

Spatial Arrangement

- The term broadly refers to:
 - Arrangement of objects in space
 - Spatial interrelationship among objects
 - To some extent, data organization for “spatial” modeling
- Deals with:
 - Placement
 - Ordering
 - Concentration
 - Connectedness; and/or
 - Dispersion of multiple objects



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Spatial Arrangement

Spatial Arrangement - 2

- Purpose:
 - Study and analyze the spatially distributed phenomenon
 - Look at the objects and identify “patterns”
 - Analyze and understand the “interaction” among the objects in “space”
- Complexity
 - Simple computation to extremely complex
- GIS is a *host* for analytical tools for spatial arrangement



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Point Patterns

➤ Dot density maps

- *Dot density*: Number of points in a given window of space (unit area)
- Visual descriptor(s) of the entity spread across space – a very useful tool!



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Types of Point Patterns

➤ Uniform

- Dot density for one small sub-area is the same across all the area!

➤ Regular

- If a uniform pattern is separated by same distance, the pattern is *regular!*

➤ Random

- No particular pattern

➤ Clustered

- Grouped in tight arrangements



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Quadrant Analysis

➤ Idea: how does the dot-density deviate from an “expected” value!

- Expected density in a given spatial window, E
- Actual density, Q
- Analysis is statistical in nature
 - From the simplest test – *chi-square* (χ^2) test

$$\chi^2 = \sum [(Q - E)^2 / E]$$

- To some of the most complex statistical tests (multivariate analysis of variance MANOVA)



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Nearest Neighbors

➤ Alternative analysis to “dot density”

➤ Centers on:

- What is the average distance to the “nearest neighbor?”

➤ Computation:

- Truly spatial:
 - Pythagorean theorem
- Via connected network
 - Network analysis



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Nearest Neighbor - Spatial

- From each *point*,
 - Compute distances to all other *points*
 - Find out which is the closest, note the distance (*NND*)
 - Compute average of the *NND*
- This *NND* is a measure of spatial distribution of the points in the selected space



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Nearest Neighbor - Network

- What if the aerial distance is irrelevant?
- *That is*, what if “practical” distance between the points is more important?
- Solution:
 - Treat all the “points” in question as zones.
 - Add them to the network layer
 - From each “zone”
 - Find the *BEST* paths to all other nodes along the network links
 - Note the nearest neighbor



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Thiessen Polygons

- Polygons around a *point* feature
 - Think “Jurisdiction” – region of influence
- Also referred to as:
 - Dirichlet diagrams
 - Voronoi diagrams
- 2 Methods of creating T polygons
- Other methods for delineating *jurisdiction*:
 - Natural boundaries
 - Street networks etc..



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Polygon Patterns

- Recall the discussion on: shape!
 - Orientation
 - Contiguity
 - Euler's Number
- Other topics (read: pp 307-311)
 - Free sampling
 - Non-free sampling
 - Isolation
 - Accessibility
 - Polygon interaction
 - Polygon dispersion



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Linear Patters

- Analysis of linear patterns is more complicated than point patterns
- Line density
 - Number of lines in a given spatial window?
 - Total length of lines divided by a area of the coverage or map (e.g. meters per hectare): L/A
 - How about adjusting length for number of lines?
 - $((n-1)L)/(nA)$
- We can also do nearest neighbor
 - Measure perpendicular distance with other lines
 - Find out which is the nearest
 - Somewhat complicated



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Linear Patters - 2

- Rose Diagram
 - Linear features drawn at the center of a circle
 - Each observation as a single line
 - Line length represents the magnitude of the observation
- Resultant vector - think "Statics"
 - Direction
 - Length



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Connectivity of Linear Objects

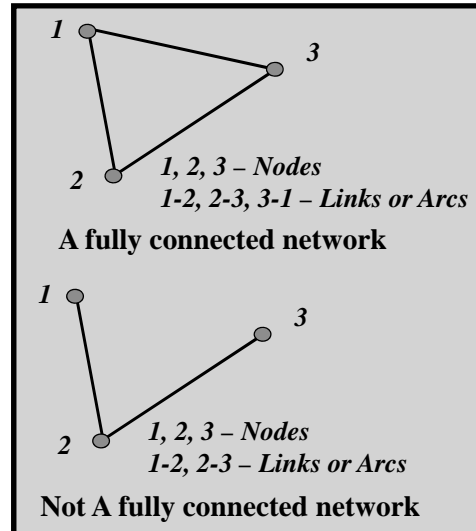
➤ Important issue for higher level linear objects – *a la* “networks”

➤ Network:

- Set of nodes and links
- Often with super nodes or zones

➤ Both nodes and arcs can have “costs”

➤ Costs (also called impedances) determine the path



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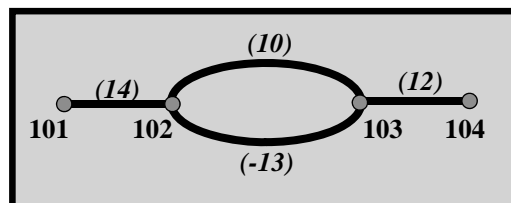
Circuitry

➤ “Circuitry” in a network

- The network contains “circuits”
- That is, you can get to certain nodes in the network by more than one way!

➤ Circuits with negative costs

- Nightmare!



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Network Indices

➤ Gamma index, γ (*Connectivity Index*)

- $\gamma = L/[3(V-2)]$
- 1.0 for a fully connected network

➤ Alpha index, α (*Circuitry Index*)

- $\alpha = \text{actual no of circuits}/\text{max no of circuits or } [(L-V)+1]/(2V-5)$
- 0 for no circuits
- 1.0 for maximum number of circuits



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Network Modeling

➤ Simplest:

- Finding the shortest path

➤ To most complex:

- Solving non-linear heuristic algorithms

➤ Key:

- Data organization



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Topological Models

- Recall "TIGER" data:
 - Topological encoding
 - Based on "*graph theory*"
- Topological *Vector* models
 - Basis for address geocoding
 - Enables address matching

Address Matching

- Why?
 - Businesses like to "see" where customers are!
 - Emergency operator can "locate" incident spots
 - Several (almost endless) applications
- One of the most prevalent uses of GIS
- Process:
 - Matching two addresses in a text oriented database is easy
 - Matching and then "Flagging" the location on the map (Pin-mapping) – the challenge in GIS!

Address Components

➤ Address files for "Geocoding"

- Store addresses as attributes for feature data source (searched into – e.g. geocoded TIGER data)
 - Meticulous data arrangement (sound data structures) is needed
 - Arrangement differs for point, line and polygon features
- Table of addresses for which matches are to be found (the keys – e.g. a customer list)



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Address Files

➤ Line Features

- Common patterns - most urban street segments in the US are addressed with:
 - Odd numbers on one side, even numbers on the other
 - Numbers do not jump – *i.e.* they are continuous
 - Range from low to high in the same direction on both sides
 - Each block is numbered separately
- Take advantage of this system!!!!

Example: (This is just an illustration – data may not be correct)

George Mason University street address would be in:

<u>Left from</u>	<u>Left to</u>	<u>Right from</u>	<u>Right to</u>	<u>Street Name</u>	<u>Type</u>
9401	9501	9400	9500	University	Dr.



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Address Files – 2

➤ Polygon features

- Lots can be identified by their permit numbers
- Larger areas can be represented by postal *zip* and/or *zip+4* codes

Example:

George Mason University is located in
Zip Code 22030, 4 digit extension – 4444

First look-up this polygon then look
into the geocoded street (line) feature!

Permit num

123455

Zip Zip4

22030 4444

❖ Point features

- May also have descriptive address – not very common



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Geocoding

➤ Most common term for “preparing the data” for *address matching*

➤ Big issue:

- Data comes in all forms and shapes
- How do you screen data that can have zillion mistakes?
- How accurate do you want to and will be able to match addresses?

- Depends on application

➤ Most GIS packages have tools (editors) for Geocoding!

- In batch or interactive mode



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Steps

- Prepare data for a “matchable” theme
 - Line feature
 - Polygon feature
 - Point feature (if available)
- Set-up GIS for “matchable” theme
- Create table(s) for matching
- Perform address matching
 - Pin-mapping
 - Other GIS functions



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