What is GIS?

Dr Sarah Lindley
School of Environment & Development (Geography)
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Overview

- Introduction: GIS & GISc
- Basic principles
- Key operations
- Analysis examples
- Conclusions: Reflective GIS
- Further information

GIS has been usefully defined as ‘a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth’ (DoE, 1987)


GIS has strong connections and shared principles with other spatial data handling techniques & technologies – now recognised as a distinct geography sub-discipline GISc
A Multifaceted GIS Community (GeoWorld January, 2007)
How we represent spatial and attribute data in GIS is affected by how we view the world.

- Field vs. Entity-Oriented View

Discrete valleys & hills or elevation continually varying in space?
Representing space

**VECTOR**
Simple **point, line & area** entity layers which can be visualised together giving the appearance of an OS map. They can also form the basis of more complex entities or represent a continuous surface.

**RASTER**
**Cells** or pixels, like on a satellite image, which each contain a data value which can be interpreted as simple entities or used to represent a continuous surface.
Representing the ‘real world’

- Information about the real world is held in the form of **layers of data**
- Each layer has been carefully overlaid on the others & **every location is precisely matched to its corresponding location on all the other maps**.

**GIS: An Integrating Technology**

Internet lecture - [Foote and Lynch](#)
Analysing the ‘real world’

- Layers can be compared and *analysed* → **new information**
- GIS offers a means of:
  - searching for spatial patterns and processes.
  - answering research questions

Where are particular features found?
What geographical patterns exist?
Where have changes occurred over a given time period?
Where do certain conditions apply?
What will the spatial implications be if an organisation takes certain actions?
A digital elevation model (DEM) contains x, y, z data (z = height)

DEMs can be created from a range of data sources too (e.g. maps, GPS, RS)
Table 1. The 20 universal GIS operations

<table>
<thead>
<tr>
<th>Search:</th>
<th>Location Analysis:</th>
<th>Terrain Analysis:</th>
<th>Distribution/Neighborhood:</th>
<th>Spatial Analysis:</th>
<th>Measurements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpolation</td>
<td>Buffer</td>
<td>Slope/Aspect</td>
<td>Cost/Diffusion/Spread</td>
<td>Multivariate Analysis</td>
<td>Measurements</td>
</tr>
<tr>
<td>Thematic Search</td>
<td>Corridor</td>
<td>Catchment/Basins</td>
<td>Proximity</td>
<td>Pattern/Dispersion</td>
<td></td>
</tr>
<tr>
<td>Spatial Search</td>
<td>Overlay</td>
<td>Drainage/Network</td>
<td>Nearest Neighbor</td>
<td>Centrality/Connectedness</td>
<td></td>
</tr>
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<td>(Re-)classification</td>
<td>Thiessen/Voronoi</td>
<td>Viewshed Analysis</td>
<td></td>
<td>Shape</td>
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"The true potential value of GIS lies in their ability to analyse spatial data....Spatial analysis provides the value-added products from existing datasets" (Goodchild, 1988)

Example techniques & their application

- Data manipulation
  - Density estimation (MFF fire risk estimation, work with Julia McMorrow, Geography)
    - number of discrete objects per unit area
    - A means of going from object-based \( \rightarrow \) ‘continuous’ measure
    - Examples of point and line density measures

- Analysis techniques
  - Network analysis (Anna Mölter, PhD student)
    - Estimating shortest paths

- Overlay analysis
  - MCE/MCA (MFF fire risk)

- Case study
  - Historical GIS for material flow analysis (Hiroki Tanikawa, visiting research fellow in Geography, 2005)
Density estimation (point)
Point density estimation via kernels

Figure 4-41 Point data

Figure 4-42 Simple linear (box or uniform) kernel smoothing

http://www.spatialanalysisonline.com/output/html/Pointdensity.html

5/20 = 0.25 pts per unit length

3/10 = 0.3 pts/unit or 2/10 = 0.2 p/u

Spreading the influence of each point allows a relative density to be calculated
Spreading can be carried out via a normal distribution based kernel (highest weighting given to the centre of each point with reduced influence with increasing distance).

Moving to 2D, a more sophisticated representation of density can be calculated.
Relative path popularity Aug04 & Jan05 Bleaklow

- Individual paths digitised from ‘Mark your route on the map’ question in MFF Visitor attitude surveys
- A line density estimation procedure then used to look for relative density of paths → path popularity

Necessary because multiple line features, each line was one questionnaire response
Overlay analysis for site selection

- Waste disposal site selection
  - Within a certain distance of roads (distance buffers)
  - Within areas of clay soil/geology

- Multi Criteria Evaluation
  - Criteria or factors as maps which can be combined to produce a solution

- Flexible methods
- ‘What if’ scenarios
Risk mapping: Which areas of PDNP are most at risk of ignition?

Aim: To develop a stakeholder-informed map of the risk of wildfire ignition for Section 3 moorlands of Peak District National Park.

Based on:
- Where fires have been most common in the past; reported fires in Rangers’ fire log, 1976-2004
- Expert opinion: FOG and other stakeholders

Legend:
- Settlements
- National Park Boundary
- Study Area
- Pennine Way
- Wildfires 1976-2004

Scale: 0 5 10 20 30 Kilometers

Peak District National Park
Fire Operations Group
Scoring & weighting factors

Model 6a

Open Water areas

Risk of reported fire

= weighted combinations of spatial layers

Habitat x 0.23

Settlements x 0.158

Minor roads x 0.035

HiPop PW x 0.277

PROW x 0.202

Waylines x 0.098
Network analysis example

- Network routing
  - Find optimal path from A to B
    - Traveline journey planner → public transport
- Network allocation
  - Area covered by supply centres
    - Emergency Services
    - Delivery depots
- Research application
  - Effect of air pollution on children’s health
  - Estimate children’s exposure at home, school, journey using geocoded home and school addresses
- Aim:
  - **Determine shortest route between home and school**

Slides courtesy of Anna Mölter, PhD student, Centre for Occupational and Environmental Health
Example: Multiple homes → 1 school

Slides courtesy of Anna Mölter, PhD student, Centre for Occupational and Environmental Health
Estimated NO$_2$ concentrations related to the road network

Slides courtesy of Anna Mölter, PhD student, Centre for Occupational and Environmental Health
Spatial Estimation and Visualization of Regional MFA with GIS mapping

Hiroki Tanikawa
Associate Professor, Wakayama University, Japan
Visiting Research Fellow, The University of Manchester, U.K.

Nigel Lawson
School of Environment and Development, The University of Manchester, U.K.

Seiji Hashimoto
National Institute for Environmental Studies, Japan

Yuichi Moriguchi
National Institute for Environmental Studies, Japan

Contents:
- Linkage of Local MFA and Spatial Information
- How do we know Spatial Metabolism?
- Case study of Construction Sector, U.K. and Japan
For establishing Historical GIS...

**Current GIS**
- 1/2500
- 2004

**Paper Maps**
- 1/2500
- 1849 - current

**Aerial Photos**
- 1920 – current

**Other Photos and Picture**
- 1850 - current

Drawing each shape and adding some attributes of “Urban Morphology Types”, “Floors of each Building”, “Width of Roadways”.

www.wakayama-u.ac.jp/~tanikawa/
Old Trafford, Stretford Town Hall by GIS database

1932

2004
Historical 3D GIS database
Salford Quay and Old Trafford 2004
Historical 3D GIS database
Salford Quay and Old Trafford 1990
Historical 3D GIS database
Salford Quay and Old Trafford 1980
Historical 3D GIS database
Salford Quay and Old Trafford 1972
Historical 3D GIS database
Salford Quay and Old Trafford 1953
Historical 3D GIS database
Salford Quay and Old Trafford 1932
Historical 3D GIS database
Salford Quay and Old Trafford 1908
Historical 3D GIS database
Salford Quay and Old Trafford 1896
Historical 3D GIS database
Salford Quay and Old Trafford 1849
In 2004, Aggregate and Stone Block is 28%, 24% of Concrete, 20% of Bricks.
Conclusion

- GIS/GISc is associated with many methods and many exciting opportunities for interrogating and analysing spatial data.
- However, methods must (of course!) be used with care:
  - Whose view?
  - Individuals vs. groups?
  - Ethics?
  - Too technology led?
  - Too positivist?
- Reflective use is key!
Conceptual view of uncertainty

1st Filter associated with real world → conception (e.g. units, entities, scale, generalisation)

2nd Filter = conception → measurement/representation (e.g. positional error)

3rd filter = measurement/representation → analysis (e.g. propagation)

Berry (online) “think with maps” instead of just “mapping.”
More information

- Some starter references are given at the end
- Courses
  - MSc Geographical Information Science
  - ESRI (ArcGIS) online training
- Academic data services
  - EDINA
  - Landmap
- Support
  - School of Environment and Development Spatial Data Officer

[Image: Optical, Radar, Elevation, Feature]

http://landmap.mimas.ac.uk/

Landmap is a free UK academic data service, based in the University of Manchester…please use it!
GIS support services

- Short consultancy - e.g. on project start-up and data sourcing. Contact Karl Hennermann.
- Software. Our main software is ESRI ArcGIS Desktop. For download from IT Services website.
- ArcGIS software support. Contact IT Service Desk.
- ArcGIS training (online). Provided by ESRI. See IT Services software website.
- Geospatial data, e.g. administrative boundaries. Provided by EDINA Digimap. See EDINA Digimap website.
- Equipment loan (GPS, etc). Contact Karl Hennermann.

Paid for services, provided by SED:
- Consultancy
- Data processing and map production
- System analysis, design and implementation
- Instructor led training
- GIS project management

Contact Karl Hennermann about these services.

Further information:
Karl Hennermann, 0161 275 3655, karl.hennermann@manchester.ac.uk
Further reading

- http://www.innovativegis.com/basis/
- http://www.spatialanalysisonline.com/