Introduction to Spatial Analysis

I. Conceptualizing space

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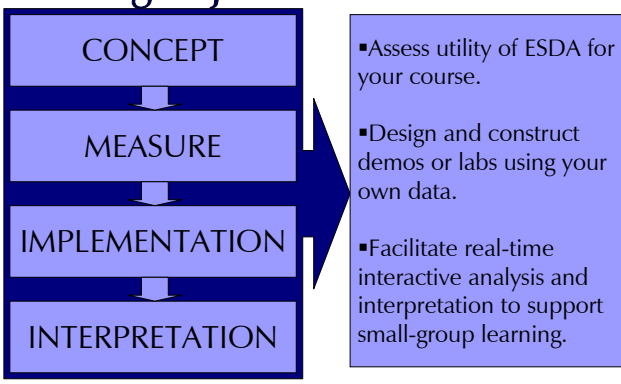
Session organization

- Module 1: Conceptualizing space
- Module 2: Spatial analysis of lattice data
- Module 3: Spatial analysis of point patterns
- Module 4: Spatial analysis of field data
- Module 5: Additional demonstrations

Learning Objectives

- Importance of conceptualizing space
- Spatial measures and spatial operations are derived from spatial concepts
- Implementation in GeoDa
- Construction and interpretation of ESDA "views", especially spatial autocorrelation.
- Instructional technique

Learning objectives



Module organization

- GIS and spatial analysis
- Spatial analytic traditions
- Why ESDA?
- Three basic concepts
  - Spatial scale and extent
  - Connectivity
  - Aggregation and MAUP

GIS and spatial analysis

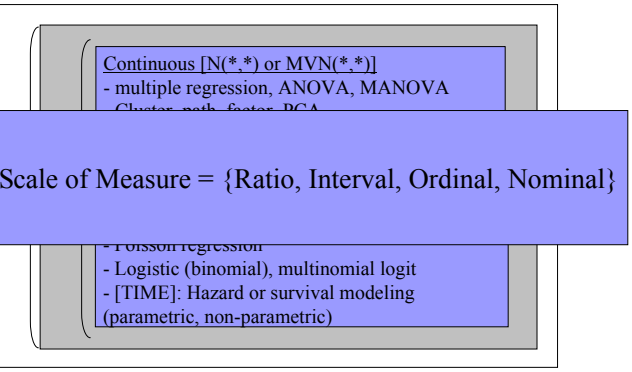
- GIS: Geographic Information System
  - Storage, retrieval, and display of spatially-referenced data
  - GIS "analysis": buffers, map algebra, layering
- Spatial Analysis
  - Quantitative analysis of spatial processes
  - Spatial econometrics, statistics, optimization

GIS and Spatial Analysis

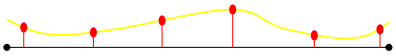
- Spatial Analysis (cont.)
  - Traditions:
    - Spatial econometrics: irregular lattice, cross-section
    - Spatial statistics: spatial processes
    - Geostatistics: continuous fields, regular lattice

Spatial analytic traditions

- Statistics
  - Measurement scale→Information→Method
- Spatial analysis
  - Spatial data type→Information→Method



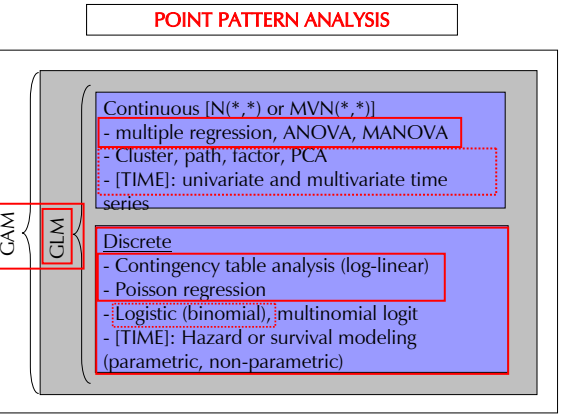
- Spatial continuous (fields) → Geostatistics



- Points (objects) → Point Pattern Analysis

- Irregular / Regular lattice (objects) → Spatial Econometrics

- Volume of interaction among areas → Spatial Interaction Model



Spatial analytic traditions

- Common themes:
  - Spatial process underlying observed spatial pattern
  - Spatial variation can be decomposed into:
    - Large scale variation: mean of spatial process

      $z_s = X_s'B + e_s$
    - Small scale variation: covariance of spatial process

      $Cov(e_i, e_j) \neq 0$

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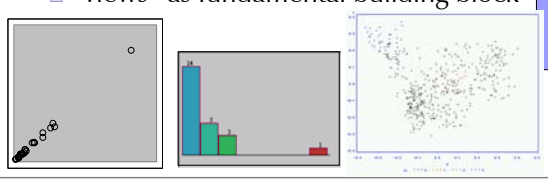
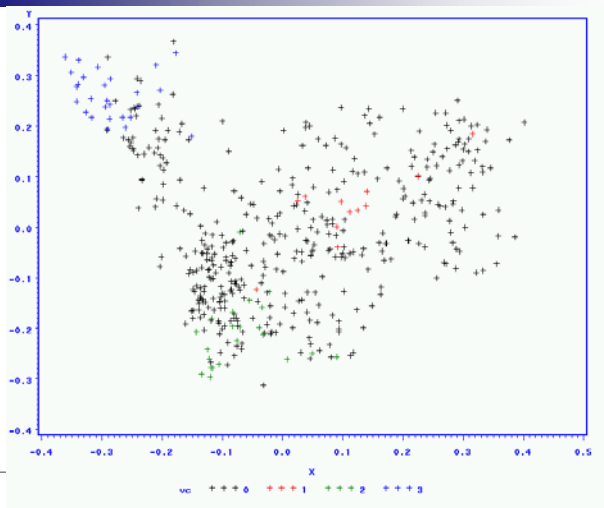
Why E(S)DA?

- EDA: Exploratory Data Analysis
  - "discover" patterns in multivariate data
  - data-driven not theory-driven
  - augmented visual processing power
  - "views" as fundamental building block

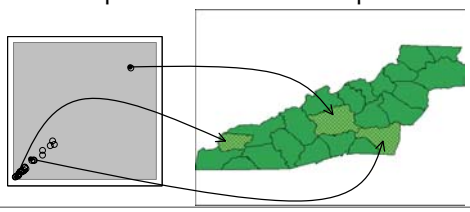
3.98
7.22
6.99
98.48
34.46
30.93
8.91
1.64
2.07
15.65
32.78
9.43
17.06
9.67
3.92
5.29
4.56
24.32
5.88
10.57
17.29
24.33
4.62





Why E(S)DA?

- EDA: Exploratory Data Analysis
- ESDA: Exploratory *Spatial* Data Analysis
  - EDA tools adapted to spatially-referenced data
  - Concepts and measures adapted to SDA



GeoDa

- ESDA platform
- Dynamic ESDA
  - Broad array of measures and views
  - Multiple data views
  - Views are dynamically linked
  - Bounding box can be used to "brush" over observations in any view

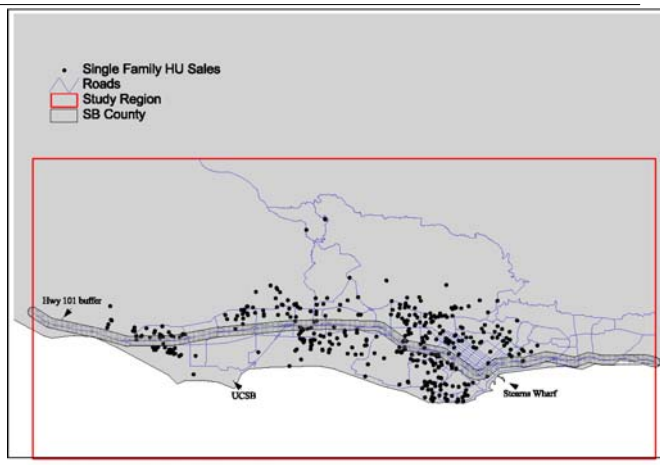


Figure 2: South Coast single family home sales

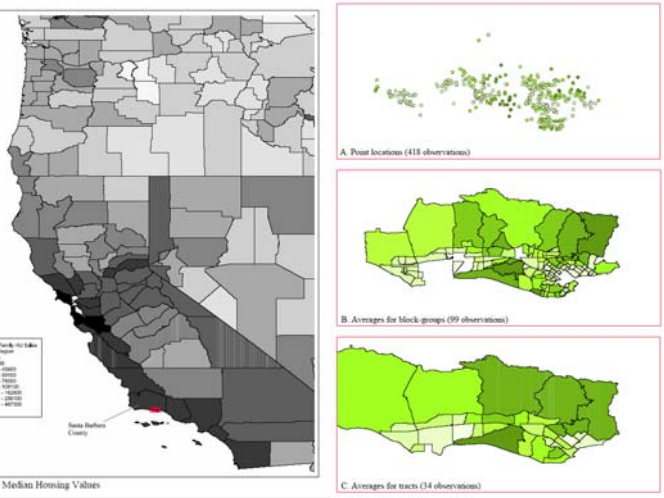
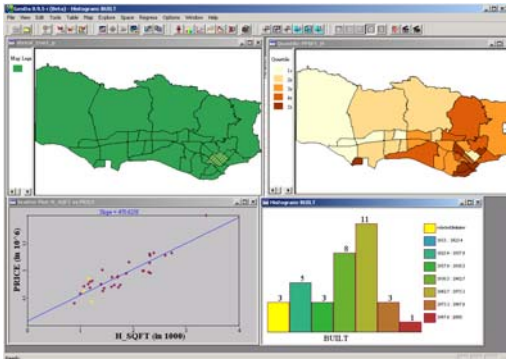


Figure 3: Housing price sales gradients for individual observations (A) and two areal aggregates (B and C)

Geoda: Basic Mapping and EDA



Demo I: Basic Mapping & EDA

- Input Files:
  - ArcGIS shapefile format
  - .shp (polygons), .idx (index), .dbf (attributes)
- Limited spatial database functionality
  - GIS operations: buffer, dissolve, … are not available
- Does include "join" function
  - Allows for analysis in Excel or other package to be merged with spatial data.

Application I: Mapping

- Start GeoDa
- Opening map file
  - Choose: File >Open Project
  - Input Map= sb_real_tract_p.shp
  - Key Variable = ID_TRCT
- Choropleth maps:
  - Right-click on map
  - Select: Choropleth Map>Quantile
  - Select Variable: PPSFT_H
  - Set Classes=5

Application I: Mapping (cont.)

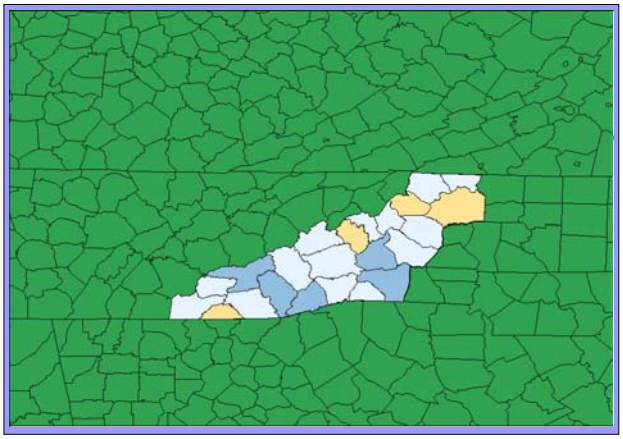
- Create histogram
  - Choose: Explore>Histogram
  - Select: Built
- Create scatterplot
  - Choose: Explore>Scatterplot
  - Select: X=H_SQFT, Y=PRICE

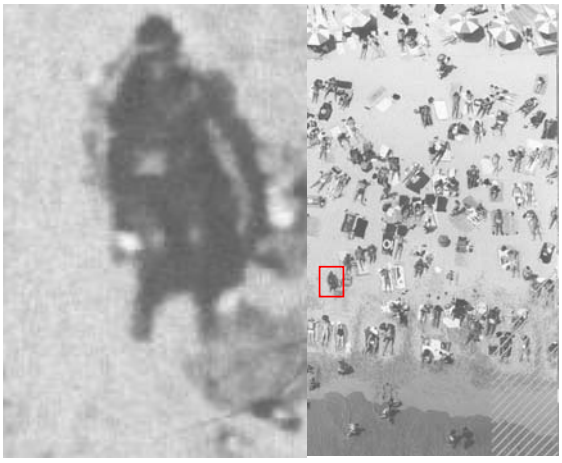
Module organization

- GIS and spatial analysis
- Spatial analytic traditions
- Why ESDA?
- Three basic concepts
  - Spatial scale and extent
  - Connectivity
  - Aggregation and MAUP

Concept 1: Spatial Scale & Extent

- Ratio of map units to real world units
- "Zooming in (out)" represents scale change
  - Fixed bounding box → Extent changes
- Associated Issues:
  - Process scale
  - Visual resolution
  - Non-trivial issue in designing an analysis
  - Spatial support ("datum")
  - Cross-scale interactions

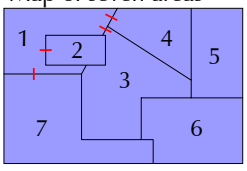


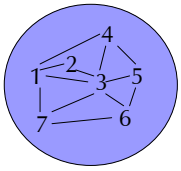


Concept 2: Connectivity

- Network view of geographic space
  - Connectivity: spatial units are linked
- Neighborhood
  - Everything is linked!…
  - What is the correct threshold?
- Generalizing space
  - I-O reduction gives metric space
  - What is the "correct" metric of connectivity?

Connectivity example:
Map of seven areas

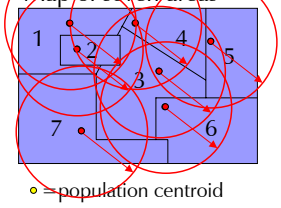




Share border:

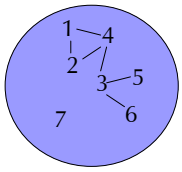
Neighbor(1)={2,3,4,7}
Neighbor(2)={1,3}
..
Neighbor(7)={1,3,6}

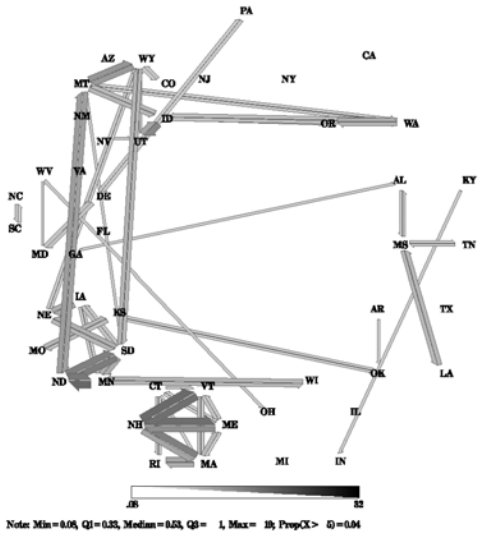
Connectivity example:
Map of seven areas



Distance threshold:

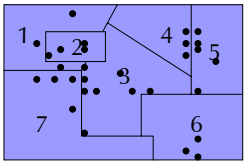
Neighbor(1)={2,4}
Neighbor(2)={1,4}
Neighbor(3)={4,5,6}
Neighbor(4)={1,2,3}
Neighbor(5)={3}
Neighbor(6)={3}
Neighbor(7)={none}





Concept 3: Aggregation & MAUP

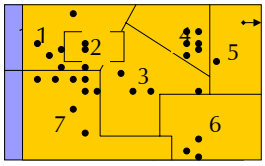
- Choice of Spatial Support implies:
  - …a spatial aggregation
    - areal values are an average of underlying points (or spatial process)
  - …a scale of analysis
    - imposes a fixed scale
  - …conditional empirical results
    - MAUP: Modifiable Areal Unit Problem
    - Frame-dependence



Areal data:

	SD1	SD2	SD3
1	3		
2	4		
3	8		
4	3		
5	5		
6	3		
7	4		

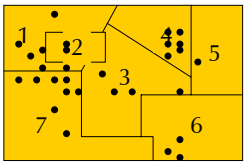
Aggregation & Frame Dependence Example:



Areal data:

	SD1	SD2	SD3
1	3	6	
2	4	2	
3	8	4	
4	3	6	
5	5	1	
6	3	3	
7	4	8	

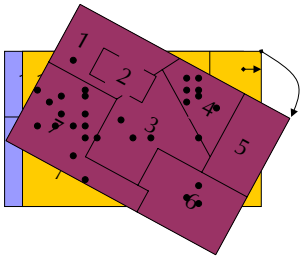
Aggregation & Frame Dependence Example:



Areal data:

	SD1	SD2	SD3
1	3	6	
2	4	2	
3	8	4	
4	3	6	
5	5	1	
6	3	3	
7	4	8	

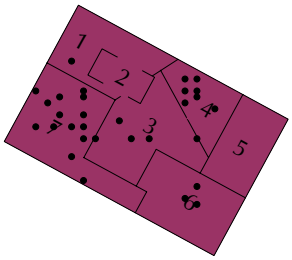
Aggregation & Frame Dependence Example:



Areal data:

	SD1	SD2	SD3
1	3	6	1
2	4	2	0
3	8	4	5
4	3	6	7
5	5	1	0
6	3	3	3
7	4	8	14

Aggregation & Frame Dependence Example:



Areal data:

	SD1	SD2	SD3
1	3	6	1
2	4	2	0
3	8	4	5
4	3	6	7
5	5	1	0
6	3	3	3
7	4	8	14

Aggregation & Frame Dependence Example:

Module I review

- GIS and spatial analysis
- Spatial analytic traditions
  - Spatial data types
  - Process decomposition: mean + stochastic
- Three basic concepts
  - Spatial scale and extent
  - Connectivity
  - Aggregation and MAUP

Discussion:

- Are the concepts of spatial scale, connectivity, and aggregation important or relevant to your discipline?
- How might the explicit use of those concepts change the learning experience for undergraduates in your courses?