GEOGRAPHY 38/42:376
GIS II

Topic 7: Point Pattern Analysis

POINT PATTERN ANALYSIS

- Points are zero dimensional, so no geometric properties to analyze
- Instead, quantitative techniques for evaluating :
  - spatial distribution
  - arrangement or pattern
  - . . . of a set of points
- Occurrence is sufficient, but may also consider attributes values

SPATIAL DISTRIBUTION

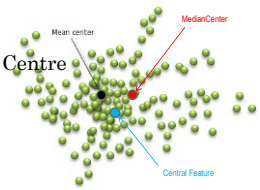
- **Spatial distribution** of points can be described by:
  1. Frequency
  2. Density
  3. Measures of central tendency
  4. Dispersion
- Useful when evaluating:
  1.
  2.
  3.

Spatial Distribution

- Frequency
  - Total number per defined area
  - Useful when?
    -
    -
  - Not useful when?
    -
- Density
  - Number of points per unit area

Spatial Distribution

- Central Tendency
  - Geometric or Mean Centre
  - Median Centre
  - Centre of Minimum Travel



The Mean Center is given as:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad , \quad \bar{Y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{1}$$

where x_i and y_i are the coordinates for feature i, and n is equal to the total number of features.

The Weighted Mean Center extends to the following:

$$\bar{X}_w = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \quad , \quad \bar{Y}_w = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \tag{2}$$

where w_i is the weight at feature i.

The tool also calculates the center for a 3rd dimension if a z attribute exists for each feature:

$$\bar{Z} = \frac{\sum_{i=1}^{n} z_i}{n} \quad , \quad \bar{Z}_w = \frac{\sum_{i=1}^{n} w_i z_i}{\sum_{i=1}^{n} w_i} \tag{3}$$

Spatial Distribution

- Measures of Dispersion
  - Dispersion is spacing around the <u>mean centre</u>
  - Standard Distance/Deviation

The Standard Distance is given as:

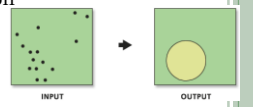
$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n} + \frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}} \quad (1)$$

where x_i and y_i are the coordinates for feature i, $\{\bar{X},\ \bar{Y}\}$ represents the Mean Center for the features, and n is equal to the total number of features.

The Weighted Standard Distance extends to the following:

$$SD_w = \sqrt{\frac{\sum_{i=1}^{n} w_i(x_i - \bar{X}_w)^2}{\sum_{i=1}^{n} w_i} + \frac{\sum_{i=1}^{n} w_i(y_i - \bar{Y}_w)^2}{\sum_{i=1}^{n} w_i}} \quad (2)$$

where w_i is the weight at feature i and $\{\bar{X}_w,\ \bar{Y}_w\}$ represents the weighted Mean Center.



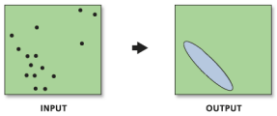
Spatial Distribution

- Measures of Dispersion
  - Dispersion is spacing around the <u>mean centre</u>
  - Standard Deviation Ellipse

Standard Deviational Ellipse is given as:

$$SDE_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n}}$$

$$SDE_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}}$$



Spatial Arrangement (Pattern)

- Location of points relative to one another
- Typically described as:
  -
  -
  -

Spatial Arrangement (Pattern)

- Nearest Neighbour Analysis
  - Based on measure of mean distance between each point and nearest neighbour
  - Basic idea is that mean distance will be:
    - large for scattered patterns
    - small for clustered patterns
    - and somewhere between for random patterns
  - Nearest Neighbour Index compares observed mean distance to expected distance

Spatial Arrangement (Pattern)

- Nearest Neighbour Analysis
  - Expected distance for a random distribution of points

$$D_{ran} = 0.5\ [N/A]^{-1/2}$$

where:

N = number points

A = area

Spatial Arrangement (Pattern)

- Nearest Neighbour Analysis
  - Nearest neighbour index (NNI) is ratio of observed dist over expected NN dist
  - NNI ranges between 0 and 2.1491
    - NNI = 0 for perfectly clustered points
    - NNI = 2.1491 for perfectly scattered
    - NNI = 1 for perfectly random

  - Limited because it only considers neighbouring pts.

Spatial Arrangement (Pattern)

- Spatial Autocorrelation
  - Spatial autocorrelation determines extent to which:
    - occurrence (and value) of one point affects occurrence (and value) of adjacent points
  - Traditionally viewed as a bad thing since it violates assumptions of correlation and regression analysis
  - However, it can also tell us something about the distribution of point features

Spatial Arrangement (Pattern)

- Spatial Autocorrelation
  - Moran's I common measure of spatial autocorrelation
    - If occurrence of a point facilitates or increases probability of occurrence of another point nearby, then I will be closer to +1.0 (clustered)
    - If occurrence decreases probability of another point nearby, I will be closer to –1.0 (scattered)
    - If a point has no influence on the probability of another point being located nearby, I will be closer to 0.0 (random)