Quantitative Geography

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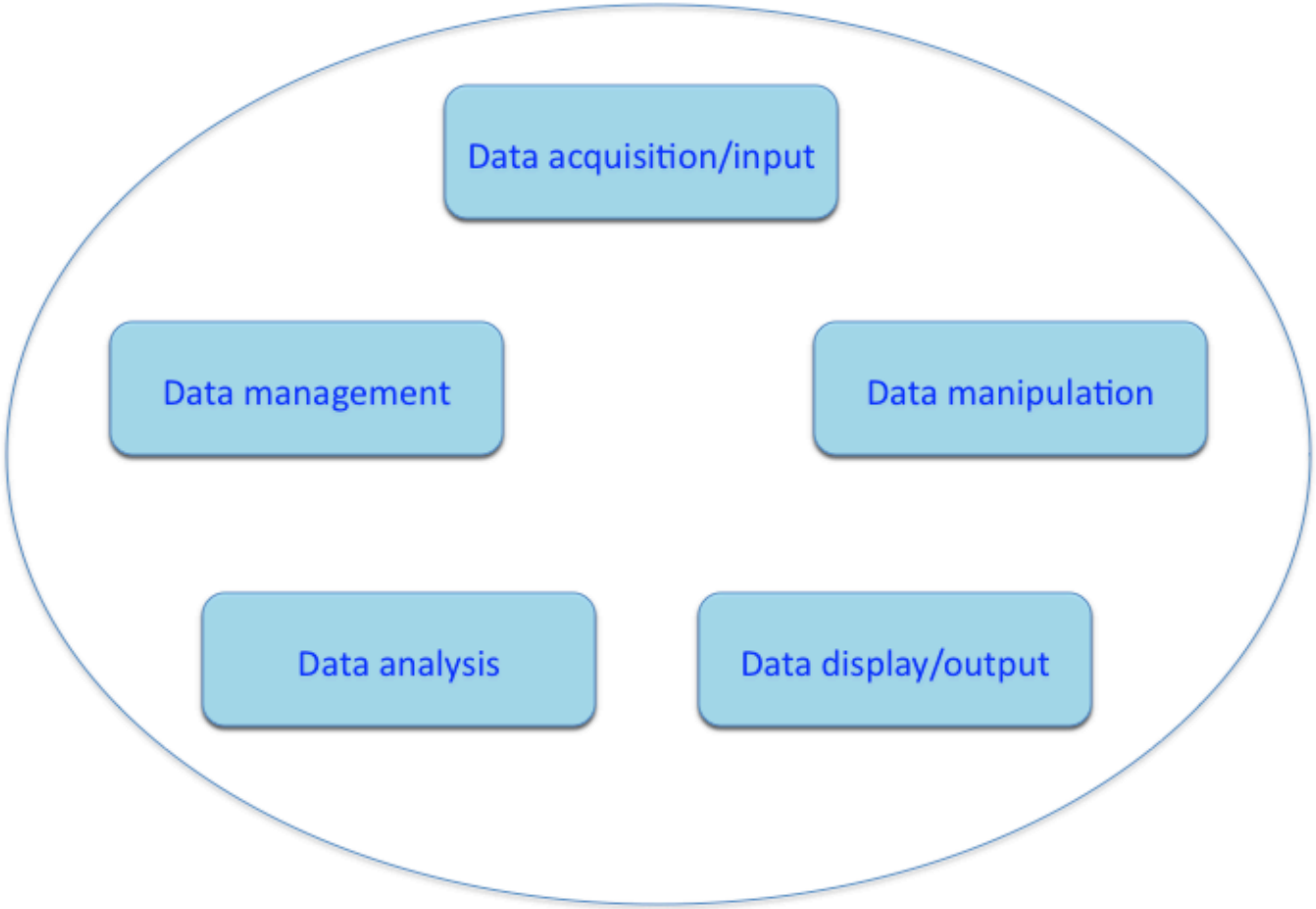
Quantitative Methods

- Approaches for developing a better understanding of phenomena
- Descriptive summary techniques
- Tools which help to explain or give insight into what is taking place
- Systematic methods for analyzing information

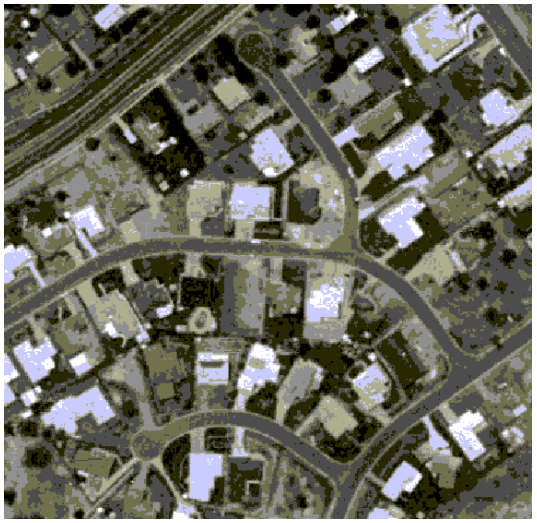
Quantitative Geography

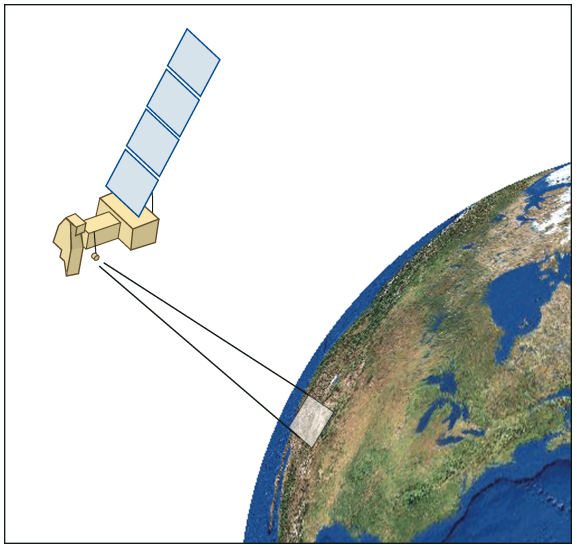
- Collection of methods that are applied, or could/can be applied, by geographers and others to study spatial phenomena, issues and problems
- Methods
  - GIS
  - Areal sensing (GPS, photogrammetry, remote sensing)
  - Mathematics and optimization
  - Statistics and ESDA
  - Regional Analysis
  - Computer science and simulation

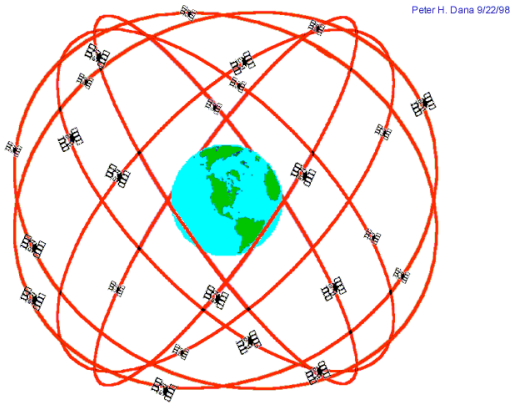
GIS


Data acquisition/input
Data management
Data manipulation
Data analysis
Data display/output

Areal Sensing







GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

Mathematics and Optimization

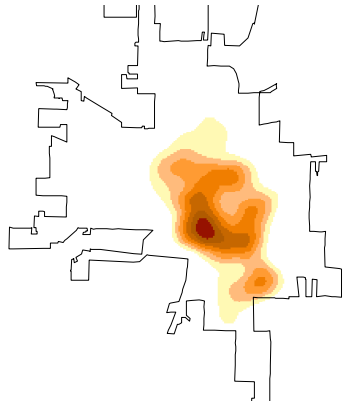
- Classic methods
  - Basics of algebra, geometry, calculus and linear algebra
  - Fourier analysis, differential equations, Laplace transformations, numerical methods, complex analysis, etc.
  - Linear, integer and dynamic programming
  - Heuristic methods
- Spatial interaction
- Spatial optimization
- Network analysis

$$Max \quad cx$$
$$S.t. \quad Ax \leq b$$
$$x \geq 0$$

Statistics and ESDA

- Classic methods
- Surveying and spatial sampling
- Point pattern analysis
  - Nearest neighbor
  - Quadrat
  - Kernel density
  - k functions
  - Clustering

$$K(r) = \frac{E\left[\left|C(p,r)\right|\right]}{\lambda}$$

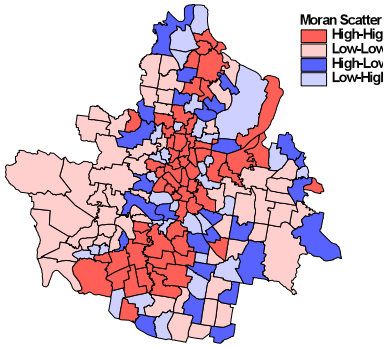


- Spatial autocorrelation
  - Global
  - Local

$$I = \frac{z'Wz}{z'z}$$

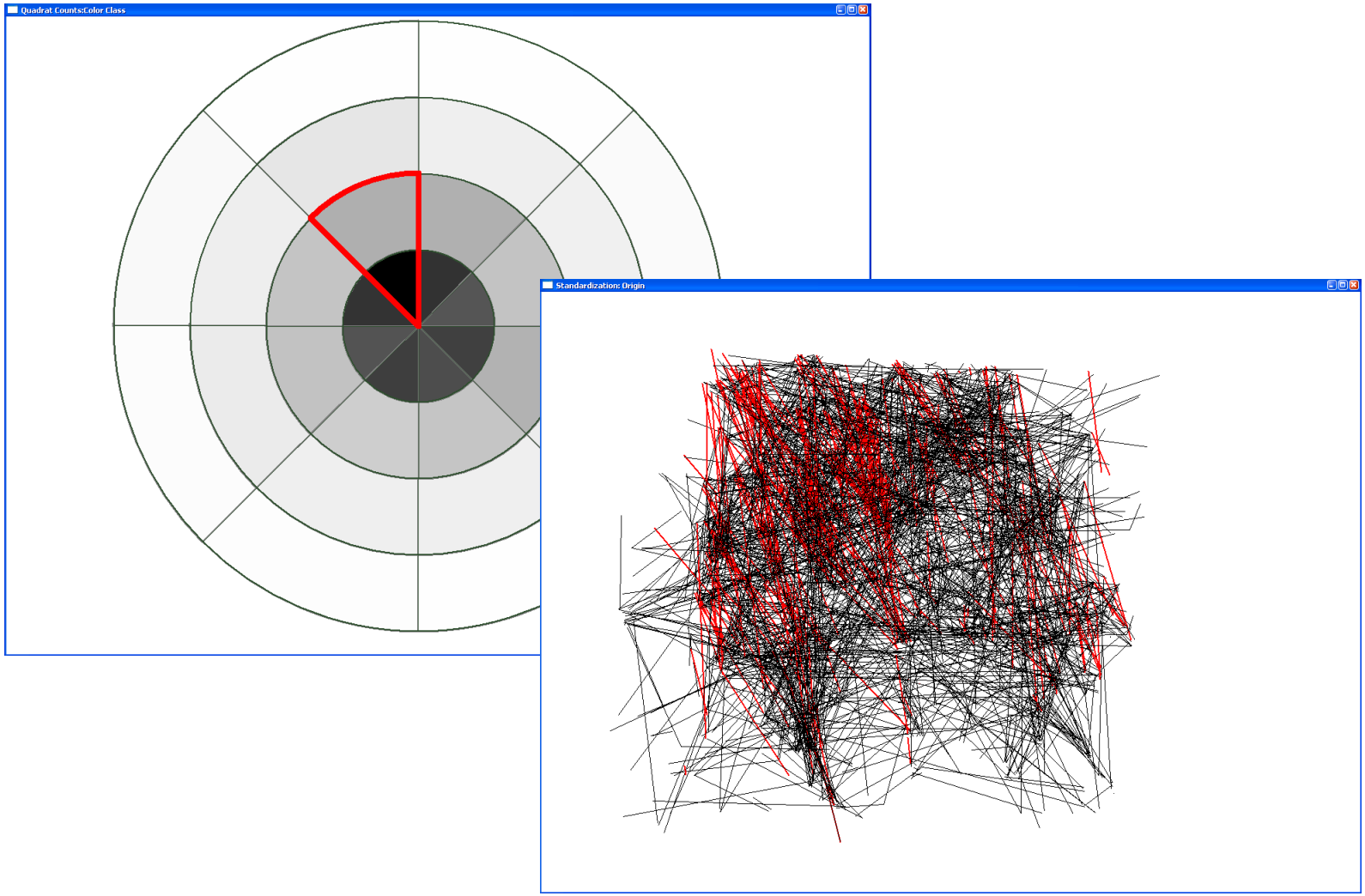
- Spatial statistical models
  - Spatial lag
  - Expansion method
  - GWR
  - Interpolation

$$y = X\beta + \rho Wy + \varepsilon$$



- ESDA

ESDA



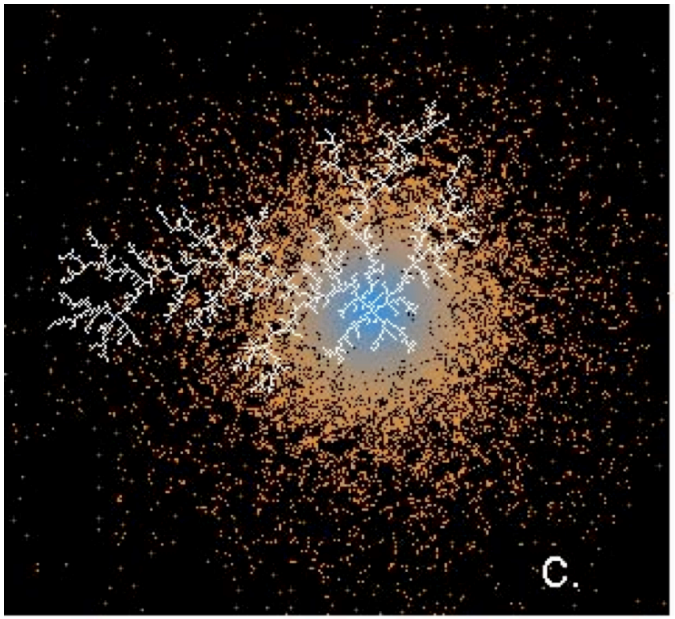
Regional Analysis

- Classic methods
  - fundamentals of location theory (land rent models, cost minimization, central place hierarchies, competition, etc.)
  - computable general equilibrium models
- Location quotient
- Shift-share
- Input-output
- Regional models
  - Spatial interaction
  - Optimization

$$X = (I - A)^{-1} Y$$

Computer Science and Simulation

- Classic methods
  - Programming
  - Data architectures
  - Parallel computing
  - Distributed computing
- Spatial database design
- Algorithms
  - Spatial optimization heuristics
  - TIN creation
- Simulating spatial processes
  - Cellular automata
  - Agent based
  - Neural networks



Major Unresolved Issues

- Spatial data uncertainty
- Modifiable areal unit problem
- Frame dependence
- Patterns and shapes
- Spatio-temporal methods
- Category interaction

Spatial Data Uncertainty

- Data model abstractions
- Positional accuracy
- Object accuracy
- Attribute accuracy

- What are the implications in analysis, understanding and knowledge acquisition?
  - Much on this in GIScience literature
    - ⇒ Goodchild and Gopal (1989), etc.

MAUP and Frame Dependence

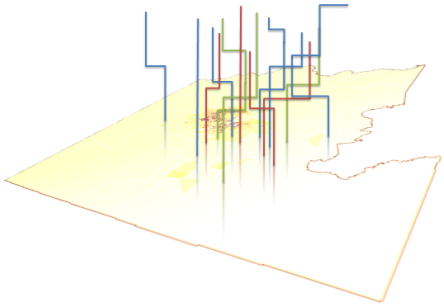
- Recognition that model results may be dependent on the scale of analysis or unit definition
  - Openshaw and Taylor (1981), Tobler (1979)
- Wong (2003)
  - Less frame dependent segregation measure
- Murray (2005)
  - Location coverage model that is less sensitive to scale and/or unit definition
- Aldstadt and Getis (2006)
  - Endogenous specification of *W*

Patterns and Shapes

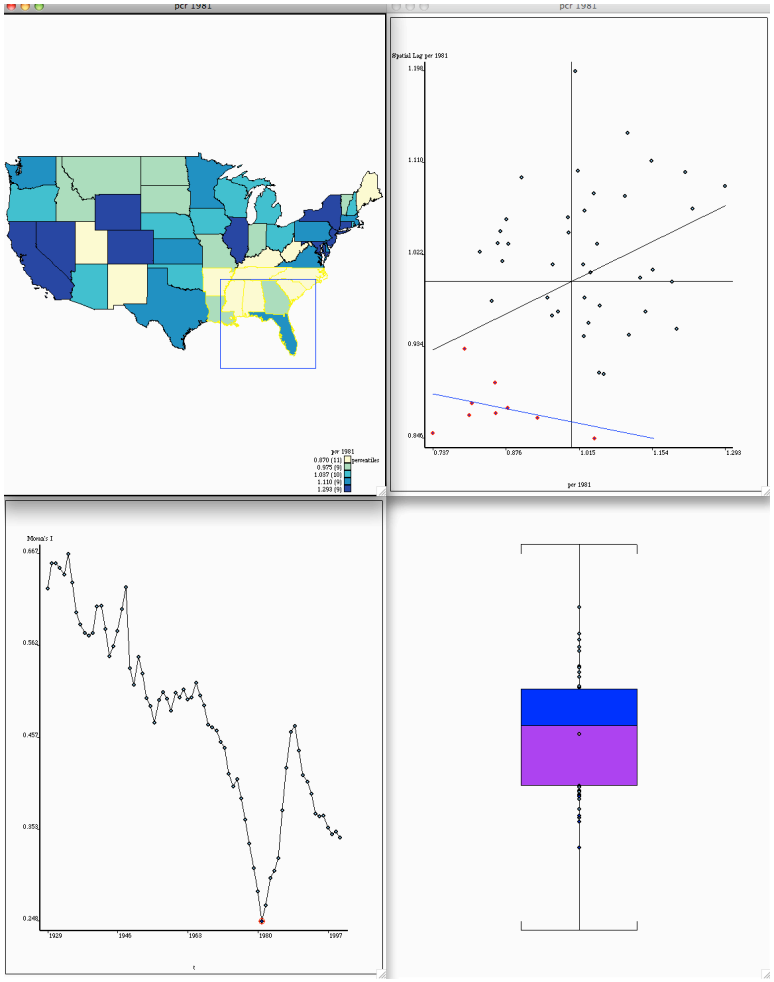
- Increasing interest in explicitly measuring, modeling and optimizing pattern and/or shape
- Wiliams and Wentz (2008)
  - Formal specification of components of shape
- Wu and Murray (2008)
  - Formal specification of relative contiguity

$$C = \frac{\sum_{k \in M}\left(\frac{N_k\left(N_k - 1\right)}{2}\right) + \frac{1}{2}\sum_{k \in M}\sum_{\substack{l \in M \\ l \neq k}}\left(\frac{N_k N_l}{D_{kl}^{\gamma}}\right)}{\frac{\left(\sum_{k \in M} N_k\right)\left(\sum_{k \in M} N_k - 1\right)}{2}}$$

Spatio-Temporal Methods



- Miller (2005)
  - Framework for addressing space -time change
- Rey and Janikas (2006)
  - STARS
- Murray and Liu (2009)



Category Interaction

- Ward et al. (2003)
  - Spatial optimization and simulation of spatial processes
- Matisziw et al. (2009)
  - Spatial optimization and GIS