Lecture 3: Spatial Modeling

GEOG413/613
Dr. Anthony Jjumba

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Spatial Modeling

- **Spatial analysis (more from last week)**
  - Nearest Neighbor Analysis
  - Spatial Autocorrelation
- **Spatial modeling**

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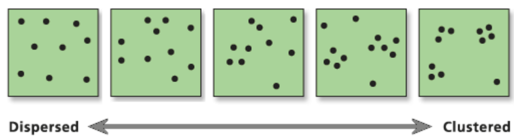
Spatial Analysis

- Nearest Neighbor Analysis
  - A method used to determine whether a distribution is clustered, random or regular.



ESRI

  - To assess the spacing of points, the average nearest neighbor distance is determined.

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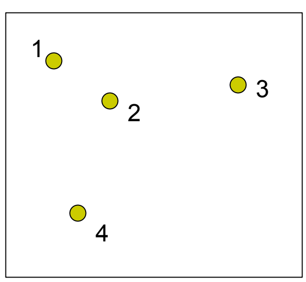
Spatial Analysis

- Nearest Neighbor Analysis



$d_1 = l_{12}$

$d_2 = l_{21}$

$d_3 = l_{32}$

$d_4 = l_{42}$

$$r_{obs} = \frac{\sum d_i}{n}$$

The Average Nearest neighbor distance = r_{obs}

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Spatial Analysis

- The nearest Neighbor statistic is determined as a ratio of r_{obs} *to* r_{exp}, the expected average nearest neighbor distance for a random distribution

$$r_{\exp} = \frac{1}{2\sqrt{n/A}}$$

Where :
A is area of study region
n is number of points

$$R = \frac{r_{obs}}{r_{\exp}}$$

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Spatial Autocorrelation

- The **First Law of Geography** by Waldo Tobler (1970): "everything is related to everything else, but near things are more related than distant things".
- Spatial Autocorrelation:
  - The degree to which the values representing a phenomenon tend to be clustered together in space (positive spatial autocorrelation) or dispersed (negative spatial autocorrelation).

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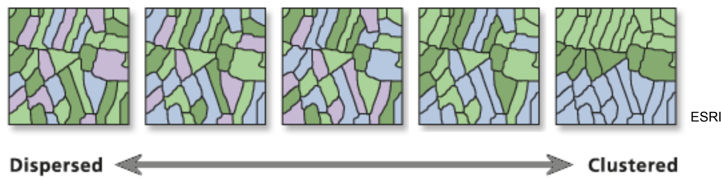
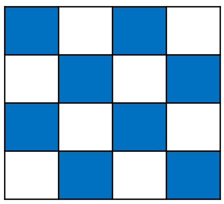
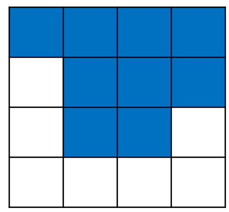
Spatial Autocorrelation







Spatial Autocorrelation

- The autocorrelation coefficients for interval and ordinal data are Moran's statistic *I* and Geary's coefficient *c*, respectively.

There is more depth to spatial pattern analysis and spatial autocorrelation
We may need a lecture session to cover these.

Modeling

- Modeling as in the application of GIS-based techniques to represent the real world
- A **model** is a simplified representation of reality
  - A map is an example of a model
    - It's ***a*** representation of the real world
    - It's ***a*** simplification of the real world
    - It serves a purpose (objective)
- Modeling should be considered as a procedure

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Modeling

- Some Types of GIS Models
  - Static/Dynamic
  - Descriptive/Predictive/Prescriptive
  - Deterministic/Stochastic
  - Inductive/Deductive

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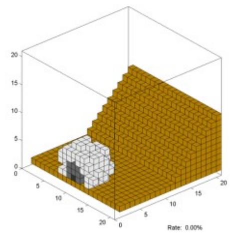
Types of GIS Models

- Static/Dynamic
  - A static model represents a temporal snapshot of a phenomenon (state of the phenomenon is stable).
  - A dynamic model emphasizes the spatiotemporal changes of a phenomenon (changes over time).



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Types of GIS Models

- Descriptive/Predictive/Prescriptive
  - Descriptive models provide insights about a study area. E.g. Thematic map of land cover
  - Predictive models offer a forecast of what could happen in the future. Models use past and present data in addition to statistical models and predictive algorithms to generate what-if (alternative) scenarios
    - E.g. Prediction of future land use patterns
  - Prescriptive models use optimization techniques to provide the best solution.
    - E.g. Best route from A to B

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Types of GIS Models

- Deterministic/Stochastic
  - Both deterministic and stochastic models are mathematical models.
    - Deterministic models the process is fully described by the parameter values and the initial conditions.
    - Stochastic models consider the presence of some randomness in one or more of its parameters or variables.
      - Although the real world is characterized by stochasticity, there are times when deterministic models are sufficient

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Types of GIS Models

- Inductive/Deductive
  - A deductive model presents outcomes derived from established theories, physical laws or relationships.
    - E.g. Model is based on established laws of climatology
  - An inductive model represents the conclusion derived from data.
    - E.g. model based on past climatology observations can be relied upon

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The Modeling Process

- The development of a model follows a series of steps.
  - Define the goals of the model (objectives of the study)
    - Phenomenon to be modeled
    - Required data
    - Appropriate spatial and temporal scales
  - Model Specification
    - Determine the elements in the model, their properties,
    - Design the interrelations and interactions between the elements
    - Specify the parameters of the model (properties of the elements)
    - Specify the mathematical/statistical models

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The Modeling Process

- The development of a model follows a series of steps:
  - Model Verification
    - Model is tested to check that it is correctly implemented with respect to the conceptual model (implementation matches the literature)
  - Model Calibration
    - Adjust parameter values so that the model's output appropriately represent the phenomenon

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The Modeling Process

- The development of a model follows a series of steps.
  - Sensitivity Analysis
    - Determine how the different variables impact the model's output
  - Model Validation
    - Evaluate the correctness of the model's output. Comparison is made to an existing dataset.

Integrating GIS with Models

- There are three ways of linking a GIS to a model
  - **Loose coupling:** The model and GIS are not directly connected. Generally data files are transferred between the GIS and the model through each application's independent import and export functions.
  - **Tight coupling:** The GIS and the model software are linked and are dependent on each other.
  - **Embedded system:** The GIS and the model share memory and a common interface.

References

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