenced in a projection and a coordinate system.

PROJECTION
A method of representing the earth's three-dimensional surface as a flat two-dimensional surface.

COORDINATE SYSTEM
A fixed reference framework superimposed onto the surface of an area to designate the position of a point within it; Common coordinate systems are geographic (three-dimensional), in which locations are measured in degrees of latitude and longitude, and planar (also called Cartesian), in which the earth's surface is projected onto a two-dimensional plane and locations are measured in meters or feet.

Elevation

Longitude  Latitude

29° 43' 7.10" N
95° 23' 55.74" W
GCS_WGS_1984
Each spatial attribute is referenced in a projection and a coordinate system.

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- Latitude
- Longitude
- Elevation

29° 43’ 7.10 “ N
95° 23’ 55.74” W
GCS_WGS_1984

Sidewalks
1/2m Aerial Photo
Each spatial attribute is referenced in a projection and a coordinate system.

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- Latitude
- Longitude
- Elevation

29° 43’ 7.10” N
95° 23’ 55.74” W
GCS_WGS_1984

Buildings
Sidewalks
1/2m Aerial Photo
Each spatial attribute is referenced in a projection and a coordinate system.

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- Streets
- Buildings
- Sidewalks
- 1/2m Aerial Photo

29° 43' 7.10 " N
95° 23' 55.74" W
GCS_WGS_1984

### Elevation
- Latitude
- Longitude
Map projections

There are many different map projections. All map projections distort shape, area, distance, or direction.
The Mercator projection maintains shape and direction.

The Sinusoidal and Peters projections both maintain area, but look quite different from each other.

The Robinson projection does not enforce any specific properties but is widely used because it makes the earth’s surface and its features "look right."
“Three Different Map Projections” from The Geographer’s Craft, Map Projections webpage:
http://www.colorado.edu/geography/gcraft/notes/mapproj/mapproj_f.html
Projection Problem Illustration

Connecticut River
Projection Problem Illustration

Connecticut River flow rate data
Projection Problem Illustration

Connecticut River flow rate data
Data Types - Tabular

• Table (CSV, Excel) or database (Access, Oracle, PostgreSQL)

• Join with spatial data file by common attribute (state, county, etc)

• Mapped as points using coordinate points such as latitude and longitude gathered from a GPS

• Geocode: associate address field with GIS street file
Data Types – Spatial Data

Spatial or coordinate data represents features that have a known location on the earth.

**Vector:** Points, Lines and Polygons

**Raster:** Row and column matrix
Data Types – Spatial Data - Vector

**Vector**: Points, lines and polygons

<table>
<thead>
<tr>
<th>Shape</th>
<th>ID</th>
<th>Landuse</th>
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<td>HIGHLAND</td>
</tr>
<tr>
<td>Polygon</td>
<td>2</td>
<td>WETLAND</td>
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</table>
Data Types – Spatial Data - Raster

A raster is a model of the world as a surface that is divided into a regular grid of cells, arranged into rows and columns. All cells (or pixels) must be the same size.

- images (such as aerial photographs)
- grids (derived data representing continuous values such as an elevation surface or categories such as vegetation types)
Tabular, Vector, or Raster?
Tabular, Vector, or Raster?
Tabular, Vector, or Raster?

<table>
<thead>
<tr>
<th>OID</th>
<th>FEATURE_ID</th>
<th>FEATURE_NM</th>
<th>FEATURE_CL</th>
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<th>STATE_NUM</th>
<th>COUNTY_HUM</th>
<th>COUNTY_NUM</th>
<th>PRIMARY_LA</th>
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<td>MD</td>
<td>24</td>
<td>Allegany</td>
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<td>Allegany</td>
<td></td>
<td></td>
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</tbody>
</table>
Tabular, Vector, or Raster?
Data from different sources, covering the same area, can look very different. Evaluate scale, accuracy and file size when selecting data for a project.
Where to Get GIS Data

1. MIT Geodata Repository (http://libraries.mit.edu/gis/data)
   – GeoWeb – use any web browser
   – MIT Geodata Search Tool for ArcGIS software

2. MIT GIS Lab
   Use Barton to search the collection of data on CD’s and DVD’s
   http://library.mit.edu/F/?func=file&file_name=find-a&local_base=GIS

3. Internet
   http://libraries.mit.edu/gis/data/
   http://lyceum.massgis.state.ma.us/wiki/ - WMS, WFS, ArcIMS, download
   http://resources.esri.com/arcgisdesktop/index.cfm?fa=content&tab=Layers

4. Create your own
   GPS, Digitize, etc.

Not finding what you want? GIS data purchase requests?
Contact gishelp@mit.edu
Collect your own data.
Global Positioning Systems (GPS) are available for checkout from the Rotch Library Circulation desk.
Census

The libraries and GIS Services can help you with:

- Navigating through the sea of data to find what you want
- Providing tools to increase access and ease of use
- Mapping demographics
- Providing historical print records for Massachusetts

http://libraries.mit.edu/guides/types/census/tools-overview.html

Overview of Demographic Mapping Tools

<table>
<thead>
<tr>
<th>Mapping Tools</th>
<th>Geolytics</th>
<th>Social Explorer</th>
<th>MIT Census Tool in ArcGIS</th>
<th>Census Website</th>
<th>ICPSR</th>
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</thead>
<tbody>
<tr>
<td>Simple to use Easy to bring maps into GIS system.</td>
<td>Simple online mapping interface</td>
<td>Simple tool inside ArcGIS</td>
<td>Limited pre-set web tools in American Factfinder</td>
<td>None</td>
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</table>
Social Science Data Services

Offers assistance with finding social science data, such as:

<table>
<thead>
<tr>
<th>Economic Development</th>
<th>Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Indicators</td>
<td>Political Science and Government</td>
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<tr>
<td>Finance</td>
<td>Public Opinion</td>
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<tr>
<td>Health</td>
<td>Social Surveys</td>
</tr>
<tr>
<td>Industry</td>
<td>Trade Statistics: International &amp; U.S.</td>
</tr>
</tbody>
</table>

and statistical software and methodology consultations.

http://libraries.mit.edu/guides/subjects/data/

- Available in Dewey Library
Data Formats

ArcGIS can read many formats including:
- Shapefile, geodatabase, coverage, grid
- Image formats (JPG, TIF, geotif)
- CAD (DXF & DWG)
- Google Earth (KML, KMZ) can be read in ArcGlobe
  - (turn on KML toolbar)

Data can be exported from ArcGIS to a variety of formats including:
*Use ArcToolbox Conversion tools*
- Google Earth (.KML, .KMZ)
- CAD (.DWG, .DXF, .DGN)
- Adobe Illustrator (.AI)
- TIF
- JPG
Shapefiles are bundles of files that must be kept together!
## GIS Desktop Software

### Open Source
- GRASS GIS
- OSSIM *
- Quantum GIS
- gvSIG *

(* in incubation)

### Proprietary
- ESRI ArcGIS Desktop
- MapInfo

Open Source means the source code is made available under a license that allows the modification, and re-distribution of the software at will. For a more in-depth definition visit the Open Source Initiative: http://opensource.org/docs/definition.php

For more information about open source projects visit OSGEO – the Open Source Geospatial Foundation website: http://osgeo.org

For a longer list of GIS software visit: http://en.wikipedia.org/wiki/List_of_GIS_software
ArcGIS - ArcMap

- Provides the most tools for processing data, doing analysis and creating maps
- Work in 2D
- Use MIT created tools for easily accessing the MIT Geodata Repository with a full GIS software package
ArcGIS - ArcScene

Work in 3D
ArcGIS - ArcCatalog

- Manage Files and folders
- Create new shapefiles and geodatabases
- Preview files
- View metadata in format of choice
- create metadata so your data can be understood and shared with others
- Save metadata files as .xml, .txt, .html or .sgml
ArcGlobe - ArcGIS

- View the world as a globe
- 3D effects
- Animated fly-throughs on a globe surface
- Tools for recording
- Movies
### ArcGIS Extensions

<table>
<thead>
<tr>
<th>3D Analyst</th>
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<tr>
<td>ArcScan</td>
<td>Spatial Analyst</td>
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<td>Data Interoperability</td>
<td>Survey Analyst</td>
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<tr>
<td>Geostatistical Analyst</td>
<td>Tracking Analyst</td>
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http://www.esri.com/software/arcgis/about/desktop_extensions.html

This workshop is introducing the ESRI desktop GIS software suite. For more information about their Server GIS and Mobile GIS products visit:

http://www.esri.com/
# Google Earth Pro

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<th>Google Earth Pro</th>
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<td>Integrate GPS data</td>
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<td>Gain email support</td>
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<td>Create premium movies</td>
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<td></td>
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<tr>
<td>Import and overlay images</td>
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<td>Perform batch geocoding</td>
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<td>Measure area</td>
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<tr>
<td>Cost</td>
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</table>

Available in MIT GIS Lab
Data Management Tips

GIS projects tend to generate many files, which are frequently large in size

- File naming
  - Use file names that represent the file (default names like export_output are not helpful later)
  - Some software programs and tools can have file name constraints like an 8 character limit and no spaces – watch out for this with ESRI ArcToolbox
Data Management Tips

Track your process / keep good notes about

• Data sources – where did you gather your data from and does it have licensing constraints restricting what you can do with it legally?

• Data processing (merging, clipping, joining, and other types of manipulation of the files) – model builder can also help you create visuals of your processes

• What is stored where
  • The GIS project maintains links to the individuals files/ data layers (the data is not embedded in the project itself)
  • GIS formats, like shapefile, have many files that are linked together and must stay together to work (when moving files keep everything with the same name and different extensions together)

• Descriptions of the files you create and use – ArcCatalog has built in tools for creating and editing metadata using standards like FGDC or ISO
Data Management Tips

Backup your data!

Data Management and Publishing Guide:
http://libraries.mit.edu/guides/subjects/data-management/
Use GIS to: Create Maps

Legend
- Hotels
- Stations
- BLUE
- GREEN
- ORANGE
- RED
- SILVER
- Water
- Town Boundaries

Major Roads
Road Classification
- Limited Access Highway
- Multi-lane Hwy, not limited access
- Other Numbered Highway
- Major Road, Collector
- Open Space
Use GIS to:

Create buffers

Calculate what is

• inside

• outside

• within a certain distance

Buffers in ½ mile increments around Fenway Park
Use GIS to: perform spatial statistics

• Analyzing patterns
• Mapping clusters
• Measuring geographic distributions
• Modeling spatial relationships
Use GIS to: Map Data

Geocoding Addresses:
77 Massachusetts Ave.
Cambridge, MA 02139

Add X, Y Data
71 5” 36.45’ W
42 21” 32.75’ N
Use GIS to: do network analysis
Use GIS to:

- Georeference maps and images
- Calculate area and volume
- Perform surface analysis
  - contour
  - slope
  - aspect
  - hillshade
  - Viewshed

MIT GIS Services

- GIS lab accessible during all Rotch open hours
- Individual GIS assistance (software and data)
  - walk-in help during lab hours: M-TH 12:30-4
  - gishelp@mit.edu – request help with GIS
  - mitgis@mit.edu – listserv for GIS announcements
- GIS data: Geodata Repository
  (GeoWeb & ArcMap Interface)
- Loan GPS units to MIT community
More Learning Opportunities

• Data Collection workshop
  • 4 sessions + field work
  • late October (after ½ semester GIS module)

• GIS Lab general workshops
  • IAP workshop series (January)
    • *US Census, programming, more*
  • http://libraries.mit.edu/gis/teach/previous-workshops.html

• ESRI virtual campus classes and online help
  • http://libraries.mit.edu/gis/teach/esrivc.html
Rotch Library of Architecture & Planning Tour

- Meet the helpful & friendly staff that will help you find, access, use, manage, and cite the information and data you will need for your projects and thesis

- Learn about image tools and services

- Tour the space with the
  - Art and Architecture books and journals
  - GIS lab
  - Maps and atlases
  - Limited access to rare materials

Thursday, 9/2 3-4 pm Rotch Library: 7-238